

GnuTLS

Transport Layer Security Library for the GNU system
for version 3.0.0, 23 July 2011



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Table of Contents

1	Preface	1
2	The Library	2
2.1	General idea	2
2.2	Error handling	3
2.3	Memory handling	4
2.4	Thread safety	4
2.5	Callback functions	5
3	Introduction to TLS and DTLS	6
3.1	TLS layers	6
3.2	The transport layer	6
3.3	The TLS record protocol	7
3.3.1	Encryption algorithms used in the record layer	8
3.3.2	Compression algorithms used in the record layer	10
3.3.3	Weaknesses and countermeasures	10
3.3.4	On record padding	10
3.4	The TLS alert protocol	11
3.5	The TLS handshake protocol	12
3.5.1	TLS ciphersuites	12
3.5.2	Priority strings	12
3.5.3	Client authentication	16
3.5.4	Resuming sessions	16
3.5.5	Interoperability	17
3.6	TLS extensions	17
3.6.1	Maximum fragment length negotiation	17
3.6.2	Server name indication	17
3.6.3	Session tickets	18
3.6.4	Safe renegotiation	18
3.7	Selecting cryptographic key sizes	19
3.8	On SSL 2 and older protocols	21
4	Authentication methods	22
4.1	Certificate authentication	22
4.1.1	Authentication using X.509 certificates	22
4.1.2	Authentication using OpenPGP keys	22
4.1.3	Using certificate authentication	22
4.2	Anonymous authentication	24
4.3	Authentication using SRP	25
4.4	Authentication using PSK	26
4.5	Authentication and credentials	27
4.6	Parameters stored in credentials	27

5	More on certificate authentication	29
5.1	The X.509 trust model	29
5.1.1	X.509 certificates	29
5.1.2	Verifying X.509 certificate paths	31
5.1.3	PKCS #10 certificate requests	35
5.1.4	PKCS #12 structures	37
5.2	The OpenPGP trust model	40
5.2.1	OpenPGP keys	41
5.2.2	Verifying an OpenPGP key	41
5.3	Hardware tokens	41
5.3.1	Introduction	41
5.3.2	Initialization	42
5.3.3	Reading objects	42
5.3.4	Writing objects	45
5.3.5	Using a PKCS #11 token with TLS	45
5.4	Abstract key types	45
5.5	Digital signatures	46
5.5.1	Trading security for interoperability	46
6	How to use GnuTLS in applications	48
6.1	Preparation	48
6.1.1	Headers	48
6.1.2	Initialization	48
6.1.3	Version check	48
6.1.4	Debugging and auditing	48
6.1.5	Building the source	49
6.2	Client examples	49
6.2.1	Simple client example with anonymous authentication	49
6.2.2	Simple client example with X.509 certificate support	52
6.2.3	Simple datagram TLS client example	54
6.2.4	Obtaining session information	57
6.2.5	Verifying peer's certificate	60
6.2.6	Using a callback to select the certificate to use	64
6.2.7	Verifying a certificate	71
6.2.8	Using a PKCS #11 token with TLS	74
6.2.9	Client with resume capability example	81
6.2.10	Simple client example with SRP authentication	84
6.2.11	Simple client example using the C++ API	87
6.2.12	Helper function for TCP connections	89
6.3	Server examples	90
6.3.1	Echo server with X.509 authentication	90
6.3.2	Echo server with OpenPGP authentication	95
6.3.3	Echo server with SRP authentication	99
6.3.4	Echo Server with anonymous authentication	102
6.4	Miscellaneous examples	106
6.4.1	Checking for an alert	106
6.4.2	X.509 certificate parsing example	107
6.5	Advanced and other topics	110

6.5.1	Parameter generation	110
6.5.2	Keying material exporters	111
6.5.3	Channel bindings	111
6.5.4	Compatibility with the OpenSSL library	112
7	How to use TLS in application protocols ...	113
7.1	Separate ports	113
7.2	Upward negotiation	113
8	Included programs	115
8.1	Invoking certtool	115
8.1.1	Diffie-Hellman parameter generation	117
8.1.2	Self-signed certificate generation	117
8.1.3	Private key generation	117
8.1.4	Certificate generation	117
8.1.5	Certificate information	117
8.1.6	PKCS #12 structure generation	118
8.1.7	Proxy certificate generation	118
8.1.8	Certificate revocation list generation	118
8.1.9	Certtool's template file format:	118
8.2	Invoking gnutls-cli	120
8.2.1	Example client PSK connection	122
8.3	Invoking gnutls-cli-debug	122
8.4	Invoking gnutls-serv	123
8.4.1	Setting up a test HTTPS server	124
8.4.2	Example server PSK connection	127
8.5	Invoking psktool	127
8.6	Invoking srptool	127
8.6.1	How to use srptool	127
8.7	Invoking p11tool	128
8.7.1	List all tokens	129
8.7.2	List all objects	129
8.7.3	Exporting an object	129
8.7.4	Copy an object to a token	129
9	Internal Architecture of GnuTLS	130
9.1	The TLS Protocol	130
9.2	TLS Handshake Protocol	131
9.3	TLS Authentication Methods	132
9.4	TLS Extension Handling	133
9.4.1	Adding a New TLS Extension	133
9.5	Certificate Handling	137
9.6	Cryptographic Backend	138
9.6.1	Cryptographic Library layer	139
9.6.2	External cryptography provider	139
9.6.2.1	Override specific algorithms	140
9.6.2.2	Override parts of the backend	140

Appendix A	Support	141
A.1	Getting Help	141
A.2	Commercial Support	141
A.3	Downloading and Installing.....	141
A.4	Bug Reports	142
A.5	Contributing	142
Appendix B	Error Codes and Descriptions ..	144
Appendix C	Function Reference.....	152
C.1	Core Functions	152
C.2	X.509 Certificate Functions	245
C.3	GnuTLS-extra Functions.....	318
C.4	OpenPGP Functions	318
Appendix D	Supported Ciphersuites in GnuTLS	
.....		339
Appendix E	Copying Information.....	344
E.1	GNU Free Documentation License	344
Bibliography	352
Function and Data Index	355
Concept Index	362

1 Preface

This document demonstrates and explains the GnuTLS library API. A brief introduction to the protocols and the technology involved is also included so that an application programmer can better understand the GnuTLS purpose and actual offerings. Even if GnuTLS is a typical library software, it operates over several security and cryptographic protocols which require the programmer to make careful and correct usage of them. Otherwise it is likely to only obtain a false sense of security. The term of security is very broad even if restricted to computer software, and cannot be confined to a single cryptographic library. For that reason, do not consider any program secure just because it uses GnuTLS; there are several ways to compromise a program or a communication line and GnuTLS only helps with some of them.

Although this document tries to be self contained, basic network programming and public key infrastructure (PKI) knowledge is assumed in most of it. A good introduction to networking can be found in [*STEVENS*] and for public key infrastructure in [*GUTPKI*]. Updated versions of the GnuTLS software and this document will be available from <http://www.gnutls.org/> and <http://www.gnu.org/software/gnutls/>.

2 The Library

In brief GnuTLS can be described as a library which offers an API to access secure communication protocols. These protocols provide privacy over insecure lines, and were designed to prevent eavesdropping, tampering, or message forgery.

Technically GnuTLS is a portable ANSI C based library which implements the protocols ranging from SSL 3.0 to TLS 1.2 (see [Chapter 3 \[Introduction to TLS\]](#), page 6, for a detailed description of the protocols), accompanied with the required framework for authentication and public key infrastructure. Important features of the GnuTLS library include:

- Support for TLS 1.2, TLS 1.1, TLS 1.0 and SSL 3.0 protocols.
- Support for Datagram TLS 1.0.
- Support for both X.509 and OpenPGP certificates.
- Support for handling and verification of certificates.
- Support for SRP for TLS authentication.
- Support for PSK for TLS authentication.
- Support for TLS safe renegotiation.
- Support for PKCS #11 tokens.

GnuTLS consists of three independent parts, namely the “TLS protocol part”, the “Certificate part”, and the “Cryptographic back-end” part. The ‘TLS protocol part’ is the actual protocol implementation, and is entirely implemented within the GnuTLS library. The ‘Certificate part’ consists of the certificate parsing, and verification functions which is partially implemented in the GnuTLS library. The `libtasn1`¹, a library which offers ASN.1 parsing capabilities, is used for the X.509 certificate parsing functions. The “Cryptographic back-end” is provided by `nettle`² library. In order to ease integration in embedded systems, parts of the GnuTLS library can be disabled at compile time. That way a smaller library, with the required features, can be generated.

2.1 General idea

A brief description of how GnuTLS works internally is shown at [Figure 2.1](#). This section may be easier to understand after having seen the examples at [\[examples\]](#), page 48. As shown in the figure, there is a read-only global state that is initialized once by the global initialization function. This global structure, among others, contains the memory allocation functions used, and some structures needed for the ASN.1 parser. This structure is never modified by any GnuTLS function, except for the deinitialization function which frees all memory allocated in the global structure and is called after the program has permanently finished using GnuTLS.

¹ <http://www.gnu.org/software/libtasn1/>

² <http://www.lysator.liu.se/~nisse/nettle/>

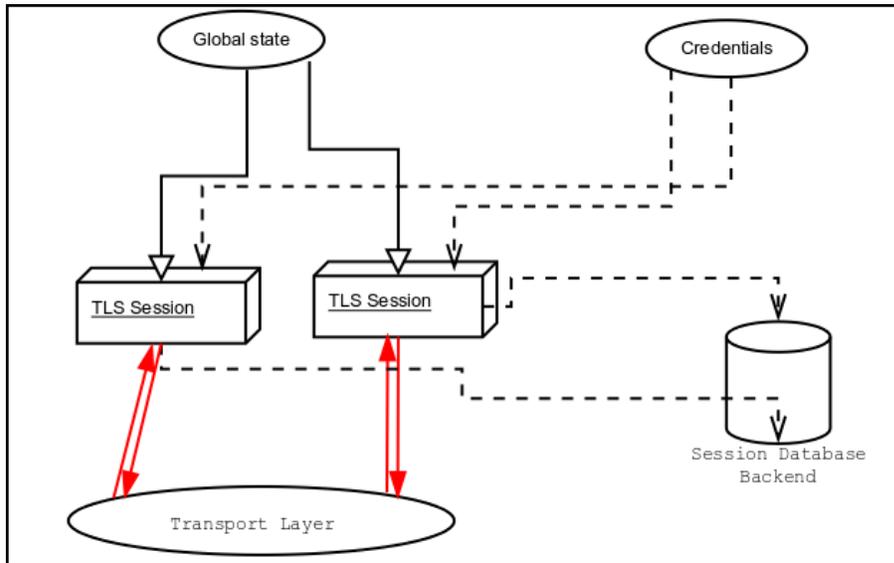


Figure 2.1: High level design of GnuTLS.

The credentials structure is used by some authentication methods, such as certificate authentication. A credentials structure may contain certificates, private keys, temporary parameters for Diffie-Hellman or RSA key exchange, and other stuff that may be shared between several TLS sessions.

This structure should be initialized using the appropriate initialization functions. For example an application which uses certificate authentication would probably initialize the credentials, using the appropriate functions, and put its trusted certificates in this structure. The next step is to associate the credentials structure with each TLS session.

A GnuTLS session contains all the required information for a session to handle one secure connection. This session calls directly to the transport layer functions, in order to communicate with the peer. Every session has a unique session ID shared with the peer.

Since TLS sessions can be resumed, servers would probably need a database back-end to hold the session's parameters. Every GnuTLS session after a successful handshake calls the appropriate back-end function (see [resume], page 16, for information on initialization) to store the newly negotiated session. The session database is examined by the server just after having received the client hello³, and if the session ID sent by the client, matches a stored session, the stored session will be retrieved, and the new session will be a resumed one, and will share the same session ID with the previous one.

2.2 Error handling

In GnuTLS most functions return an integer type as a result. In almost all cases a zero or a positive number means success, and a negative number indicates failure, or a situation that some action has to be taken. Thus negative error codes may be fatal or not.

³ The first message in a TLS handshake

Fatal errors terminate the connection immediately and further sends and receives will be disallowed. Such an example is `GNUTLS_E_DECRYPTION_FAILED`. Non-fatal errors may warn about something, i.e., a warning alert was received, or indicate the some action has to be taken. This is the case with the error code `GNUTLS_E_REHANDSHAKE` returned by [\[gnutls_record_recv\]](#), page 224. This error code indicates that the server requests a re-handshake. The client may ignore this request, or may reply with an alert. You can test if an error code is a fatal one by using the [\[gnutls_error_is_fatal\]](#), page 183.

If any non fatal errors, that require an action, are to be returned by a function, these error codes will be documented in the function's reference. See [Appendix B \[Error codes\]](#), page 144, for a description of the available error codes.

2.3 Memory handling

GnuTLS internally handles heap allocated objects differently, depending on the sensitivity of the data they contain. However for performance reasons, the default memory functions do not overwrite sensitive data from memory, nor protect such objects from being written to the swap. In order to change the default behavior the [\[gnutls_global_set_mem_functions\]](#), page 185 function is available which can be used to set other memory handlers than the defaults.

2.4 Thread safety

Although the GnuTLS library is thread safe by design, some parts of the cryptographic backend, such as the random generator, are not. Applications can either call [\[gnutls_global_init\]](#), page 184 which will use the default operating system provided locks (i.e. `pthread`s on GNU/Linux and `CriticalSection` on Windows), or specify manually the locking system using the function [\[gnutls_global_set_mutex\]](#), page 186 before calling [\[gnutls_global_init\]](#), page 184. Setting manually mutexes is recommended only to applications that have full control of the underlying libraries. If this is not the case, the use of the operating system defaults is recommended. Examples are shown below.

```
#include <gnutls.h>

/* Native threads
 */

int main()
{
    gnutls_global_init();
}

#include <gnutls.h>

/* Other thread packages
 */

int main()
{
    gnutls_global_mutex_set (mutex_init, mutex_deinit,
```

```
                                mutex_lock, mutex_unlock);  
    gnutls_global_init();  
}
```

2.5 Callback functions

There are several cases where GnuTLS may need some out of band input from your program. This is now implemented using some callback functions, which your program is expected to register.

An example of this type of functions are the push and pull callbacks which are used to specify the functions that will retrieve and send data to the transport layer.

- [\[gnutls_transport_set_push_function\]](#), page 243
- [\[gnutls_transport_set_pull_function\]](#), page 242

Other callback functions may require more complicated input and data to be allocated. Such an example is [\[gnutls_srp_set_server_credentials_function\]](#), page 239. All callbacks should allocate and free memory using the functions shown below.

- [\[gnutls_malloc\]](#), page 194
- [\[gnutls_free\]](#), page 184

3 Introduction to TLS and DTLS

TLS stands for “Transport Layer Security” and is the successor of SSL, the Secure Sockets Layer protocol [SSL3] designed by Netscape. TLS is an Internet protocol, defined by IETF¹, described in [RFC5246]. The protocol provides confidentiality, and authentication layers over any reliable transport layer. The description, below, refers to TLS 1.0 but also applies to TLS 1.2 [RFC5246] and SSL 3.0, since the differences of these protocols are not major.

The DTLS protocol, or “Datagram TLS” [RFC4347] is a protocol with identical goals as TLS, but can operate under unreliable transport layers, such as UDP. The discussions below apply to this protocol as well, except when noted otherwise.

3.1 TLS layers

TLS is a layered protocol, and consists of the record protocol, the handshake protocol and the alert protocol. The record protocol is to serve all other protocols and is above the transport layer. The record protocol offers symmetric encryption, data authenticity, and optionally compression. The alert protocol offers some signaling to the other protocols. It can help informing the peer for the cause of failures and other error conditions. See [The Alert Protocol], page 11, for more information. The alert protocol is above the record protocol.

The handshake protocol is responsible for the security parameters’ negotiation, the initial key exchange and authentication. See [The Handshake Protocol], page 12, for more information about the handshake protocol. The protocol layering in TLS is shown in Figure 3.1.

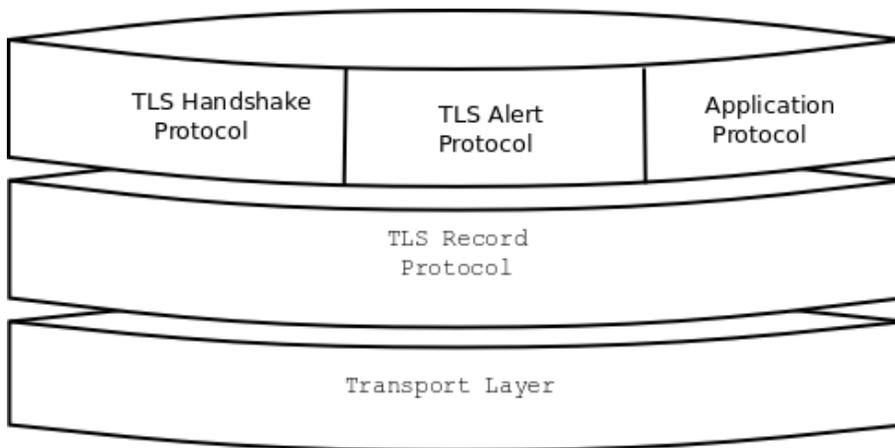


Figure 3.1: The TLS protocol layers.

3.2 The transport layer

TLS is not limited to any transport layer and can be used above any transport layer, as long as it is a reliable one. DTLS can be used over reliable and unreliable transport layers.

¹ IETF, or Internet Engineering Task Force, is a large open international community of network designers, operators, vendors, and researchers concerned with the evolution of the Internet architecture and the smooth operation of the Internet. It is open to any interested individual.

A set of functions is provided and their purpose is to load to GnuTLS the required callbacks to access the transport layer.

- [\[gnutls_transport_set_push_function\]](#), page 243
- [\[gnutls_transport_set_vec_push_function\]](#), page 243
- [\[gnutls_transport_set_pull_timeout_function\]](#), page 242
- [\[gnutls_transport_set_pull_function\]](#), page 242
- [\[gnutls_transport_set_ptr\]](#), page 242

The function [\[gnutls_transport_set_pull_timeout_function\]](#), page 242 is only applicable to DTLS sessions. All those functions accept a callback function as a parameter. The callback functions should return the number of bytes written, or -1 on error and should set `errno` appropriately.

In some environments, setting `errno` is unreliable, for example Windows have several `errno` variables in different CRTs, or it may be that `errno` is not a thread-local variable. If this is a concern to you, call [\[gnutls_transport_set_errno\]](#), page 241 with the intended `errno` value instead of setting `errno` directly.

- [\[gnutls_transport_set_errno\]](#), page 241

GnuTLS currently only interprets the `EINTR` and `EAGAIN` `errno` values and returns the corresponding GnuTLS error codes:

- `GNUTLS_E_INTERRUPTED`
- `GNUTLS_E_AGAIN`

These values are usually returned by interrupted system calls, or when non blocking IO is used. All GnuTLS functions can be resumed (called again), if any of these error codes is returned. The error codes above refer to the system call, not the GnuTLS function, since signals do not interrupt GnuTLS' functions.

DTLS however deviates from this rule. Because it requires timers and waiting for peer's messages during the handshake process, GnuTLS will block and might be interrupted by signals. The blocking operation of GnuTLS during DTLS handshake can be changed using the appropriate flags in [\[gnutls_init\]](#), page 192.

- [\[gnutls_init\]](#), page 192

By default, if the transport functions are not set, GnuTLS will use the Berkeley sockets.

3.3 The TLS record protocol

The record protocol is the secure communications provider. Its purpose is to encrypt, authenticate and —optionally— compress packets.

- [\[gnutls_record_send\]](#), page 225

The record layer functions can be called at any time after the handshake process is finished, when there is need to receive or send data. In DTLS however, due to re-transmission timers used in the handshake out-of-order handshake data might be received for some time (maximum 60 seconds) after the handshake process is finished. For this reason programs using DTLS should call [\[gnutls_record_recv\]](#), page 224 or [\[gnutls_record_recv_seq\]](#), page 224 for every packet received by the peer, even if no data were expected.

As you may have already noticed, the functions which access the record protocol, are quite limited, given the importance of this protocol in TLS. This is because the record protocol's parameters are all set by the handshake protocol.

The record protocol initially starts with NULL parameters, which means no encryption, and no MAC is used. Encryption and authentication begin just after the handshake protocol has finished.

- [\[gnutls_record_rcv\]](#), page 224
- [\[gnutls_record_rcv_seq\]](#), page 224
- [\[gnutls_record_check_pending\]](#), page 223

3.3.1 Encryption algorithms used in the record layer

Confidentiality in the record layer is achieved by using symmetric block encryption algorithms like 3DES, AES or stream algorithms like ARCFOUR_128. Ciphers are encryption algorithms that use a single, secret, key to encrypt and decrypt data. Block algorithms in TLS also provide protection against statistical analysis of the data. Thus, if you're using the TLS protocol, a random number of blocks will be appended to data, to prevent eavesdroppers from guessing the actual data size.

The supported in GnuTLS ciphers and MAC algorithms are shown in [Table 3.1](#) and [Table 3.2](#).

Algorithm	Description
3DES_CBC	This is the DES block cipher algorithm used with triple encryption (EDE). Has 64 bits block size and is used in CBC mode.
ARCFOUR_128	ARCFOUR_128 is a compatible algorithm with RSA's RC4 algorithm, which is considered to be a trade secret. It is a fast cipher but considered weak today.
ARCFOUR_40	This is the ARCFOUR cipher fed with a 40 bit key, which is considered weak.
AES_CBC	AES or RIJNDAEL is the block cipher algorithm that replaces the old DES algorithm. Has 128 bits block size and is used in CBC mode.
AES_GCM	This is the AES algorithm in the authenticated encryption GCM mode. This mode combines message authentication and encryption and can be extremely fast on CPUs that support hardware acceleration.
CAMELLIA_CBC	This is an 128-bit block cipher developed by Mitsubishi and NTT. It is one of the approved ciphers of the European NESSIE and Japanese CRYPTREC projects.

Table 3.1: Supported ciphers.

Algorithm	Description
MAC_MD5	This is a cryptographic hash algorithm designed by Ron Rivest. Outputs 128 bits of data.
MAC_SHA1	A cryptographic hash algorithm designed by NSA. Outputs 160 bits of data.
MAC_SHA256	A cryptographic hash algorithm designed by NSA. Outputs 256 bits of data.
MAC_AEAD	This indicates that an authenticated encryption algorithm, such as GCM, is in use.

Table 3.2: Supported MAC algorithms.

3.3.2 Compression algorithms used in the record layer

The TLS record layer also supports compression. The algorithms implemented in GnuTLS can be found in the table below. The included algorithms perform really good when text, or other compressible data are to be transferred, but offer nothing on already compressed data, such as compressed images, zipped archives etc. These compression algorithms, may be useful in high bandwidth TLS tunnels, and in cases where network usage has to be minimized. It should be noted however that compression increases latency.

The record layer compression in GnuTLS is implemented based on the proposal [RFC3749]. The supported algorithms are:

DEFLATE: Zlib compression, using the deflate algorithm.

NULL: No compression.

3.3.3 Weaknesses and countermeasures

Some weaknesses that may affect the security of the record layer have been found in TLS 1.0 protocol. These weaknesses can be exploited by active attackers, and exploit the facts that

1. TLS has separate alerts for “decryption_failed” and “bad_record_mac”
2. The decryption failure reason can be detected by timing the response time.
3. The IV for CBC encrypted packets is the last block of the previous encrypted packet.

Those weaknesses were solved in TLS 1.1 [RFC4346] which is implemented in GnuTLS. For a detailed discussion see the archives of the TLS Working Group mailing list and [CBCATT].

3.3.4 On record padding

The TLS protocol allows for random padding of records, to prevent statistical analysis based on the length of exchanged messages (see [RFC5246] section 6.2.3.2). GnuTLS appears to be one of few implementation that take advantage of this text, and pad records by a random length.

The TLS implementation in the Symbian operating system, frequently used by Nokia and Sony-Ericsson mobile phones, cannot handle non-minimal record padding. What happens when one of these clients handshake with a GnuTLS server is that the client will fail to compute the correct MAC for the record. The client sends a TLS alert (`bad_record_mac`) and disconnects. Typically this will result in error messages such as 'A TLS fatal alert has been received', 'Bad record MAC', or both, on the GnuTLS server side.

GnuTLS implements a work around for this problem. However, it has to be enabled specifically. It can be enabled by using [gnutls_record_disable_padding], page 223, or [gnutls_priority_set], page 209 with the %COMPAT priority string (see Section 3.5.2 [Priority Strings], page 12).

If you implement an application that have a configuration file, we recommend that you make it possible for users or administrators to specify a GnuTLS protocol priority string, which is used by your application via [gnutls_priority_set], page 209. To allow the best flexibility, make it possible to have a different priority string for different incoming IP addresses.

3.4 The TLS alert protocol

The alert protocol is there to allow signals to be sent between peers. These signals are mostly used to inform the peer about the cause of a protocol failure. Some of these signals are used internally by the protocol and the application protocol does not have to cope with them (e.g. `GNUTLS_A_CLOSE_NOTIFY`), and others refer to the application protocol solely (e.g. `GNUTLS_A_USER_CANCELLED`). An alert signal includes a level indication which may be either fatal or warning. Fatal alerts always terminate the current connection, and prevent future re-negotiations using the current session ID. All alert messages are summarized in [\[tab:alerts\], page 11](#).

The alert messages are protected by the record protocol, thus the information that is included does not leak. You must take extreme care for the alert information not to leak to a possible attacker, via public log files etc. The available functions to control the alert protocol are shown below.

- [\[gnutls_alert_get\], page 152](#)
- [\[gnutls_alert_send\], page 153](#)
- [\[gnutls_error_to_alert\], page 183](#)
- [\[gnutls_alert_get_name\], page 152](#)

Available alert messages:

<code>GNUTLS_A_CLOSE_NOTIFY</code>	0	Close notify
<code>GNUTLS_A_UNEXPECTED_MESSAGE</code>	10	Unexpected message
<code>GNUTLS_A_BAD_RECORD_MAC</code>	20	Bad record MAC
<code>GNUTLS_A_DECRYPTION_FAILED</code>	21	Decryption failed
<code>GNUTLS_A_RECORD_OVERFLOW</code>	22	Record overflow
<code>GNUTLS_A_DECOMPRESSION_FAILURE</code>	30	Decompression failed
<code>GNUTLS_A_HANDSHAKE_FAILURE</code>	40	Handshake failed
<code>GNUTLS_A_SSL3_NO_CERTIFICATE</code>	41	No certificate (SSL 3.0)
<code>GNUTLS_A_BAD_CERTIFICATE</code>	42	Certificate is bad
<code>GNUTLS_A_UNSUPPORTED_CERTIFICATE</code>	43	Certificate is not supported
<code>GNUTLS_A_CERTIFICATE_REVOKED</code>	44	Certificate was revoked
<code>GNUTLS_A_CERTIFICATE_EXPIRED</code>	45	Certificate is expired
<code>GNUTLS_A_CERTIFICATE_UNKNOWN</code>	46	Unknown certificate
<code>GNUTLS_A_ILLEGAL_PARAMETER</code>	47	Illegal parameter
<code>GNUTLS_A_UNKNOWN_CA</code>	48	CA is unknown
<code>GNUTLS_A_ACCESS_DENIED</code>	49	Access was denied
<code>GNUTLS_A_DECODE_ERROR</code>	50	Decode error
<code>GNUTLS_A_DECRYPT_ERROR</code>	51	Decrypt error
<code>GNUTLS_A_EXPORT_RESTRICTION</code>	60	Export restriction
<code>GNUTLS_A_PROTOCOL_VERSION</code>	70	Error in protocol version
<code>GNUTLS_A_INSUFFICIENT_SECURITY</code>	71	Insufficient security
<code>GNUTLS_A_INTERNAL_ERROR</code>	80	Internal error
<code>GNUTLS_A_USER_CANCELLED</code>	90	User canceled
<code>GNUTLS_A_NO_RENEGOTIATION</code>	100	No renegotiation is allowed

GNUTLS_A_UNSUPPORTED_EXTENSION	110	An unsupported extension was sent
GNUTLS_A_CERTIFICATE_UNOBTAINABLE	111	Could not retrieve the specified certificate
GNUTLS_A_UNRECOGNIZED_NAME	112	The server name sent was not recognized
GNUTLS_A_UNKNOWN_PSK_IDENTITY	115	The SRP/PSK username is missing or not known

3.5 The TLS handshake protocol

The handshake protocol is responsible for the ciphersuite negotiation, the initial key exchange, and the authentication of the two peers. This is fully controlled by the application layer, thus your program has to set up the required parameters. The main handshake function is [\[gnutls_handshake\]](#), page 188. In the next paragraphs we elaborate on controlling of the handshake protocol, i.e., the ciphersuite negotiation.

- [\[gnutls_handshake\]](#), page 188

3.5.1 TLS ciphersuites

The handshake protocol of TLS negotiates cipher suites of a special form illustrated by the `TLS_DHE_RSA_WITH_3DES_CBC_SHA` cipher suite name. A typical cipher suite contains these parameters:

- The key exchange algorithm. `DHE_RSA` in the example.
- The Symmetric encryption algorithm and mode `3DES_CBC` in this example.
- The MAC² algorithm used for authentication. `MAC_SHA` is used in the above example.

The cipher suite negotiated in the handshake protocol will affect the record protocol, by enabling encryption and data authentication. Note that you should not over rely on TLS to negotiate the strongest available cipher suite. Do not enable ciphers and algorithms that you consider weak.

All the supported ciphersuites are listed in [\[ciphersuites\]](#), page 339.

3.5.2 Priority strings

In order to specify cipher suite preferences on client or server side, the previously shown priority functions accept a string that specifies the enable for the handshake algorithms. That string may contain some high level keyword such as the keywords in [Table 3.3](#) or it might contain special keywords, to be explained later on.

- [\[gnutls_priority_set_direct\]](#), page 209
- [\[gnutls_priority_init\]](#), page 208
- [\[gnutls_priority_deinit\]](#), page 208
- [\[gnutls_priority_set\]](#), page 209

² MAC stands for Message Authentication Code. It can be described as a keyed hash algorithm. See RFC2104.

Keyword	Description
PERFORMANCE	All the "secure" ciphersuites are enabled, limited to 128 bit ciphers and sorted by terms of speed performance.
NORMAL	Means all "secure" ciphersuites. The 256-bit ciphers are included as a fallback only. The ciphers are sorted by security margin.
SECURE128	Means all "secure" ciphersuites of security level 128-bit or more.
SECURE192	Means all "secure" ciphersuites of security level 192-bit or more.
SUITEB128	Means all the NSA Suite B cryptography (RFC5430) ciphersuites with an 128 bit security level.
SUITEB192	Means all the NSA Suite B cryptography (RFC5430) ciphersuites with an 192 bit security level.
EXPORT	Means all ciphersuites are enabled, including the low-security 40 bit ciphers.
NONE	Means nothing is enabled. This disables even protocols and compression methods. It should be followed by the algorithms to be enabled.

Table 3.3: Supported priority string keywords.

Unless the first keyword is "NONE" the defaults (in preference order) are for TLS protocols TLS 1.2, TLS1.1, TLS1.0, SSL3.0; for compression NULL; for certificate types X.509, OpenPGP. For key exchange algorithms when in NORMAL or SECURE levels the perfect forward secrecy algorithms take precedence of the other protocols. In all cases all the supported key exchange algorithms are enabled (except for the RSA-EXPORT which is only enabled in EXPORT level).

The NONE keyword must followed by the algorithms to be enabled, and is used to provide the exact list of requested algorithms³. The order with which every algorithm is specified is significant. Similar algorithms specified before others will take precedence. The individual algorithms are shown in [Table 3.4](#) and special keywords are in [Table 3.5](#). The prefixes for individual algorithms are:

'!' or '-' appended with an algorithm will remove this algorithm.

³ To avoid collisions in order to specify a compression algorithm in this string you have to prefix it with "COMP-", protocol versions with "VERS-", signature algorithms with "SIGN-" and certificate types with "CTYPE-". All other algorithms don't need a prefix.

"+" appended with an algorithm will add this algorithm.

Type	Keywords
Ciphers	AES-128-CBC, AES-256-CBC, AES-128-GCM, CAMELLIA-128-CBC, CAMELLIA-256-CBC, ARCFOUR-128, 3DES-CBC ARCFOUR-40. Catch all name is CIPHER-ALL which will add all the algorithms from NORMAL priority.
Key exchange	RSA, DHE-RSA, DHE-DSS, SRP, SRP-RSA, SRP-DSS, PSK, DHE-PSK, ECDHE-RSA, ANON-ECDH, ANON-DH, RSA-EXPORT. The Catch all name is KX-ALL which will add all the algorithms from NORMAL priority.
MAC	MD5, SHA1, SHA256, AEAD (used with GCM ciphers only). All algorithms from NORMAL priority can be accessed with MAC-ALL.
Compression algorithms	COMP-NULL, COMP-DEFLATE. Catch all is COMP-ALL.
TLS versions	VERS-SSL3.0, VERS-TLS1.0, VERS-TLS1.1, VERS-TLS1.2. Catch all is VERS-TLS-ALL.
Signature algorithms	SIGN-RSA-SHA1, SIGN-RSA-SHA224, SIGN-RSA-SHA256, SIGN-RSA-SHA384, SIGN-RSA-SHA512, SIGN-DSA-SHA1, SIGN-DSA-SHA224, SIGN-DSA-SHA256, SIGN-RSA-MD5. Catch all is SIGN-ALL. This is only valid for TLS 1.2 and later.
Elliptic curves	CURVE-SECP224R1, CURVE-SECP256R1, CURVE-SECP384R1, CURVE-SECP521R1. Catch all is CURVE-ALL.

Table 3.4: The supported priority strings.

Keyword	Description
%COMPAT	will enable compatibility mode. It might mean that violations of the protocols are allowed as long as maximum compatibility with problematic clients and servers is achieved.
%DISABLE_SAFE_RENEGOTIATION	will disable safe renegotiation completely. Do not use unless you know what you are doing. Testing purposes only.
%UNSAFE_RENEGOTIATION	will allow handshakes and re-handshakes without the safe renegotiation extension. Note that for clients this mode is insecure (you may be under attack), and for servers it will allow insecure clients to connect (which could be fooled by an attacker). Do not use unless you know what you are doing and want maximum compatibility.
%PARTIAL_RENEGOTIATION	will allow initial handshakes to proceed, but not re-handshakes. This leaves the client vulnerable to attack, and servers will be compatible with non-upgraded clients for initial handshakes. This is currently the default for clients and servers, for compatibility reasons.
%SAFE_RENEGOTIATION	will enforce safe renegotiation. Clients and servers will refuse to talk to an insecure peer. Currently this causes interoperability problems, but is required for full protection.
%SSL3_RECORD_VERSION	will use SSL3.0 record version in client hello. This is the default.
%LATEST_RECORD_VERSION	will use the latest TLS version record version in client hello.
%VERIFY_ALLOW_SIGN_RSA_MD5	will allow RSA-MD5 signatures in certificate chains.
%VERIFY_ALLOW_X509_V1_CA_CRT	will allow V1 CAs in chains.

Table 3.5: Special priority string keywords.

3.5.3 Client authentication

In the case of ciphersuites that use certificate authentication, the authentication of the client is optional in TLS. A server may request a certificate from the client using the [\[gnutls_certificate_server_set_request\]](#), page 159 function. If a certificate is to be requested from the client during the handshake, the server will send a certificate request message that contains a list of acceptable certificate signers. In GnuTLS the certificate signers list is constructed using the trusted Certificate Authorities by the server. That is the ones set using the following functions.

- [\[gnutls_certificate_set_x509_trust_file\]](#), page 166
- [\[gnutls_certificate_set_x509_trust_mem\]](#), page 166
- [\[gnutls_certificate_server_set_request\]](#), page 159

In cases where the server supports a large number of certificate authorities it makes sense not to advertise all of the names to save bandwidth. That can be controlled using the function [\[gnutls_certificate_send_x509_rdn_sequence\]](#), page 159. This however will have the side-effect of not restricting the client to certificates signed by server's acceptable signers.

- [\[gnutls_certificate_send_x509_rdn_sequence\]](#), page 159

3.5.4 Resuming sessions

The [\[gnutls_handshake\]](#), page 188 function, is expensive since a lot of calculations are performed. In order to support many fast connections to the same server a client may use session resuming. Session resuming is a feature of the TLS protocol which allows a client to connect to a server, after a successful handshake, without the expensive calculations. This is achieved by re-using the previously established keys. GnuTLS supports this feature, and the example in [\[ex:resume-client\]](#), page 81 illustrates a typical use of it.

Keep in mind that sessions might be expired after some time, thus it may be normal for a server not to resume a session even if you requested that. That is to prevent temporal session keys from becoming long-term keys. Also note that as a client you must enable, using the priority functions, at least the algorithms used in the last session.

The resuming capability, mostly in the server side, is one of the problems of a thread-safe TLS implementations. The problem is that all threads must share information in order to be able to resume sessions. The gnutls approach is, in case of a client, to leave all the burden of resuming to the client. That is, copy and keep the necessary parameters. The relevant functions are listed below.

- [\[gnutls_session_get_data\]](#), page 231
- [\[gnutls_session_get_id\]](#), page 232
- [\[gnutls_session_set_data\]](#), page 232

Server side is different. A server needs to specify callback functions which store, retrieve and delete session data. These can be registered with the functions shown below.

- [\[gnutls_db_set_retrieve_function\]](#), page 176
- [\[gnutls_db_set_store_function\]](#), page 176
- [\[gnutls_db_set_ptr\]](#), page 175
- [\[gnutls_db_set_remove_function\]](#), page 176

It might also be useful to be able to check for expired sessions in order to remove them, and save space. The function `[gnutls_db_check_entry]`, page 175 is provided for that reason.

- `[gnutls_db_check_entry]`, page 175

3.5.5 Interoperability

The TLS handshake is a complex procedure that negotiates all required parameters for a secure session. GnuTLS supports several TLS extensions, as well as the latest TLS protocol version 1.2. However few implementations are not able to properly interoperate once faced with extensions or version protocols they do not support and understand. The TLS protocol allows for a graceful downgrade to the commonly supported options, but practice shows it is not always implemented correctly.

Because there is no way to achieve maximum interoperability with broken peers without sacrificing security, GnuTLS ignores such peers by default. This might not be acceptable in cases where maximum compatibility is required. Thus we allow enabling compatibility with broken peers using priority strings (see [Section 3.5.2 \[Priority Strings\]](#), page 12). An example priority string that is known to provide wide compatibility even with broken peers is shown below:

```
NORMAL:-VERS-TLS-ALL:+VERS-TLS1.0:+VERS-SSL3.0:%COMPAT
```

This priority string will only enable SSL 3.0 and TLS 1.0 as protocols and will disable, via the `%COMPAT` keyword, several TLS protocol options that are known to cause compatibility problems. We suggest however only to use this mode if compatibility is preferred over security.

3.6 TLS extensions

A number of extensions to the TLS protocol have been proposed mainly in `[TLSEXT]`. The extensions supported in GnuTLS are:

- Maximum fragment length negotiation
- Server name indication
- Session tickets
- Safe Renegotiation

and they will be discussed in the subsections that follow.

3.6.1 Maximum fragment length negotiation

This extension allows a TLS implementation to negotiate a smaller value for record packet maximum length. This extension may be useful to clients with constrained capabilities. The functions shown below can be used to control this extension.

- `[gnutls_record_get_max_size]`, page 224
- `[gnutls_record_set_max_size]`, page 225

3.6.2 Server name indication

A common problem in HTTPS servers is the fact that the TLS protocol is not aware of the hostname that a client connects to, when the handshake procedure begins. For that reason the TLS server has no way to know which certificate to send.

This extension solves that problem within the TLS protocol, and allows a client to send the HTTP hostname before the handshake begins within the first handshake packet. The functions `[gnutls_server_name_set]`, page 230 and `[gnutls_server_name_get]`, page 230 can be used to enable this extension, or to retrieve the name sent by a client.

- `[gnutls_server_name_set]`, page 230
- `[gnutls_server_name_get]`, page 230

3.6.3 Session tickets

To resume a TLS session the server normally store some state. This complicates deployment, and typical situations the client can cache information and send it to the server instead. The Session Ticket extension implements this idea, and it is documented in RFC 5077 [*TLSTKT*].

Clients can enable support for TLS tickets with `[gnutls_session_ticket_enable_client]`, page 233 and servers use `[gnutls_session_ticket_key_generate]`, page 233 to generate a key and `[gnutls_session_ticket_enable_server]`, page 233 to enable the extension. Clients resume sessions using the ticket using the normal session resume functions, `[resume]`, page 16.

- `[gnutls_session_ticket_key_generate]`, page 233
- `[gnutls_session_ticket_enable_server]`, page 233
- `[gnutls_session_ticket_enable_client]`, page 233

3.6.4 Safe renegotiation

TLS gives the option to two communicating parties to renegotiate and update their security parameters. One useful example of this feature was for a client to initially connect using anonymous negotiation to a server, and the renegotiate using some authenticated ciphersuite. This occurred to avoid having the client sending its credentials in the clear.

However this renegotiation, as initially designed would not ensure that the party one is renegotiating is the same as the one in the initial negotiation. For example one server could forward all renegotiation traffic to an other server who will see this traffic as an initial negotiation attempt.

This might be seen as a valid design decision, but it seems it was not widely known or understood, thus today some application protocols the TLS renegotiation feature in a manner that enables a malicious server to insert content of his choice in the beginning of a TLS session.

The most prominent vulnerability was with HTTPS. There servers request a renegotiation to enforce an anonymous user to use a certificate in order to access certain parts of a web site. The attack works by having the attacker simulate a client and connect to a server, with server-only authentication, and send some data intended to cause harm. The server will then require renegotiation from him in order to perform the request. When the proper client attempts to contact the server, the attacker hijacks that connection and forwards traffic to the initial server that requested renegotiation. The attacker will not be able to read the data exchanged between the client and the server. However, the server will (incorrectly) assume that the initial request sent by the attacker was sent by the now authenticated client. The result is a prefix plain-text injection attack.

The above is just one example. Other vulnerabilities exists that do not rely on the TLS renegotiation to change the client's authenticated status (either TLS or application layer).

While fixing these application protocols and implementations would be one natural reaction, an extension to TLS has been designed that cryptographically binds together any renegotiated handshakes with the initial negotiation. When the extension is used, the attack is detected and the session can be terminated. The extension is specified in [RFC5746].

GnuTLS supports the safe renegotiation extension. The default behavior is as follows. Clients will attempt to negotiate the safe renegotiation extension when talking to servers. Servers will accept the extension when presented by clients. Clients and servers will permit an initial handshake to complete even when the other side does not support the safe renegotiation extension. Clients and servers will refuse renegotiation attempts when the extension has not been negotiated.

Note that permitting clients to connect to servers when the safe renegotiation extension is not enabled, is open up for attacks. Changing this default behavior would prevent interoperability against the majority of deployed servers out there. We will reconsider this default behavior in the future when more servers have been upgraded. Note that it is easy to configure clients to always require the safe renegotiation extension from servers (see below on the `%SAFE_RENEGOTIATION` priority string).

To modify the default behavior, we have introduced some new priority strings. The priority strings can be used by applications ([`gnutls_priority_set`], page 209) and end users (e.g., `--priority` parameter to `gnutls-cli` and `gnutls-serv`).

The `%UNSAFE_RENEGOTIATION` priority string permits (re-)handshakes even when the safe renegotiation extension was not negotiated. The default behavior is `%PARTIAL_RENEGOTIATION` that will prevent renegotiation with clients and servers not supporting the extension. This is secure for servers but leaves clients vulnerable to some attacks, but this is a trade-off between security and compatibility with old servers. The `%SAFE_RENEGOTIATION` priority string makes clients and servers require the extension for every handshake. The latter is the most secure option for clients, at the cost of not being able to connect to legacy servers. Servers will also deny clients that do not support the extension from connecting.

It is possible to disable use of the extension completely, in both clients and servers, by using the `%DISABLE_SAFE_RENEGOTIATION` priority string however we strongly recommend you to only do this for debugging and test purposes.

The default values if the flags above are not specified are:

Server: `%PARTIAL_RENEGOTIATION`

Client: `%PARTIAL_RENEGOTIATION`

For applications we have introduced a new API related to safe renegotiation. The [`gnutls_safe_renegotiation_status`], page 229 function is used to check if the extension has been negotiated on a session, and can be used both by clients and servers.

3.7 Selecting cryptographic key sizes

In TLS, since a lot of algorithms are involved, it is not easy to set a consistent security level. For this reason in Table 3.6 we present some correspondence between key sizes of symmetric algorithms and public key algorithms based on [ECRYPT]. Those can be used to generate certificates with appropriate key sizes as well as select parameters for Diffie-Hellman and SRP authentication.

Security bits	RSA, DH and SRP parameter size	ECC key size	Security parameter	Description
64	816	128	WEAK	Very short term protection against small organizations
80	1248	160	LOW	Very short term protection against agencies
112	2432	224	NORMAL	Medium-term protection
128	3248	256	HIGH	Long term protection
256	15424	512	ULTRA	Foreseeable future

Table 3.6: Key sizes and security parameters.

The first column provides a security parameter in a number of bits. This gives an indication of the number of combinations to be tried by an adversary to brute force a key. For example to test all possible keys in a 112 bit security parameter 2^{112} combinations have to be tried. For today's technology this is infeasible. The next two columns correlate the security parameter with actual bit sizes of parameters for DH, RSA, SRP and ECC algorithms. A mapping to `gnutls_sec_param_t` value is given for each security parameter, on the next column, and finally a brief description of the level.

Note however that the values suggested here are nothing more than an educated guess that is valid today. There are no guarantees that an algorithm will remain unbreakable or that these values will remain constant in time. There could be scientific breakthroughs that cannot be predicted or total failure of the current public key systems by quantum computers. On the other hand though the cryptosystems used in TLS are selected in a conservative way and such catastrophic breakthroughs or failures are believed to be unlikely. The NIST publication SP 800-57 [*NISTSP80057*] contains a similar table.

When using GnuTLS and a decision on bit sizes for a public key algorithm is required, use of the following functions is recommended:

- [`gnutls_sec_param_to_pk_bits`], page 229
- [`gnutls_pk_bits_to_sec_param`], page 198

Those functions will convert a human understandable security parameter of `gnutls_sec_param_t` type, to a number of bits suitable for a public key algorithm.

3.8 On SSL 2 and older protocols

One of the initial decisions in the GnuTLS development was to implement the known security protocols for the transport layer. Initially TLS 1.0 was implemented since it was the latest at that time, and was considered to be the most advanced in security properties. Later the SSL 3.0 protocol was implemented since it is still the only protocol supported by several servers and there are no serious security vulnerabilities known.

One question that may arise is why we didn't implement SSL 2.0 in the library. There are several reasons, most important being that it has serious security flaws, unacceptable for a modern security library. Other than that, this protocol is barely used by anyone these days since it has been deprecated since 1996. The security problems in SSL 2.0 include:

- Message integrity compromised. The SSLv2 message authentication uses the MD5 function, and is insecure.
- Man-in-the-middle attack. There is no protection of the handshake in SSLv2, which permits a man-in-the-middle attack.
- Truncation attack. SSLv2 relies on TCP FIN to close the session, so the attacker can forge a TCP FIN, and the peer cannot tell if it was a legitimate end of data or not.
- Weak message integrity for export ciphers. The cryptographic keys in SSLv2 are used for both message authentication and encryption, so if weak encryption schemes are negotiated (say 40-bit keys) the message authentication code use the same weak key, which isn't necessary.

Other protocols such as Microsoft's PCT 1 and PCT 2 were not implemented because they were also abandoned and deprecated by SSL 3.0 and later TLS 1.0.

4 Authentication methods

The TLS protocol provides confidentiality and encryption, but also offers authentication, which is a prerequisite for a secure connection. The available authentication methods in GnuTLS are:

- Certificate authentication
- Anonymous authentication
- SRP authentication
- PSK authentication

The rule for each method is to allocate a credentials structure containing data required for authentication and associate that structure with the session using [\[gnutls_credentials_set\]](#), page 174. In the next paragraphs we elaborate on supported authentication methods.

- [\[gnutls_credentials_set\]](#), page 174

4.1 Certificate authentication

4.1.1 Authentication using X.509 certificates

X.509 certificates contain the public parameters, of a public key algorithm, and an authority's signature, which proves the authenticity of the parameters. See [Section 5.1 \[The X.509 trust model\]](#), page 29, for more information on X.509 protocols.

4.1.2 Authentication using OpenPGP keys

OpenPGP keys also contain public parameters of a public key algorithm, and signatures from several other parties. Depending on whether a signer is trusted the key is considered trusted or not. GnuTLS's OpenPGP authentication implementation is based on the [\[TLSPGP\]](#) proposal.

More information on the OpenPGP trusted model is provided in [Section 5.2 \[The OpenPGP trust model\]](#), page 40. For a more detailed introduction to OpenPGP and GnuPG see [\[GPGH\]](#).

4.1.3 Using certificate authentication

In GnuTLS both the OpenPGP and X.509 certificates are part of the certificate authentication and thus are handled using a common API.

When using certificates the server is required to have at least one certificate and private key pair. A client may or may not have such a pair. The certificate and key pair should be loaded, before any TLS session is initialized, in a certificate credentials structure. This should be done by using [\[gnutls_certificate_set_x509_key_file\]](#), page 163 or [\[gnutls_certificate_set_openpgp_key_file\]](#), page 319 depending on the certificate type. In the X.509 case, the functions will also accept and use a certificate list that leads to a trusted authority. The certificate list must be ordered in such way that every certificate certifies the one before it. The trusted authority's certificate need not to be included, since the peer should possess it already.

- [\[gnutls_certificate_set_x509_key\]](#), page 164
- [\[gnutls_certificate_set_x509_key_mem\]](#), page 164

- [\[gnutls_certificate_set_openpgp_key\]](#), page 320
- [\[gnutls_certificate_set_openpgp_key_file\]](#), page 319
- [\[gnutls_certificate_set_openpgp_key_mem\]](#), page 319
- [\[gnutls_certificate_set_x509_key_file\]](#), page 163
- [\[gnutls_certificate_set_retrieve_function\]](#), page 161

As an alternative, a callback may be used so the server or the client specifies the certificate and the key at the handshake time using [\[gnutls_certificate_set_retrieve_function\]](#), page 161. In that case a certificate should be selected according the peer's signature algorithm preferences. To get those preferences use [\[gnutls_sign_algorithm_get_requested\]](#), page 234.

- [\[gnutls_sign_algorithm_get_requested\]](#), page 234

Certificate verification is possible by loading the trusted authorities into the credentials structure by using [\[gnutls_certificate_set_x509_trust_file\]](#), page 166 or [\[gnutls_certificate_set_openpgp_keyring_file\]](#), page 320 for openpgp keys. Note however that the peer's certificate is not automatically verified, you should call [\[gnutls_certificate_verify_peers2\]](#), page 168, after a successful handshake or during if [\[gnutls_certificate_set_verify_function\]](#), page 162 has been used, to verify the certificate's signature. An alternative way, which reports a more detailed verification output, is to use [\[gnutls_certificate_get_peers\]](#), page 158 to obtain the raw certificate of the peer and verify it using the functions discussed in [Section 5.1 \[The X.509 trust model\]](#), page 29.

- [\[gnutls_certificate_verify_peers2\]](#), page 168

In a handshake, the negotiated cipher suite depends on the certificate's parameters, so not all key exchange methods will be available with some certificates. GnuTLS will disable ciphersuites that are not compatible with the key, or the enabled authentication methods. For example keys marked as sign-only, will not be able to access the plain RSA ciphersuites, but only the DHE_RSA ones. It is recommended not to use RSA keys for both signing and encryption. If possible use the same key for the DHE_RSA and RSA_EXPORT ciphersuites, which use signing, and a different key for the plain RSA ciphersuites, which use encryption. All the key exchange methods shown below are available in certificate authentication.

- [\[gnutls_certificate_set_verify_function\]](#), page 162

Note that the DHE key exchange methods are generally slower¹ than plain RSA and require Diffie Hellman parameters to be generated and associated with a credentials structure, by the server. For more information check the [Section 6.5.1 \[Parameter generation\]](#), page 110 section. The key exchange algorithms for OpenPGP and X.509 certificates are shown in [Table 4.1](#).

¹ It really depends on the group used. Primes with lesser bits are always faster, but also easier to break. See [Section 3.7 \[Selecting cryptographic key sizes\]](#), page 19 for the acceptable security levels.

Key exchange	Description
RSA	The RSA algorithm is used to encrypt a key and send it to the peer. The certificate must allow the key to be used for encryption.
RSA_EXPORT	The RSA algorithm is used to encrypt a key and send it to the peer. In the EXPORT algorithm, the server signs temporary RSA parameters of 512 bits — which are considered weak — and sends them to the client.
DHE_RSA	The RSA algorithm is used to sign ephemeral Diffie-Hellman parameters which are sent to the peer. The key in the certificate must allow the key to be used for signing. Note that key exchange algorithms which use ephemeral Diffie-Hellman parameters, offer perfect forward secrecy. That means that even if the private key used for signing is compromised, it cannot be used to reveal past session data.
ECDHE_RSA	The RSA algorithm is used to sign ephemeral elliptic curve Diffie-Hellman parameters which are sent to the peer. The key in the certificate must allow the key to be used for signing. It also offers perfect forward secrecy. That means that even if the private key used for signing is compromised, it cannot be used to reveal past session data.
DHE_DSS	The DSA algorithm is used to sign ephemeral Diffie-Hellman parameters which are sent to the peer. The certificate must contain DSA parameters to use this key exchange algorithm. DSA is the algorithm of the Digital Signature Standard (DSS).
ECDHE_ECDSA	The Elliptic curve DSA algorithm is used to sign ephemeral elliptic curve Diffie-Hellman parameters which are sent to the peer. The certificate must contain ECDSA parameters to use this key exchange algorithm.

Table 4.1: Supported key exchange algorithms.

4.2 Anonymous authentication

The anonymous key exchange performs encryption but there is no indication of the identity of the peer. This kind of authentication is vulnerable to a man in the middle attack, but this protocol can be used even if there is no prior communication and trusted parties with

the peer, or when full anonymity is required. Unless really required, do not use anonymous authentication. Available key exchange methods are shown below.

Note that the key exchange methods for anonymous authentication require Diffie-Hellman parameters to be generated by the server and associated with an anonymous credentials structure. Check [Section 6.5.1 \[Parameter generation\]](#), [page 110](#) for more information.

Supported anonymous key exchange algorithms:

ANON_DH: This algorithm exchanges Diffie-Hellman parameters.

ANON_ECDH:

This algorithm exchanges elliptic curve Diffie-Hellman parameters. It is more efficient than ANON_DH on equivalent security levels.

4.3 Authentication using SRP

Authentication via the Secure Remote Password protocol, SRP², is supported. The SRP key exchange is an extension to the TLS protocol, and it is a password based authentication (unlike X.509 or OpenPGP that use certificates). The two peers can be identified using a single password, or there can be combinations where the client is authenticated using SRP and the server using a certificate.

The advantage of SRP authentication, over other proposed secure password authentication schemes, is that SRP does not require the server to hold the user's password. This kind of protection is similar to the one used traditionally in the UNIX `/etc/passwd` file, where the contents of this file did not cause harm to the system security if they were revealed. The SRP needs instead of the plain password something called a verifier, which is calculated using the user's password, and if stolen cannot be used to impersonate the user. Check [\[TOMSRP\]](#) for a detailed description of the SRP protocol and the Stanford SRP libraries, which includes a PAM module that synchronizes the system's users passwords with the SRP password files. That way SRP authentication could be used for all the system's users.

The implementation in GnuTLS is based on [\[TLSSRP\]](#). The supported SRP key exchange methods are:

SRP: Authentication using the SRP protocol.

SRP_DSS: Client authentication using the SRP protocol. Server is authenticated using a certificate with DSA parameters.

SRP_RSA: Client authentication using the SRP protocol. Server is authenticated using a certificate with RSA parameters.

If clients supporting SRP know the username and password before the connection, should initialize client credentials and call [\[gnutls_srp_set_client_credentials\]](#), [page 238](#). Alternatively [\[gnutls_srp_set_client_credentials_function\]](#), [page 238](#) may be used to specify a callback function. The callback will be called once during the TLS handshake.

- [\[gnutls_srp_set_client_credentials\]](#), [page 238](#)
- [\[gnutls_srp_set_client_credentials_function\]](#), [page 238](#)

² SRP is described in [\[RFC2945\]](#)

In server side the default behavior of GnuTLS is to read the usernames and SRP verifiers from password files. These password files are the ones used by the *Stanford srp libraries* and [\[gnutls_srp_set_server_credentials_file\]](#), page 239 can be used to specify them. If a different password file format is to be used, then [\[gnutls_srp_set_server_credentials_function\]](#), page 239 should be called, to set an appropriate callback.

- [\[gnutls_srp_set_server_credentials_file\]](#), page 239
- [\[gnutls_srp_set_server_credentials_function\]](#), page 239

Helper functions are included in GnuTLS, and can be used to generate and maintain SRP verifiers and password files. A program to manipulate the required parameters for SRP authentication is also included. See [\[srptool\]](#), page 127, for more information.

- [\[gnutls_srp_verifier\]](#), page 240
- [\[gnutls_srp_base64_encode\]](#), page 237
- [\[gnutls_srp_base64_decode\]](#), page 236

4.4 Authentication using PSK

Authentication using Pre-shared keys is a method to authenticate using usernames and binary keys. This protocol avoids making use of public key infrastructure and expensive calculations, thus it is suitable for constraint clients.

The implementation in GnuTLS is based on [\[TLSPSK\]](#) . The supported PSK key exchange methods are:

PSK: Authentication using the PSK protocol.

DHE-PSK: Authentication using the PSK protocol and Diffie-Hellman key exchange. This method offers perfect forward secrecy.

ECDHE-PSK: Authentication using the PSK protocol and Elliptic curve Diffie-Hellman key exchange. This method offers perfect forward secrecy.

Clients supporting PSK should supply the username and key before the TLS session is established by calling [\[gnutls_psk_set_client_credentials\]](#), page 214. Alternatively [\[gnutls_psk_set_client_credentials_function\]](#), page 214 can be used to specify a callback function. This has the advantage that the callback will be called only if PSK has been negotiated.

- [\[gnutls_psk_set_client_credentials\]](#), page 214
- [\[gnutls_psk_set_client_credentials_function\]](#), page 214

In server side the default behavior of GnuTLS is to read the usernames and PSK keys from a password file. The password file should contain usernames and keys in hexadecimal format. The name of the password file can be stored to the credentials structure by calling [\[gnutls_psk_set_server_credentials_file\]](#), page 215. If a different password file format is to be used, then a callback should be set instead by [\[gnutls_psk_set_server_credentials_function\]](#), page 215.

The server can help the client chose a suitable username and password, by sending a hint. Note that there is no common profile for the PSK hint and applications are discouraged to use it. A server, may specify the hint by calling [\[gnutls_psk_set_server_credentials_hint\]](#),

page 216. The client can retrieve the hint, for example in the callback function, using `[gnutls_psk_client_get_hint]`, page 213.

- `[gnutls_psk_set_server_credentials_file]`, page 215
- `[gnutls_psk_set_server_credentials_function]`, page 215
- `[gnutls_psk_set_server_credentials_hint]`, page 216
- `[gnutls_psk_client_get_hint]`, page 213

Helper functions are included in GnuTLS, and may be used to generate and maintain PSK keys.

- `[gnutls_hex_encode]`, page 190
- `[gnutls_hex_decode]`, page 190

4.5 Authentication and credentials

In GnuTLS every key exchange method is associated with a credentials type. So in order to enable to enable a specific method, the corresponding credentials type should be initialized and set using `[gnutls_credentials_set]`, page 174. A mapping is shown in Table 4.2.

Key exchange	Client credentials	Server credentials
KX_RSA, KX_DHE_RSA, KX_DHE_DSS, KX_ECDHE_RSA, KX_ECDHE_ECDSA, KX_RSA_EXPORT	CRD_CERTIFICATE	CRD_CERTIFICATE
KX_SRP_RSA, KX_SRP_DSS	CRD_SRP	CRD_CERTIFICATE
KX_SRP	CRD_SRP	CRD_SRP
KX_ANON_DH, KX_ANON_ECDH	CRD_ANON	CRD_ANON
KX_PSK, KX_DHE_PSK, KX_ECDHE_PSK	CRD_PSK	CRD_PSK

Table 4.2: Key exchange algorithms and the corresponding credential types.

4.6 Parameters stored in credentials

Several parameters such as the ones used for Diffie-Hellman authentication are stored within the credentials structures, so all sessions can access them. Those parameters are stored in structures such as `gnutls_dh_params_t` and `gnutls_rsa_params_t`, and functions like `[gnutls_certificate_set_dh_params]`, page 160 and `[gnutls_certificate_set_rsa_export_params]`, page 161 can be used to associate those parameters with the given credentials structure.

Since those parameters need to be renewed from time to time and a global structure such as the credentials, may not be easy to modify since it is accessible by all sessions, an alternative interface is available using a callback function. This can be set using the `[gnutls_certificate_set_params_function]`, page 160. An example is shown below.

```
#include <gnutls.h>
```

```
gnutls_rsa_params_t rsa_params;
gnutls_dh_params_t dh_params;

/* This function will be called once a session requests DH
 * or RSA parameters. The parameters returned (if any) will
 * be used for the first handshake only.
 */
static int get_params( gnutls_session_t session,
                      gnutls_params_type_t type,
                      gnutls_params_st *st)
{
    if (type == GNUTLS_PARAMS_RSA_EXPORT)
        st->params.rsa_export = rsa_params;
    else if (type == GNUTLS_PARAMS_DH)
        st->params.dh = dh_params;
    else return -1;

    st->type = type;
    /* do not deinitialize those parameters.
     */
    st->deinit = 0;

    return 0;
}

int main()
{
    gnutls_certificate_credentials_t cert_cred;

    initialize_params();

    /* ...
     */

    gnutls_certificate_set_params_function( cert_cred, get_params);
}
```

5 More on certificate authentication

5.1 The X.509 trust model

The X.509 protocols rely on a hierarchical trust model. In this trust model Certification Authorities (CAs) are used to certify entities. Usually more than one certification authorities exist, and certification authorities may certify other authorities to issue certificates as well, following a hierarchical model.

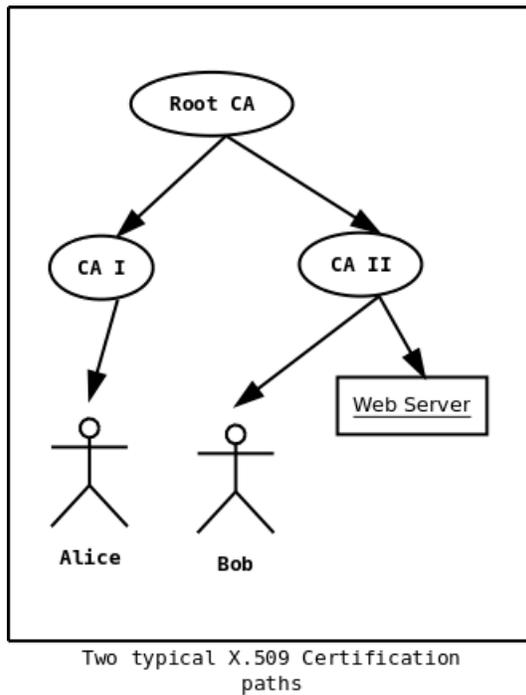


Figure 5.1: The X.509 hierarchical trust model.

One needs to trust one or more CAs for his secure communications. In that case only the certificates issued by the trusted authorities are acceptable. The framework is illustrated on [Figure 5.1](#). Detailed examples involving X.509 certificates are listed below.

5.1.1 X.509 certificates

An X.509 certificate usually contains information about the certificate holder, the signer, a unique serial number, expiration dates and some other fields [*PKIX*] as shown in [Table 5.1](#).

Field	Description
version	The field that indicates the version of the certificate.
serialNumber	This field holds a unique serial number per certificate.
issuer	Holds the issuer's distinguished name.
validity	The activation and expiration dates.
subject	The subject's distinguished name of the certificate.
extensions	The extensions are fields only present in version 3 certificates.

Table 5.1: X.509 certificate fields.

The certificate's *subject or issuer name* is not just a single string. It is a Distinguished name and in the ASN.1 notation is a sequence of several object identifiers with their corresponding values. Some of available OIDs to be used in an X.509 distinguished name are defined in 'gnutls/x509.h'.

The *Version* field in a certificate has values either 1 or 3 for version 3 certificates. Version 1 certificates do not support the extensions field so it is not possible to distinguish a CA from a person, thus their usage should be avoided.

The *validity* dates are there to indicate the date that the specific certificate was activated and the date the certificate's key would be considered invalid.

Certificate *extensions* are there to include information about the certificate's subject that did not fit in the typical certificate fields. Those may be e-mail addresses, flags that indicate whether the belongs to a CA etc. All the supported X.509 version 3 extensions are shown in [Table 5.2](#).

Extension	OID	Description
Subject key id	2.5.29.14	An identifier of the key of the subject.
Authority key id	2.5.29.35	An identifier of the authority's key used to sign the certificate.
Subject alternative name	2.5.29.17	Alternative names to subject's distinguished name.
Key usage	2.5.29.15	Constraints the key's usage of the certificate.
Extended key usage	2.5.29.37	Constraints the purpose of the certificate.
Basic constraints	2.5.29.19	Indicates whether this is a CA certificate or not, and specify the maximum path lengths of certificate chains.
CRL distribution points	2.5.29.31	This extension is set by the CA, in order to inform about the issued CRLs.
Proxy Certification Information	1.3.6.1.5.5.7.1.14	Proxy Certificates includes this extension that contains the OID of the proxy policy language used, and can specify limits on the maximum lengths of proxy chains. Proxy Certificates are specified in <i>[RFC3820]</i> .

Table 5.2: X.509 certificate extensions.

In GnuTLS the X.509 certificate structures are handled using the `gnutls_x509_cert_t` type and the corresponding private keys with the `gnutls_x509_privkey_t` type. All the available functions for X.509 certificate handling have their prototypes in `'gnutls/x509.h'`. An example program to demonstrate the X.509 parsing capabilities can be found at [\[ex:x509-info\]](#), page 107.

5.1.2 Verifying X.509 certificate paths

Verifying certificate paths is important in X.509 authentication. For this purpose the following functions are provided.

- [\[gnutls_x509_trust_list_init\]](#), page 317
- [\[gnutls_x509_trust_list_deinit\]](#), page 316
- [\[gnutls_x509_trust_list_add_cas\]](#), page 315
- [\[gnutls_x509_trust_list_add_named_cert\]](#), page 316
- [\[gnutls_x509_trust_list_add_crls\]](#), page 315

- [\[gnutls_x509_trust_list_verify_cert\]](#), page 317
- [\[gnutls_x509_trust_list_verify_named_cert\]](#), page 317

The verification function will verify a given certificate chain against a list of certificate authorities and certificate revocation lists, and output a bit-wise OR of elements of the `gnutls_certificate_status_t` enumeration. It is also possible to have a set of certificates that are trusted for a particular server but not to authorize other certificates. This purpose is served by the functions [\[gnutls_x509_trust_list_add_named_cert\]](#), page 316 and [\[gnutls_x509_trust_list_verify_named_cert\]](#), page 317. A detailed description of these elements can be found in [Table 5.3](#). An example of certificate verification is shown in [\[ex:verify2\]](#), page 71.

When operating in the context of a TLS session, the trusted certificate authority list has been set via the [\[gnutls_certificate_set_x509_trust_file\]](#), page 166 and [\[gnutls_certificate_set_x509_crl_file\]](#), page 162, thus it is not required to setup a trusted list as above. Convenience functions such as [\[gnutls_certificate_verify_peers2\]](#), page 168 are equivalent and will verify the peer's certificate chain in a TLS session.

Flag	Description
<code>GNUTLS_CERT_INVALID</code>	The certificate is not signed by one of the known authorities, or the signature is invalid.
<code>GNUTLS_CERT_REVOKED</code>	The certificate has been revoked by its CA.
<code>GNUTLS_CERT_SIGNER_NOT_FOUND</code>	The certificate's issuer is not known. This is the case when the issuer is not in the trusted certificates list.
<code>GNUTLS_CERT_SIGNER_NOT_CA</code>	The certificate's signer was not a CA. This may happen if this was a version 1 certificate, which is common with some CAs, or a version 3 certificate without the basic constraints extension.
<code>GNUTLS_CERT_INSECURE_ALGORITHM</code>	The certificate was signed using an insecure algorithm such as MD2 or MD5. These algorithms have been broken and should not be trusted.

Table 5.3: Certificate verification output flags.

There is also to possibility to pass some input to the verification functions in the form of flags. For [\[gnutls_x509_trust_list_verify_cert\]](#), page 317 the flags are passed straightforward, but [\[gnutls_certificate_verify_peers2\]](#), page 168 depends on the flags set by calling

[`gnutls_certificate_set_verify_flags`], page 162. All the available flags are part of the enumeration `gnutls_certificate_verify_flags` and are explained in Table 5.4.

Flag	Description
GNUTLS_VERIFY_\-DISABLE_CA_SIGN	If set a signer does not have to be a certificate authority. This flag should normally be disabled, unless you know what this means.
GNUTLS_VERIFY_\ ALLOW_X509_V1_CA_CERT	Allow only trusted CA certificates that have version 1. This is safer than GNUTLS_VERIFY_\ ALLOW_ANY_X509_V1_CA_CERT, and should be used instead. That way only signers in your trusted list will be allowed to have certificates of version 1. This is the default.
GNUTLS_VERIFY_\ DO_NOT_ALLOW_X509_V1_CA_CERT	Do not allow trusted version 1 CA certificates. This option is to be used in order consider all V1 certificates as deprecated.
GNUTLS_VERIFY_\ ALLOW_ANY_X509_V1_CA_CERT	Allow CA certificates that have version 1 (both root and intermediate). This is dangerous since those haven't the basicConstraints extension. Must be used in combination with GNUTLS_VERIFY_\ ALLOW_X509_V1_CA_CERT.
GNUTLS_VERIFY_\ DO_NOT_ALLOW_SAME	If a certificate is not signed by anyone trusted but exists in the trusted CA list do not treat it as trusted.
GNUTLS_VERIFY_\ ALLOW_SIGN_RSA_MD2	Allow certificates to be signed using the old MD2 algorithm.
GNUTLS_VERIFY_\ ALLOW_SIGN_RSA_MD5	Allow certificates to be signed using the broken MD5 algorithm.
GNUTLS_VERIFY_\ DISABLE_TIME_CHECKS	Disable checking of activation and expiration validity periods of certificate chains. Don't set this unless you understand the security implications.
GNUTLS_VERIFY_\ DISABLE_CRL_CHECKS	Disables checking for validity using certificate revocation lists.

Table 5.4: Certificate verification flags.

Although the verification of a certificate path indicates that the certificate is signed by trusted authority, does not reveal anything about the peer's identity. It is required to verify if the certificate's owner is the one you expect. For more information consult [RFC2818] and section [ex:verify], page 60 for an example.

5.1.3 PKCS #10 certificate requests

A certificate request is a structure, which contain information about an applicant of a certificate service. It usually contains a private key, a distinguished name and secondary data such as a challenge password. GnuTLS supports the requests defined in PKCS #10 [RFC2986]. Other certificate request's format are not currently supported.

The following example is about generating a certificate request, and a private key. A certificate request can be later be processed by a CA, which should return a signed certificate.

```
/* This example code is placed in the public domain. */

#ifdef HAVE_CONFIG_H
#include <config.h>
#endif

#include <stdio.h>
#include <stdlib.h>
#include <string.h>
#include <gnutls/gnutls.h>
#include <gnutls/x509.h>
#include <gnutls/abstract.h>
#include <time.h>

/* This example will generate a private key and a certificate
 * request.
 */

int
main (void)
{
    gnutls_x509_crq_t crq;
    gnutls_x509_privkey_t key;
    gnutls_privkey_t pkey;          /* object used for signing */
    unsigned char buffer[10 * 1024];
    size_t buffer_size = sizeof (buffer);
    unsigned int bits;

    gnutls_global_init ();

    /* Initialize an empty certificate request, and
     * an empty private key.
     */
    gnutls_x509_crq_init (&crq);
```

```
gnutls_x509_privkey_init (&key);
gnutls_privkey_init (&pkey);

/* Generate an RSA key of moderate security.
 */
bits = gnutls_sec_param_to_pk_bits (GNUTLS_PK_RSA, GNUTLS_SEC_PARAM_NORMAL);
gnutls_x509_privkey_generate (key, GNUTLS_PK_RSA, bits, 0);

/* Add stuff to the distinguished name
 */
gnutls_x509_crq_set_dn_by_oid (crq, GNUTLS_OID_X520_COUNTRY_NAME,
                               0, "GR", 2);

gnutls_x509_crq_set_dn_by_oid (crq, GNUTLS_OID_X520_COMMON_NAME,
                               0, "Nikos", strlen ("Nikos"));

/* Set the request version.
 */
gnutls_x509_crq_set_version (crq, 1);

/* Set a challenge password.
 */
gnutls_x509_crq_set_challenge_password (crq, "something to remember here");

/* Associate the request with the private key
 */
gnutls_x509_crq_set_key (crq, key);

/* Self sign the certificate request.
 */
gnutls_privkey_import_x509 (pkey, key, 0);
gnutls_x509_crq_privkey_sign (crq, pkey, GNUTLS_DIG_SHA1, 0);

/* Export the PEM encoded certificate request, and
 * display it.
 */
gnutls_x509_crq_export (crq, GNUTLS_X509_FMT_PEM, buffer, &buffer_size);

printf ("Certificate Request:  \n%s", buffer);

/* Export the PEM encoded private key, and
 * display it.
 */
buffer_size = sizeof (buffer);
gnutls_x509_privkey_export (key, GNUTLS_X509_FMT_PEM, buffer, &buffer_size);
```

```

printf ("\n\nPrivate key:  \n%s", buffer);

gnutls_x509_crq_deinit (crq);
gnutls_x509_privkey_deinit (key);

return 0;

}

```

5.1.4 PKCS #12 structures

A PKCS #12 structure [PKCS12] usually contains a user's private keys and certificates. It is commonly used in browsers to export and import the user's identities.

In GnuTLS the PKCS #12 structures are handled using the `gnutls_pkcs12_t` type. This is an abstract type that may hold several `gnutls_pkcs12_bag_t` types. The Bag types are the holders of the actual data, which may be certificates, private keys or encrypted data. An Bag of type encrypted should be decrypted in order for its data to be accessed.

An example of a PKCS #12 structure generation can be found below.

```

/* This example code is placed in the public domain. */

#ifdef HAVE_CONFIG_H
#include <config.h>
#endif

#include <stdio.h>
#include <stdlib.h>
#include <gnutls/gnutls.h>
#include <gnutls/pkcs12.h>

#include "examples.h"

#define OUTFILE "out.p12"

/* This function will write a pkcs12 structure into a file.
 * cert: is a DER encoded certificate
 * pkcs8_key: is a PKCS #8 encrypted key (note that this must be
 * encrypted using a PKCS #12 cipher, or some browsers will crash)
 * password: is the password used to encrypt the PKCS #12 packet.
 */
int
write_pkcs12 (const gnutls_datum_t * cert,
              const gnutls_datum_t * pkcs8_key, const char *password)
{
    gnutls_pkcs12_t pkcs12;
    int ret, bag_index;
    gnutls_pkcs12_bag_t bag, key_bag;

```

```
char pkcs12_struct[10 * 1024];
size_t pkcs12_struct_size;
FILE *fd;

/* A good idea might be to use gnutls_x509_privkey_get_key_id()
 * to obtain a unique ID.
 */
gnutls_datum_t key_id = { (char *) "\x00\x00\x07", 3 };

gnutls_global_init ();

/* Firstly we create two helper bags, which hold the certificate,
 * and the (encrypted) key.
 */

gnutls_pkcs12_bag_init (&bag);
gnutls_pkcs12_bag_init (&key_bag);

ret = gnutls_pkcs12_bag_set_data (bag, GNUTLS_BAG_CERTIFICATE, cert);
if (ret < 0)
{
    fprintf (stderr, "ret: %s\n", gnutls_strerror (ret));
    return 1;
}

/* ret now holds the bag's index.
 */
bag_index = ret;

/* Associate a friendly name with the given certificate. Used
 * by browsers.
 */
gnutls_pkcs12_bag_set_friendly_name (bag, bag_index, "My name");

/* Associate the certificate with the key using a unique key
 * ID.
 */
gnutls_pkcs12_bag_set_key_id (bag, bag_index, &key_id);

/* use weak encryption for the certificate.
 */
gnutls_pkcs12_bag_encrypt (bag, password, GNUTLS_PKCS_USE_PKCS12_RC2_40);

/* Now the key.
 */

ret = gnutls_pkcs12_bag_set_data (key_bag,
```

```

                                GNUTLS_BAG_PKCS8_ENCRYPTED_KEY,
                                pkcs8_key);

if (ret < 0)
{
    fprintf (stderr, "ret: %s\n", gnutls_strerror (ret));
    return 1;
}

/* Note that since the PKCS #8 key is already encrypted we don't
 * bother encrypting that bag.
 */
bag_index = ret;

gnutls_pkcs12_bag_set_friendly_name (key_bag, bag_index, "My name");

gnutls_pkcs12_bag_set_key_id (key_bag, bag_index, &key_id);

/* The bags were filled. Now create the PKCS #12 structure.
 */
gnutls_pkcs12_init (&pkcs12);

/* Insert the two bags in the PKCS #12 structure.
 */

gnutls_pkcs12_set_bag (pkcs12, bag);
gnutls_pkcs12_set_bag (pkcs12, key_bag);

/* Generate a message authentication code for the PKCS #12
 * structure.
 */
gnutls_pkcs12_generate_mac (pkcs12, password);

pkcs12_struct_size = sizeof (pkcs12_struct);
ret =
    gnutls_pkcs12_export (pkcs12, GNUTLS_X509_FMT_DER, pkcs12_struct,
                        &pkcs12_struct_size);
if (ret < 0)
{
    fprintf (stderr, "ret: %s\n", gnutls_strerror (ret));
    return 1;
}

fd = fopen (OUTFILE, "w");
if (fd == NULL)
{
```

```

    fprintf (stderr, "cannot open file\n");
    return 1;
}
fwrite (pkcs12_struct, 1, pkcs12_struct_size, fd);
fclose (fd);

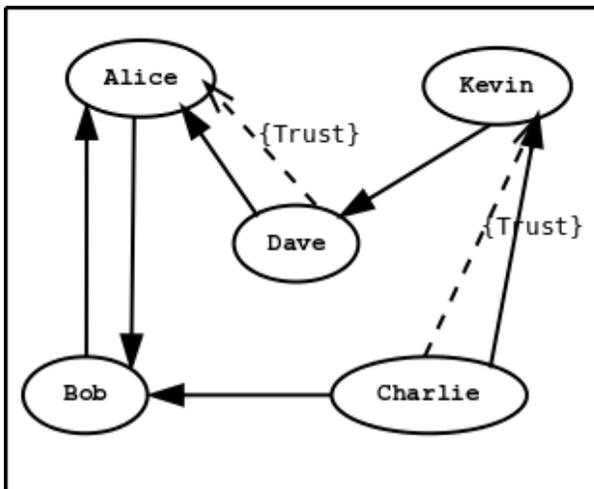
gnutls_pkcs12_bag_deinit (bag);
gnutls_pkcs12_bag_deinit (key_bag);
gnutls_pkcs12_deinit (pkcs12);

return 0;
}

```

5.2 The OpenPGP trust model

The OpenPGP key authentication relies on a distributed trust model, called the “web of trust”. The “web of trust” uses a decentralized system of trusted introducers, which are the same as a CA. OpenPGP allows anyone to sign anyone else’s public key. When Alice signs Bob’s key, she is introducing Bob’s key to anyone who trusts Alice. If someone trusts Alice to introduce keys, then Alice is a trusted introducer in the mind of that observer. For example in [Figure 5.2](#), David trusts Alice to be an introducer and Alice signed Bob’s key thus Dave trusts Bob’s key to be the real one.



An example of the
web of trust model

Figure 5.2: The OpenPGP trust model.

There are some key points that are important in that model. In the example Alice has to sign Bob’s key, only if she is sure that the key belongs to Bob. Otherwise she may also make Dave falsely believe that this is Bob’s key. Dave has also the responsibility to know who to trust. This model is similar to real life relations.

Just see how Charlie behaves in the previous example. Although he has signed Bob's key - because he knows, somehow, that it belongs to Bob - he does not trust Bob to be an introducer. Charlie decided to trust only Kevin, for some reason. A reason could be that Bob is lazy enough, and signs other people's keys without being sure that they belong to the actual owner.

5.2.1 OpenPGP keys

In GnuTLS the OpenPGP key structures [RFC2440] are handled using the `gnutls_openpgp_cert_t` type and the corresponding private keys with the `gnutls_openpgp_privkey_t` type. All the prototypes for the key handling functions can be found at '`gnutls/openpgp.h`'.

5.2.2 Verifying an OpenPGP key

The verification functions of OpenPGP keys, included in GnuTLS, are simple ones, and do not use the features of the "web of trust". For that reason, if the verification needs are complex, the assistance of external tools like GnuPG and GPGME¹ is recommended.

There is one verification function in GnuTLS, the [`gnutls_openpgp_cert_verify_ring`], page 329. This checks an OpenPGP key against a given set of public keys (keyring) and returns the key status. The key verification status is the same as in X.509 certificates, although the meaning and interpretation are different. For example an OpenPGP key may be valid, if the self signature is ok, even if no signers were found. The meaning of verification status is shown in the figure below.

CERT_INVALID:

A signature on the key is invalid. That means that the key was modified by somebody, or corrupted during transport.

CERT_REVOKED:

The key has been revoked by its owner.

CERT_SIGNER_NOT_FOUND:

The key was not signed by a known signer.

GNUTLS_CERT_INSECURE_ALGORITHM:

The certificate was signed using an insecure algorithm such as MD2 or MD5. These algorithms have been broken and should not be trusted.

5.3 Hardware tokens

5.3.1 Introduction

This section copes with hardware token support in GnuTLS using PKCS #11 [*PKCS11*]. PKCS #11 is plugin API allowing applications to access cryptographic operations on a token, as well as to objects residing on the token. A token can be a real hardware token such as a smart card, or it can be a software component such as Gnome Keyring. The objects residing on such token can be certificates, public keys, private keys or even plain data or secret keys. Of those certificates and public/private key pairs can be used with GnuTLS. Its main advantage is that it allows operations on private key objects such as decryption and signing without accessing the key itself.

¹ http://www.gnupg.org/related_software/gpgme/

Moreover it can be used to allow all applications in the same operating system to access shared cryptographic keys and certificates in a uniform way, as in [Figure 5.3](#).

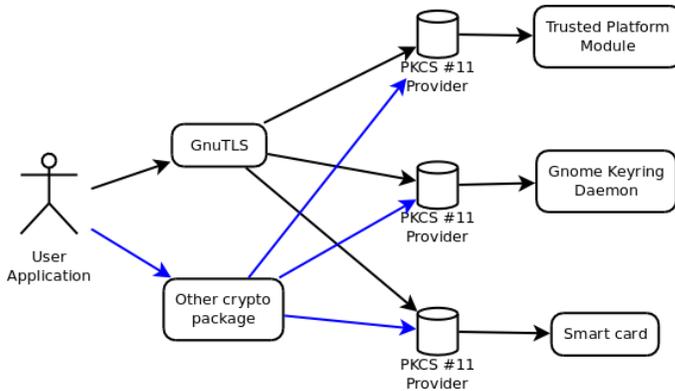


Figure 5.3: PKCS #11 module usage.

5.3.2 Initialization

To allow all the GnuTLS applications to access PKCS #11 tokens it is advisable to use `/etc/pkcs11/modules/mymodule.conf`. This file has the following format:

```
module: /usr/lib/opensc-pkcs11.so
```

If you use this file, then there is no need for other initialization in GnuTLS, except for the PIN and token functions. Those allow retrieving a PIN when accessing a protected object, such as a private key, as well as probe the user to insert the token. All the initialization functions are below.

- [\[gnutls_pkcs11_init\]](#), page 200
- [\[gnutls_pkcs11_deinit\]](#), page 200
- [\[gnutls_pkcs11_set_token_function\]](#), page 205
- [\[gnutls_pkcs11_set_pin_function\]](#), page 204
- [\[gnutls_pkcs11_add_provider\]](#), page 199

Note that due to limitations of PKCS #11 there are issues when multiple libraries are sharing a module. To avoid this problem GnuTLS uses `p11-kit`² that provides a middleware to control access to resources over the multiple users.

5.3.3 Reading objects

All PKCS #11 objects are referenced by GnuTLS functions by URLs as described in `draft-pechanec-pkcs11uri-03`. For example a public key on a smart card may be referenced as:

```
pkcs11:token=Nikos;serial=307521161601031;model=PKCS%2315; \
manufacturer=EnterSafe;object=test1;objecttype=public;\
id=32f153f3e37990b08624141077ca5dec2d15faed
```

while the smart card itself can be referenced as:

² <http://p11-glue.freedesktop.org/>

`pkcs11:token=Nikos;serial=307521161601031;model=PKCS%2315;manufacturer=EnterSafe`
 PKCS #11 objects can be accessed with the functions shown below.

- [\[gnutls_pkcs11_obj_init\]](#), page 202
- [\[gnutls_pkcs11_obj_deinit\]](#), page 201
- [\[gnutls_pkcs11_obj_import_url\]](#), page 202
- [\[gnutls_pkcs11_obj_export_url\]](#), page 201
- [\[gnutls_pkcs11_obj_export\]](#), page 201
- [\[gnutls_pkcs11_obj_get_info\]](#), page 201
- [\[gnutls_pkcs11_obj_list_import_url\]](#), page 202
- [\[gnutls_x509_cert_import_pkcs11\]](#), page 244
- [\[gnutls_x509_cert_import_pkcs11_url\]](#), page 244
- [\[gnutls_x509_cert_list_import_pkcs11\]](#), page 244

Functions that relate to token handling are shown below.

- [\[gnutls_pkcs11_token_init\]](#), page 206
- [\[gnutls_pkcs11_token_set_pin\]](#), page 206
- [\[gnutls_pkcs11_token_get_url\]](#), page 206
- [\[gnutls_pkcs11_token_get_info\]](#), page 205
- [\[gnutls_pkcs11_token_get_flags\]](#), page 205

The following example will list all available PKCS #11 tokens in a system.

```
int i;
char* url;

gnutls_global_init();

for (i=0;;i++)
{
    ret = gnutls_pkcs11_token_get_url(i, &url);
    if (ret == GNUTLS_E_REQUESTED_DATA_NOT_AVAILABLE)
        break;

    if (ret < 0)
        exit(1);

    fprintf(stdout, "Token[%d]: URL: %s\n", i, url);
    gnutls_free(url);
}
gnutls_global_deinit();
```

That example will only list all certificates in a token that have a corresponding private key.

```
#include <gnutls/gnutls.h>
#include <gnutls/pkcs11.h>
#include <stdio.h>
#include <stdlib.h>
```

```
#define URL "pkcs11:URL"

int
main (int argc, char** argv)
{
    gnutls_pkcs11_obj_t *obj_list;
    gnutls_x509_cert_t xcrt;
    unsigned int obj_list_size = 0;
    gnutls_datum_t cinfo;
    int i, ret;

    obj_list_size = 0;
    ret = gnutls_pkcs11_obj_list_import_url (NULL, &obj_list_size, URL,
                                           GNUTLS_PKCS11_OBJ_ATTR_CERT_WITH_PRIVKEY,
                                           0);
    if (ret < 0 && ret != GNUTLS_E_SHORT_MEMORY_BUFFER)
        return -1;

    /* no error checking from now on */
    obj_list = malloc (sizeof (*obj_list) * obj_list_size);

    gnutls_pkcs11_obj_list_import_url (obj_list, &obj_list_size, URL,
                                       GNUTLS_PKCS11_OBJ_ATTR_CERT_WITH_PRIVKEY,
                                       0);

    /* now all certificates are in obj_list */
    for (i = 0; i < obj_list_size; i++)
    {
        gnutls_x509_cert_init (&xcrt);

        gnutls_x509_cert_import_pkcs11 (xcrt, obj_list[i]);

        gnutls_x509_cert_print (xcrt, GNUTLS_CERT_PRINT_FULL, &cinfo);

        fprintf (stdout, "cert[%d]:\n %s\n\n", i, cinfo.data);

        gnutls_free (cinfo.data);
        gnutls_x509_cert_deinit (xcrt);
    }

    return 0;
}
```

5.3.4 Writing objects

With GnuTLS you can copy existing private keys and certificates to a token. This can be achieved with the following functions

- [\[gnutls_pkcs11_delete_url\]](#), page 200
- [\[gnutls_pkcs11_copy_x509_privkey\]](#), page 200
- [\[gnutls_pkcs11_copy_x509_cert\]](#), page 199

5.3.5 Using a PKCS #11 token with TLS

It is possible to use a PKCS #11 token to a TLS session, as shown in [\[ex:pkcs11-client\]](#), page 74. In addition the following functions can be used to load PKCS #11 key and certificates.

- [\[gnutls_certificate_set_x509_trust_file\]](#), page 166
- [\[gnutls_certificate_set_x509_key_file\]](#), page 163

5.4 Abstract key types

Since there are many forms of a public or private keys supported by GnuTLS such as X.509, OpenPGP, or PKCS #11 it is desirable to allow common operations on them. For these reasons the abstract `gnutls_privkey_t` and `gnutls_pubkey_t` were introduced in `gnutls/abstract.h` header. Those types are initialized using a specific type of key and then can be used to perform operations in an abstract way. For example in order for someone to sign an X.509 certificate with a key that resides in a smart he has to follow the steps below:

```
#include <gnutls/abstract.h>
#include <gnutls/pkcs11.h>

void sign_cert( gnutls_x509_cert_t to_be_signed)
{
    gnutls_pkcs11_privkey_t ca_key;
    gnutls_x509_cert_t ca_cert;
    gnutls_privkey_t abs_key;

    /* load the PKCS #11 key and certificates */
    gnutls_pkcs11_privkey_init(&ca_key);
    gnutls_pkcs11_privkey_import_url(ca_key, key_url);

    gnutls_x509_cert_init(&ca_cert);
    gnutls_x509_cert_import_pkcs11_url(&ca_cert, cert_url);

    /* initialize the abstract key */
    gnutls_privkey_init(&abs_key);
    gnutls_privkey_import_pkcs11(abs_key, ca_key);

    /* sign the certificate to be signed */
    gnutls_x509_cert_privkey_sign(to_be_signed, ca_cert, ca_key,
```

```

GNUTLS_DIG_SHA1, 0);
}

```

5.5 Digital signatures

In this section we will provide some information about digital signatures, how they work, and give the rationale for disabling some of the algorithms used.

Digital signatures work by using somebody's secret key to sign some arbitrary data. Then anybody else could use the public key of that person to verify the signature. Since the data may be arbitrary it is not suitable input to a cryptographic digital signature algorithm. For this reason and also for performance cryptographic hash algorithms are used to preprocess the input to the signature algorithm. This works as long as it is difficult enough to generate two different messages with the same hash algorithm output. In that case the same signature could be used as a proof for both messages. Nobody wants to sign an innocent message of donating 1 € to Greenpeace and find out that he donated 1.000.000 € to Bad Inc.

For a hash algorithm to be called cryptographic the following three requirements must hold:

1. Preimage resistance. That means the algorithm must be one way and given the output of the hash function $H(x)$, it is impossible to calculate x .
2. 2nd preimage resistance. That means that given a pair x, y with $y = H(x)$ it is impossible to calculate an x' such that $y = H(x')$.
3. Collision resistance. That means that it is impossible to calculate random x and x' such $H(x') = H(x)$.

The last two requirements in the list are the most important in digital signatures. These protect against somebody who would like to generate two messages with the same hash output. When an algorithm is considered broken usually it means that the Collision resistance of the algorithm is less than brute force. Using the birthday paradox the brute force attack takes $2^{(\text{hash size})/2}$ operations. Today colliding certificates using the MD5 hash algorithm have been generated as shown in [WEGER].

There has been cryptographic results for the SHA-1 hash algorithms as well, although they are not yet critical. Before 2004, MD5 had a presumed collision strength of 2^{64} , but it has been showed to have a collision strength well under 2^{50} . As of November 2005, it is believed that SHA-1's collision strength is around 2^{63} . We consider this sufficiently hard so that we still support SHA-1. We anticipate that SHA-256/386/512 will be used in publicly-distributed certificates in the future. When 2^{63} can be considered too weak compared to the computer power available sometime in the future, SHA-1 will be disabled as well. The collision attacks on SHA-1 may also get better, given the new interest in tools for creating them.

5.5.1 Trading security for interoperability

If you connect to a server and use GnuTLS' functions to verify the certificate chain, and get a `GNUTLS_CERT_INSECURE_ALGORITHM` validation error (see [Section 5.1.2 \[Verifying X.509 certificate paths\]](#), page 31), it means that somewhere in the certificate chain there is a certificate signed using RSA-MD2 or RSA-MD5. These two digital signature algorithms are considered broken, so GnuTLS fail when attempting to verify the certificate. In some situations, it may be useful to be able to verify the certificate chain anyway, assuming an

attacker did not utilize the fact that these signatures algorithms are broken. This section will give help on how to achieve that.

First, it is important to know that you do not have to enable any of the flags discussed here to be able to use trusted root CA certificates signed using RSA-MD2 or RSA-MD5. The only attack today is that it is possible to generate certificates with colliding signatures (collision resistance); you cannot generate a certificate that has the same signature as an already existing signature (2nd preimage resistance).

If you are using `[gnutls_certificate_verify_peers2]`, page 168 to verify the certificate chain, you can call `[gnutls_certificate_set_verify_flags]`, page 162 with the flags:

- `GNUTLS_VERIFY_ALLOW_SIGN_RSA_MD2`
- `GNUTLS_VERIFY_ALLOW_SIGN_RSA_MD5`

as in the following example:

```
gnutls_certificate_set_verify_flags (x509cred,  
                                   GNUTLS_VERIFY_ALLOW_SIGN_RSA_MD5);
```

This will tell the verifier algorithm to enable RSA-MD5 when verifying the certificates.

If you are using `[gnutls_x509_cert_verify]`, page 304 or `[gnutls_x509_cert_list_verify]`, page 295, you can pass the `GNUTLS_VERIFY_ALLOW_SIGN_RSA_MD5` parameter directly in the `flags` parameter.

If you are using these flags, it may also be a good idea to warn the user when verification failure occur for this reason. The simplest is to not use the flags by default, and only fall back to using them after warning the user. If you wish to inspect the certificate chain yourself, you can use `[gnutls_certificate_get_peers]`, page 158 to extract the raw server's certificate chain, then use `[gnutls_x509_cert_import]`, page 294 to parse each of the certificates, and then use `[gnutls_x509_cert_get_signature_algorithm]`, page 290 to find out the signing algorithm used for each certificate. If any of the intermediary certificates are using `GNUTLS_SIGN_RSA_MD2` or `GNUTLS_SIGN_RSA_MD5`, you could present a warning.

6 How to use GnuTLS in applications

6.1 Preparation

To use GnuTLS, you have to perform some changes to your sources and your build system. The necessary changes are explained in the following subsections.

6.1.1 Headers

All the data types and functions of the GnuTLS library are defined in the header file `'gnutls/gnutls.h'`. This must be included in all programs that make use of the GnuTLS library.

The extra functionality of the GnuTLS-extra library is available by including the header file `'gnutls/extra.h'` in your programs.

6.1.2 Initialization

GnuTLS must be initialized before it can be used. The library is initialized by calling [\[gnutls_global_init\]](#), page 184. The resources allocated by the initialization process can be released if the application no longer has a need to call GnuTLS functions, this is done by calling [\[gnutls_global_deinit\]](#), page 184.

The extra functionality of the GnuTLS-extra library is available after calling [\[gnutls_global_init_extra\]](#), page 318.

In order to take advantage of the internationalization features in GnuTLS, such as translated error messages, the application must set the current locale using `setlocale` before initializing GnuTLS.

6.1.3 Version check

It is often desirable to check that the version of 'gnutls' used is indeed one which fits all requirements. Even with binary compatibility new features may have been introduced but due to problem with the dynamic linker an old version is actually used. So you may want to check that the version is okay right after program start-up. See the function [\[gnutls_check_version\]](#), page 168.

6.1.4 Debugging and auditing

In many cases things may not go as expected and further information, to assist debugging, from GnuTLS is desired. Those are the cases where the [\[gnutls_global_set_log_level\]](#), page 185 and [\[gnutls_global_set_log_function\]](#), page 185 are to be used. Those will print verbose information on the GnuTLS functions internal flow.

When debugging is not required, important issues, such as detected attacks on the protocol still need to be logged. This is provided by the logging function set by [\[gnutls_global_set_audit_log_function\]](#), page 184. The set function accepts the detected error message and the corresponding TLS session. The session information might be used to derive IP addresses or other information about the peer involved.

6.1.5 Building the source

If you want to compile a source file including the `gnutls/gnutls.h` header file, you must make sure that the compiler can find it in the directory hierarchy. This is accomplished by adding the path to the directory in which the header file is located to the compilers include file search path (via the `-I` option).

However, the path to the include file is determined at the time the source is configured. To solve this problem, the library uses the external package `pkg-config` that knows the path to the include file and other configuration options. The options that need to be added to the compiler invocation at compile time are output by the `--cflags` option to `pkg-config gnutls`. The following example shows how it can be used at the command line:

```
gcc -c foo.c `pkg-config gnutls --cflags`
```

Adding the output of `pkg-config gnutls --cflags` to the compilers command line will ensure that the compiler can find the `gnutls/gnutls.h` header file.

A similar problem occurs when linking the program with the library. Again, the compiler has to find the library files. For this to work, the path to the library files has to be added to the library search path (via the `-L` option). For this, the option `--libs` to `pkg-config gnutls` can be used. For convenience, this option also outputs all other options that are required to link the program with the library (for instance, the `-ltaasn1` option). The example shows how to link `foo.o` with the library to a program `foo`.

```
gcc -o foo foo.o `pkg-config gnutls --libs`
```

Of course you can also combine both examples to a single command by specifying both options to `pkg-config`:

```
gcc -o foo foo.c `pkg-config gnutls --cflags --libs`
```

6.2 Client examples

This section contains examples of TLS and SSL clients, using GnuTLS. Note that these examples contain little or no error checking. Some of the examples require functions implemented by another example.

6.2.1 Simple client example with anonymous authentication

The simplest client using TLS is the one that doesn't do any authentication. This means no external certificates or passwords are needed to set up the connection. As could be expected, the connection is vulnerable to man-in-the-middle (active or redirection) attacks. However, the data is integrity and privacy protected.

```
/* This example code is placed in the public domain. */
```

```
#ifdef HAVE_CONFIG_H
#include <config.h>
#endif

#include <stdio.h>
#include <stdlib.h>
#include <string.h>
#include <sys/types.h>
#include <sys/socket.h>
```

```
#include <arpa/inet.h>
#include <unistd.h>
#include <gnutls/gnutls.h>

/* A very basic TLS client, with anonymous authentication.
 */

#define MAX_BUF 1024
#define MSG "GET / HTTP/1.0\r\n\r\n"

extern int tcp_connect (void);
extern void tcp_close (int sd);

int
main (void)
{
    int ret, sd, ii;
    gnutls_session_t session;
    char buffer[MAX_BUF + 1];
    gnutls_anon_client_credentials_t anoncred;
    /* Need to enable anonymous KX specifically. */

    gnutls_global_init ();

    gnutls_anon_allocate_client_credentials (&anoncred);

    /* Initialize TLS session
     */
    gnutls_init (&session, GNUTLS_CLIENT);

    /* Use default priorities */
    gnutls_priority_set_direct (session, "PERFORMANCE:+ANON-ECDH:+ANON-DH",
                                NULL);

    /* put the anonymous credentials to the current session
     */
    gnutls_credentials_set (session, GNUTLS_CRD_ANON, anoncred);

    /* connect to the peer
     */
    sd = tcp_connect ();

    gnutls_transport_set_ptr (session, (gnutls_transport_ptr_t) sd);

    /* Perform the TLS handshake
     */
    ret = gnutls_handshake (session);
```

```
if (ret < 0)
{
    fprintf (stderr, "*** Handshake failed\n");
    gnutls_perror (ret);
    goto end;
}
else
{
    printf ("- Handshake was completed\n");
}

gnutls_record_send (session, MSG, strlen (MSG));

ret = gnutls_record_recv (session, buffer, MAX_BUF);
if (ret == 0)
{
    printf ("- Peer has closed the TLS connection\n");
    goto end;
}
else if (ret < 0)
{
    fprintf (stderr, "*** Error: %s\n", gnutls_strerror (ret));
    goto end;
}

printf ("- Received %d bytes: ", ret);
for (ii = 0; ii < ret; ii++)
{
    fputc (buffer[ii], stdout);
}
fputs ("\n", stdout);

gnutls_bye (session, GNUTLS_SHUT_RDWR);

end:

tcp_close (sd);

gnutls_deinit (session);

gnutls_anon_free_client_credentials (anoncred);

gnutls_global_deinit ();

return 0;
}
```

6.2.2 Simple client example with X.509 certificate support

Let's assume now that we want to create a TCP client which communicates with servers that use X.509 or OpenPGP certificate authentication. The following client is a very simple TLS client, it does not support session resuming, not even certificate verification. The TCP functions defined in this example are used in most of the other examples below, without redefining them.

```

/* This example code is placed in the public domain. */

#ifdef HAVE_CONFIG_H
#include <config.h>
#endif

#include <stdio.h>
#include <stdlib.h>
#include <string.h>
#include <sys/types.h>
#include <sys/socket.h>
#include <arpa/inet.h>
#include <unistd.h>
#include <gnutls/gnutls.h>

/* A very basic TLS client, with X.509 authentication.
 */

#define MAX_BUF 1024
#define CAFILE "ca.pem"
#define MSG "GET / HTTP/1.0\r\n\r\n"

extern int tcp_connect (void);
extern void tcp_close (int sd);

int
main (void)
{
    int ret, sd, ii;
    gnutls_session_t session;
    char buffer[MAX_BUF + 1];
    const char *err;
    gnutls_certificate_credentials_t xcred;

    gnutls_global_init ();

    /* X509 stuff */
    gnutls_certificate_allocate_credentials (&xcred);

    /* sets the trusted cas file

```

```
    */
    gnutls_certificate_set_x509_trust_file (xcred, CAFILE, GNUTLS_X509_FMT_PEM);

    /* Initialize TLS session
    */
    gnutls_init (&session, GNUTLS_CLIENT);

    /* Use default priorities */
    ret = gnutls_priority_set_direct (session, "PERFORMANCE", &err);
    if (ret < 0)
    {
        if (ret == GNUTLS_E_INVALID_REQUEST)
        {
            fprintf (stderr, "Syntax error at: %s\n", err);
        }
        exit (1);
    }

    /* put the x509 credentials to the current session
    */
    gnutls_credentials_set (session, GNUTLS_CRD_CERTIFICATE, xcred);

    /* connect to the peer
    */
    sd = tcp_connect ();

    gnutls_transport_set_ptr (session, (gnutls_transport_ptr_t) sd);

    /* Perform the TLS handshake
    */
    ret = gnutls_handshake (session);

    if (ret < 0)
    {
        fprintf (stderr, "*** Handshake failed\n");
        gnutls_perror (ret);
        goto end;
    }
    else
    {
        printf ("- Handshake was completed\n");
    }

    gnutls_record_send (session, MSG, strlen (MSG));

    ret = gnutls_record_recv (session, buffer, MAX_BUF);
    if (ret == 0)
```

```

    {
        printf ("- Peer has closed the TLS connection\n");
        goto end;
    }
else if (ret < 0)
    {
        fprintf (stderr, "*** Error:  %s\n", gnutls_strerror (ret));
        goto end;
    }

printf ("- Received %d bytes:  ", ret);
for (ii = 0; ii < ret; ii++)
    {
        fputc (buffer[ii], stdout);
    }
fputs ("\n", stdout);

gnutls_bye (session, GNUTLS_SHUT_RDWR);

end:

tcp_close (sd);

gnutls_deinit (session);

gnutls_certificate_free_credentials (xcred);

gnutls_global_deinit ();

return 0;
}

```

6.2.3 Simple datagram TLS client example

This is a client that uses UDP to connect to a server. This is the DTLS equivalent to [Section 6.2.2 \[Simple client example with X.509 certificate support\]](#), page 52 above.

```
/* This example code is placed in the public domain. */
```

```

#ifdef HAVE_CONFIG_H
#include <config.h>
#endif

#include <stdio.h>
#include <stdlib.h>
#include <string.h>
#include <sys/types.h>
#include <sys/socket.h>

```

```
#include <arpa/inet.h>
#include <unistd.h>
#include <gnutls/gnutls.h>
#include <gnutls/dtls.h>

/* A very basic Datagram TLS client, over UDP with X.509 authentication.
 */

#define MAX_BUF 1024
#define CAFILE "ca.pem"
#define MSG "GET / HTTP/1.0\r\n\r\n"

extern int udp_connect (void);
extern void udp_close (int sd);

int
main (void)
{
    int ret, sd, ii;
    gnutls_session_t session;
    char buffer[MAX_BUF + 1];
    const char *err;
    gnutls_certificate_credentials_t xcred;

    gnutls_global_init ();

    /* X509 stuff */
    gnutls_certificate_allocate_credentials (&xcred);

    /* sets the trusted cas file */
    gnutls_certificate_set_x509_trust_file (xcred, CAFILE, GNUTLS_X509_FMT_PEM);

    /* Initialize TLS session */
    gnutls_init (&session, GNUTLS_CLIENT | GNUTLS_DATAGRAM);

    /* Use default priorities */
    ret = gnutls_priority_set_direct (session, "NORMAL", &err);
    if (ret < 0)
    {
        if (ret == GNUTLS_E_INVALID_REQUEST)
        {
            fprintf (stderr, "Syntax error at: %s\n", err);
        }
        exit (1);
    }

    /* put the x509 credentials to the current session */
```

```
gnutls_credentials_set (session, GNUTLS_CRD_CERTIFICATE, xcred);

/* connect to the peer */
sd = udp_connect ();

gnutls_transport_set_ptr (session, (gnutls_transport_ptr_t) sd);

/* set the connection MTU */
gnutls_dtls_set_mtu (session, 1000);

/* Perform the TLS handshake */
ret = gnutls_handshake (session);

if (ret < 0)
{
    fprintf (stderr, "*** Handshake failed\n");
    gnutls_perror (ret);
    goto end;
}
else
{
    printf ("- Handshake was completed\n");
}

gnutls_record_send (session, MSG, strlen (MSG));

ret = gnutls_record_recv (session, buffer, MAX_BUF);
if (ret == 0)
{
    printf ("- Peer has closed the TLS connection\n");
    goto end;
}
else if (ret < 0)
{
    fprintf (stderr, "*** Error:  %s\n", gnutls_strerror (ret));
    goto end;
}

printf ("- Received %d bytes:  ", ret);
for (ii = 0; ii < ret; ii++)
{
    fputc (buffer[ii], stdout);
}
fputs ("\n", stdout);

/* It is suggested not to use GNUTLS_SHUT_RDWR in DTLS
 * connections because the peer's closure message might
```

```

    * be lost */
    gnutls_bye (session, GNUTLS_SHUT_WR);

end:

    udp_close (sd);

    gnutls_deinit (session);

    gnutls_certificate_free_credentials (xcred);

    gnutls_global_deinit ();

    return 0;
}

```

6.2.4 Obtaining session information

Most of the times it is desirable to know the security properties of the current established session. This includes the underlying ciphers and the protocols involved. That is the purpose of the following function. Note that this function will print meaningful values only if called after a successful [\[gnutls_handshake\]](#), [page 188](#).

```

/* This example code is placed in the public domain. */

#ifdef HAVE_CONFIG_H
#include <config.h>
#endif

#include <stdio.h>
#include <stdlib.h>
#include <gnutls/gnutls.h>
#include <gnutls/x509.h>

#include "examples.h"

/* This function will print some details of the
 * given session.
 */
int
print_info (gnutls_session_t session)
{
    const char *tmp;
    gnutls_credentials_type_t cred;
    gnutls_kx_algorithm_t kx;
    int dhe, ecdh;

    dhe = ecdh = 0;

```

```

/* print the key exchange's algorithm name
 */
kx = gnutls_kx_get (session);
tmp = gnutls_kx_get_name (kx);
printf ("- Key Exchange:  %s\n", tmp);

/* Check the authentication type used and switch
 * to the appropriate.
 */
cred = gnutls_auth_get_type (session);
switch (cred)
{
case GNUTLS_CRD_IA:
    printf ("- TLS/IA session\n");
    break;

#ifdef ENABLE_SRP
case GNUTLS_CRD_SRP:
    printf ("- SRP session with username %s\n",
            gnutls_srp_server_get_username (session));
    break;
#endif

case GNUTLS_CRD_PSK:
    /* This returns NULL in server side.
     */
    if (gnutls_psk_client_get_hint (session) != NULL)
        printf ("- PSK authentication.  PSK hint '%s'\n",
                gnutls_psk_client_get_hint (session));
    /* This returns NULL in client side.
     */
    if (gnutls_psk_server_get_username (session) != NULL)
        printf ("- PSK authentication.  Connected as '%s'\n",
                gnutls_psk_server_get_username (session));

    if (kx == GNUTLS_KX_ECDHE_PSK)
        ecdh = 1;
    else if (kx == GNUTLS_KX_DHE_PSK)
        dhe = 1;
    break;

case GNUTLS_CRD_ANON:      /* anonymous authentication */

    printf ("- Anonymous authentication.\n");
    if (kx == GNUTLS_KX_ANON_ECDH)

```

```

        ecdh = 1;
    else if (kx == GNUTLS_KX_ANON_DH)
        dhe = 1;
    break;

case GNUTLS_CRD_CERTIFICATE:          /* certificate authentication */

    /* Check if we have been using ephemeral Diffie-Hellman.
     */
    if (kx == GNUTLS_KX_DHE_RSA || kx == GNUTLS_KX_DHE_DSS)
        dhe = 1;
    else if (kx == GNUTLS_KX_ECDHE_RSA || kx == GNUTLS_KX_ECDHE_ECDSA)
        ecdh = 1;

    /* if the certificate list is available, then
     * print some information about it.
     */
    print_x509_certificate_info (session);

}                                     /* switch */

if (ecdh != 0)
    printf ("- Ephemeral ECDH using curve %s\n",
            gnutls_ecc_curve_get_name (gnutls_ecc_curve_get (session)));
else if (dhe != 0)
    printf ("- Ephemeral DH using prime of %d bits\n",
            gnutls_dh_get_prime_bits (session));

/* print the protocol's name (ie TLS 1.0)
 */
tmp = gnutls_protocol_get_name (gnutls_protocol_get_version (session));
printf ("- Protocol:  %s\n", tmp);

/* print the certificate type of the peer.
 * ie X.509
 */
tmp =
    gnutls_certificate_type_get_name (gnutls_certificate_type_get (session));

printf ("- Certificate Type:  %s\n", tmp);

/* print the compression algorithm (if any)
 */
tmp = gnutls_compression_get_name (gnutls_compression_get (session));
printf ("- Compression:  %s\n", tmp);

/* print the name of the cipher used.

```

```

    * ie 3DES.
    */
    tmp = gnutls_cipher_get_name (gnutls_cipher_get (session));
    printf ("- Cipher:  %s\n", tmp);

    /* Print the MAC algorithms name.
    * ie SHA1
    */
    tmp = gnutls_mac_get_name (gnutls_mac_get (session));
    printf ("- MAC: %s\n", tmp);

    return 0;
}

```

6.2.5 Verifying peer's certificate

A TLS session is not secure just after the handshake procedure has finished. It must be considered secure, only after the peer's certificate and identity have been verified. That is, you have to verify the signature in peer's certificate, the hostname in the certificate, and expiration dates. Just after this step you should treat the connection as being a secure one.

```

/* This example code is placed in the public domain. */

#ifdef HAVE_CONFIG_H
#include <config.h>
#endif

#include <stdio.h>
#include <stdlib.h>
#include <string.h>
#include <gnutls/gnutls.h>
#include <gnutls/x509.h>
#include "examples.h"

/* A very basic TLS client, with X.509 authentication and server certificate
 * verification.
 */

#define MAX_BUF 1024
#define CAFILE "ca.pem"
#define MSG "GET / HTTP/1.0\r\n\r\n"

extern int tcp_connect (void);
extern void tcp_close (int sd);

/* This function will try to verify the peer's certificate, and
 * also check if the hostname matches, and the activation, expiration dates.
 */

```

```
static int
verify_certificate_callback (gnutls_session_t session)
{
    unsigned int status;
    const gnutls_datum_t *cert_list;
    unsigned int cert_list_size;
    int ret;
    gnutls_x509_cert_t cert;
    const char *hostname;

    /* read hostname */
    hostname = gnutls_session_get_ptr (session);

    /* This verification function uses the trusted CAs in the credentials
     * structure.  So you must have installed one or more CA certificates.
     */
    ret = gnutls_certificate_verify_peers2 (session, &status);
    if (ret < 0)
    {
        printf ("Error\n");
        return GNUTLS_E_CERTIFICATE_ERROR;
    }

    if (status & GNUTLS_CERT_INVALID)
        printf ("The certificate is not trusted.\n");

    if (status & GNUTLS_CERT_SIGNER_NOT_FOUND)
        printf ("The certificate hasn't got a known issuer.\n");

    if (status & GNUTLS_CERT_REVOKED)
        printf ("The certificate has been revoked.\n");

    if (status & GNUTLS_CERT_EXPIRED)
        printf ("The certificate has expired\n");

    if (status & GNUTLS_CERT_NOT_ACTIVATED)
        printf ("The certificate is not yet activated\n");

    /* Up to here the process is the same for X.509 certificates and
     * OpenPGP keys.  From now on X.509 certificates are assumed.  This can
     * be easily extended to work with openpgp keys as well.
     */
    if (gnutls_certificate_type_get (session) != GNUTLS_CERT_X509)
        return GNUTLS_E_CERTIFICATE_ERROR;

    if (gnutls_x509_cert_init (&cert) < 0)
    {
```

```
        printf ("error in initialization\n");
        return GNUTLS_E_CERTIFICATE_ERROR;
    }

    cert_list = gnutls_certificate_get_peers (session, &cert_list_size);
    if (cert_list == NULL)
    {
        printf ("No certificate was found!\n");
        return GNUTLS_E_CERTIFICATE_ERROR;
    }

    /* This is not a real world example, since we only check the first
     * certificate in the given chain.
     */
    if (gnutls_x509_cert_import (cert, &cert_list[0], GNUTLS_X509_FMT_DER) < 0)
    {
        printf ("error parsing certificate\n");
        return GNUTLS_E_CERTIFICATE_ERROR;
    }

    if (!gnutls_x509_cert_check_hostname (cert, hostname))
    {
        printf ("The certificate's owner does not match hostname '%s'\n",
                hostname);
        return GNUTLS_E_CERTIFICATE_ERROR;
    }

    gnutls_x509_cert_deinit (cert);

    /* notify gnutls to continue handshake normally */
    return 0;
}

int
main (void)
{
    int ret, sd, ii;
    gnutls_session_t session;
    char buffer[MAX_BUF + 1];
    const char *err;
    gnutls_certificate_credentials_t xcred;

    gnutls_global_init ();

    /* X509 stuff */
```

```
gnutls_certificate_allocate_credentials (&xcred);

/* sets the trusted cas file
 */
gnutls_certificate_set_x509_trust_file (xcred, CAFILE, GNUTLS_X509_FMT_PEM);
gnutls_certificate_set_verify_function (xcred, verify_certificate_callback);
gnutls_certificate_set_verify_flags (xcred,
                                     GNUTLS_VERIFY_ALLOW_X509_V1_CA_CRT);

/* Initialize TLS session
 */
gnutls_init (&session, GNUTLS_CLIENT);

gnutls_session_set_ptr (session, (void *) "my_host_name");

/* Use default priorities */
ret = gnutls_priority_set_direct (session, "PERFORMANCE", &err);
if (ret < 0)
{
    if (ret == GNUTLS_E_INVALID_REQUEST)
    {
        fprintf (stderr, "Syntax error at: %s\n", err);
    }
    exit (1);
}

/* put the x509 credentials to the current session
 */
gnutls_credentials_set (session, GNUTLS_CRD_CERTIFICATE, xcred);

/* connect to the peer
 */
sd = tcp_connect ();

gnutls_transport_set_ptr (session, (gnutls_transport_ptr_t) sd);

/* Perform the TLS handshake
 */
ret = gnutls_handshake (session);

if (ret < 0)
{
    fprintf (stderr, "*** Handshake failed\n");
    gnutls_perror (ret);
    goto end;
}
else
```

```

    {
        printf ("- Handshake was completed\n");
    }

    gnutls_record_send (session, MSG, strlen (MSG));

    ret = gnutls_record_recv (session, buffer, MAX_BUF);
    if (ret == 0)
    {
        printf ("- Peer has closed the TLS connection\n");
        goto end;
    }
    else if (ret < 0)
    {
        fprintf (stderr, "*** Error:  %s\n", gnutls_strerror (ret));
        goto end;
    }

    printf ("- Received %d bytes:  ", ret);
    for (ii = 0; ii < ret; ii++)
    {
        fputc (buffer[ii], stdout);
    }
    fputs ("\n", stdout);

    gnutls_bye (session, GNUTLS_SHUT_RDWR);

end:

    tcp_close (sd);

    gnutls_deinit (session);

    gnutls_certificate_free_credentials (xcred);

    gnutls_global_deinit ();

    return 0;
}

```

6.2.6 Using a callback to select the certificate to use

There are cases where a client holds several certificate and key pairs, and may not want to load all of them in the credentials structure. The following example demonstrates the use of the certificate selection callback.

```
/* This example code is placed in the public domain. */
```

```
#ifndef HAVE_CONFIG_H
#include <config.h>
#endif

#include <stdio.h>
#include <stdlib.h>
#include <string.h>
#include <sys/types.h>
#include <sys/socket.h>
#include <arpa/inet.h>
#include <unistd.h>
#include <gnutls/gnutls.h>
#include <gnutls/x509.h>
#include <gnutls/abstract.h>
#include <sys/types.h>
#include <sys/stat.h>
#include <fcntl.h>

/* A TLS client that loads the certificate and key.
 */

#define MAX_BUF 1024
#define MSG "GET / HTTP/1.0\r\n\r\n"

#define CERT_FILE "cert.pem"
#define KEY_FILE "key.pem"
#define CAFILE "ca.pem"

extern int tcp_connect (void);
extern void tcp_close (int sd);

static int
cert_callback (gnutls_session_t session,
               const gnutls_datum_t * req_ca_rdn, int nreqs,
               const gnutls_pk_algorithm_t * sign_algos,
               int sign_algos_length, gnutls_pcert_st ** pcert,
               unsigned int *pcert_length, gnutls_privkey_t * pkey);

gnutls_pcert_st crt;
gnutls_privkey_t key;

/* Helper functions to load a certificate and key
 * files into memory.
 */
static gnutls_datum_t
load_file (const char *file)
{
```

```
FILE *f;
gnutls_datum_t loaded_file = { NULL, 0 };
long filelen;
void *ptr;

if (!(f = fopen (file, "r"))
    || fseek (f, 0, SEEK_END) != 0
    || (filelen = ftell (f)) < 0
    || fseek (f, 0, SEEK_SET) != 0
    || !(ptr = malloc ((size_t) filelen))
    || fread (ptr, 1, (size_t) filelen, f) < (size_t) filelen)
{
    return loaded_file;
}

loaded_file.data = ptr;
loaded_file.size = (unsigned int) filelen;
return loaded_file;
}

static void
unload_file (gnutls_datum_t data)
{
    free (data.data);
}

/* Load the certificate and the private key.
*/
static void
load_keys (void)
{
    int ret;
    gnutls_datum_t data;
    gnutls_x509_privkey_t x509_key;

    data = load_file (CERT_FILE);
    if (data.data == NULL)
    {
        fprintf (stderr, "*** Error loading certificate file.\n");
        exit (1);
    }

    ret = gnutls_pcert_import_x509_raw (&crt, &data, GNUTLS_X509_FMT_PEM, 0);
    if (ret < 0)
    {
        fprintf (stderr, "*** Error loading certificate file: %s\n",
                gnutls_strerror (ret));
    }
}
```

```
        exit (1);
    }

    unload_file (data);

    data = load_file (KEY_FILE);
    if (data.data == NULL)
    {
        fprintf (stderr, "*** Error loading key file.\n");
        exit (1);
    }

    gnutls_x509_privkey_init (&x509_key);

    ret = gnutls_x509_privkey_import (x509_key, &data, GNUTLS_X509_FMT_PEM);
    if (ret < 0)
    {
        fprintf (stderr, "*** Error loading key file: %s\n",
                gnutls_strerror (ret));
        exit (1);
    }

    gnutls_privkey_init (&key);

    ret =
        gnutls_privkey_import_x509 (key, x509_key,
                                   GNUTLS_PRIVKEY_IMPORT_AUTO_RELEASE);
    if (ret < 0)
    {
        fprintf (stderr, "*** Error importing key: %s\n",
                gnutls_strerror (ret));
        exit (1);
    }

    unload_file (data);
}

int
main (void)
{
    int ret, sd, ii;
    gnutls_session_t session;
    gnutls_priority_t priorities_cache;
    char buffer[MAX_BUF + 1];
    gnutls_certificate_credentials_t xcred;
    /* Allow connections to servers that have OpenPGP keys as well.
    */
}
```

```
gnutls_global_init ();

load_keys ();

/* X509 stuff */
gnutls_certificate_allocate_credentials (&xcred);

/* priorities */
gnutls_priority_init (&priorities_cache, "NORMAL", NULL);

/* sets the trusted cas file
 */
gnutls_certificate_set_x509_trust_file (xcred, CAFILE, GNUTLS_X509_FMT_PEM);

gnutls_certificate_set_retrieve_function2 (xcred, cert_callback);

/* Initialize TLS session
 */
gnutls_init (&session, GNUTLS_CLIENT);

/* Use default priorities */
gnutls_priority_set (session, priorities_cache);

/* put the x509 credentials to the current session
 */
gnutls_credentials_set (session, GNUTLS_CRD_CERTIFICATE, xcred);

/* connect to the peer
 */
sd = tcp_connect ();

gnutls_transport_set_ptr (session, (gnutls_transport_ptr_t) sd);

/* Perform the TLS handshake
 */
ret = gnutls_handshake (session);

if (ret < 0)
{
    fprintf (stderr, "*** Handshake failed\n");
    gnutls_perror (ret);
    goto end;
}
else
{
```

```

    printf ("- Handshake was completed\n");
}

gnutls_record_send (session, MSG, strlen (MSG));

ret = gnutls_record_recv (session, buffer, MAX_BUF);
if (ret == 0)
{
    printf ("- Peer has closed the TLS connection\n");
    goto end;
}
else if (ret < 0)
{
    fprintf (stderr, "*** Error:  %s\n", gnutls_strerror (ret));
    goto end;
}

printf ("- Received %d bytes:  ", ret);
for (ii = 0; ii < ret; ii++)
{
    fputc (buffer[ii], stdout);
}
fputs ("\n", stdout);

gnutls_bye (session, GNUTLS_SHUT_RDWR);

end:

tcp_close (sd);

gnutls_deinit (session);

gnutls_certificate_free_credentials (xcred);
gnutls_priority_deinit (priorities_cache);

gnutls_global_deinit ();

return 0;
}

/* This callback should be associated with a session by calling
 * gnutls_certificate_client_set_retrieve_function( session, cert_callback),
 * before a handshake.
 */

```

```
static int
cert_callback (gnutls_session_t session,
               const gnutls_datum_t * req_ca_rdn, int nreqs,
               const gnutls_pk_algorithm_t * sign_algos,
               int sign_algos_length, gnutls_pcert_st ** pcert,
               unsigned int *pcert_length, gnutls_privkey_t * pkey)
{
    char issuer_dn[256];
    int i, ret;
    size_t len;
    gnutls_certificate_type_t type;

    /* Print the server's trusted CAs
     */
    if (nreqs > 0)
        printf ("- Server's trusted authorities:\n");
    else
        printf ("- Server did not send us any trusted authorities names.\n");

    /* print the names (if any) */
    for (i = 0; i < nreqs; i++)
    {
        len = sizeof (issuer_dn);
        ret = gnutls_x509_rdn_get (&req_ca_rdn[i], issuer_dn, &len);
        if (ret >= 0)
        {
            printf (" [%d]: ", i);
            printf ("%s\n", issuer_dn);
        }
    }

    /* Select a certificate and return it.
     * The certificate must be of any of the "sign algorithms"
     * supported by the server.
     */
    type = gnutls_certificate_type_get (session);
    if (type == GNUTLS_CERT_X509)
    {
        *pcert_length = 1;
        *pcert = &crt;
        *pkey = key;
    }
    else
    {
        return -1;
    }
}
```

```

    return 0;
}

```

6.2.7 Verifying a certificate

An example is listed below which uses the high level verification functions to verify a given certificate list.

```

/* This example code is placed in the public domain. */

#ifdef HAVE_CONFIG_H
#include <config.h>
#endif

#include <stdio.h>
#include <stdlib.h>
#include <string.h>
#include <gnutls/gnutls.h>
#include <gnutls/x509.h>

#include "examples.h"

/* All the available CRLs
 */
gnutls_x509_crl_t *crl_list;
int crl_list_size;

/* All the available trusted CAs
 */
gnutls_x509_cert_t *ca_list;
int ca_list_size;

static int print_details_func (gnutls_x509_cert_t cert,
                              gnutls_x509_cert_t issuer,
                              gnutls_x509_crl_t crl,
                              unsigned int verification_output);

/* This function will try to verify the peer's certificate chain, and
 * also check if the hostname matches.
 */
void
verify_certificate_chain (const char *hostname,
                        const gnutls_datum_t * cert_chain,
                        int cert_chain_length)
{
    int i;
    gnutls_x509_trust_list_t tlist;

```

```
gnutls_x509_cert_t *cert;

unsigned int output;

/* Initialize the trusted certificate list. This should be done
 * once on initialization. gnutls_x509_cert_list_import2() and
 * gnutls_x509_crl_list_import2() can be used to load them.
 */
gnutls_x509_trust_list_init (&tlist, 0);

gnutls_x509_trust_list_add_cas (tlist, ca_list, ca_list_size, 0);
gnutls_x509_trust_list_add_crls (tlist, crl_list, crl_list_size,
                                GNUTLS_TL_VERIFY_CRL, 0);

cert = malloc (sizeof (*cert) * cert_chain_length);

/* Import all the certificates in the chain to
 * native certificate format.
 */
for (i = 0; i < cert_chain_length; i++)
    {
        gnutls_x509_cert_init (&cert[i]);
        gnutls_x509_cert_import (cert[i], &cert_chain[i], GNUTLS_X509_FMT_DER);
    }

gnutls_x509_trust_list_verify_named_cert (tlist, cert[0], hostname,
                                          strlen (hostname),
                                          GNUTLS_VERIFY_DISABLE_CRL_CHECKS,
                                          &output, print_details_func);

/* if this certificate is not explicitly trusted verify against CAs
 */
if (output != 0)
    {
        gnutls_x509_trust_list_verify_cert (tlist, cert, cert_chain_length, 0,
                                             &output, print_details_func);
    }

if (output & GNUTLS_CERT_INVALID)
    {
        fprintf (stderr, "Not trusted");

        if (output & GNUTLS_CERT_SIGNER_NOT_FOUND)
            fprintf (stderr, ": no issuer was found");
        if (output & GNUTLS_CERT_SIGNER_NOT_CA)
            fprintf (stderr, ": issuer is not a CA");
        if (output & GNUTLS_CERT_NOT_ACTIVATED)
```

```

        fprintf (stderr, ": not yet activated\n");
    if (output & GNUTLS_CERT_EXPIRED)
        fprintf (stderr, ": expired\n");

    fprintf (stderr, "\n");
}
else
    fprintf (stderr, "Trusted\n");

/* Check if the name in the first certificate matches our destination!
*/
if (!gnutls_x509_cert_check_hostname (cert[0], hostname))
{
    printf ("The certificate's owner does not match hostname '%s'\n",
           hostname);
}

gnutls_x509_trust_list_deinit (tlist, 1);

return;
}

static int
print_details_func (gnutls_x509_cert_t cert,
                   gnutls_x509_cert_t issuer, gnutls_x509_crl_t crl,
                   unsigned int verification_output)
{
    char name[512];
    char issuer_name[512];
    size_t name_size;
    size_t issuer_name_size;

    issuer_name_size = sizeof (issuer_name);
    gnutls_x509_cert_get_issuer_dn (cert, issuer_name, &issuer_name_size);

    name_size = sizeof (name);
    gnutls_x509_cert_get_dn (cert, name, &name_size);

    fprintf (stdout, "\tSubject:  %s\n", name);
    fprintf (stdout, "\tIssuer:   %s\n", issuer_name);

    if (issuer != NULL)
    {
        issuer_name_size = sizeof (issuer_name);
        gnutls_x509_cert_get_dn (issuer, issuer_name, &issuer_name_size);

        fprintf (stdout, "\tVerified against:  %s\n", issuer_name);
    }
}

```

```

    }

    if (crl != NULL)
    {
        issuer_name_size = sizeof (issuer_name);
        gnutls_x509_crl_get_issuer_dn (crl, issuer_name, &issuer_name_size);

        fprintf (stdout, "\tVerified against CRL of: %s\n", issuer_name);
    }

    fprintf (stdout, "\tVerification output: %x\n\n", verification_output);

    return 0;
}

```

6.2.8 Using a PKCS #11 token with TLS

This example will demonstrate how to load keys and certificates from a PKCS #11 token, and use it with a TLS connection.

```
/* This example code is placed in the public domain. */
```

```

#ifdef HAVE_CONFIG_H
#include <config.h>
#endif

```

```
#include <getpass.h>
```

```

#include <stdio.h>
#include <stdlib.h>
#include <string.h>
#include <sys/types.h>
#include <sys/socket.h>
#include <arpa/inet.h>
#include <unistd.h>
#include <gnutls/gnutls.h>
#include <gnutls/x509.h>
#include <gnutls/pkcs11.h>
#include <sys/types.h>
#include <sys/stat.h>
#include <fcntl.h>

```

```

/* A TLS client that loads the certificate and key.
*/

```

```

#define MAX_BUF 1024
#define MSG "GET / HTTP/1.0\r\n\r\n"
#define MIN(x,y) (((x)<(y))?(x):(y))

```

```
#define CAFILE "ca.pem"
#define KEY_URL "pkcs11:manufacturer=SomeManufacturer;object=Private%20Key" \
    ";objecttype=private;id=db:5b:3e:b5:72:33"
#define CERT_URL "pkcs11:manufacturer=SomeManufacturer;object=Certificate;" \
    "objecttype=cert;id=db:5b:3e:b5:72:33"

extern int tcp_connect (void);
extern void tcp_close (int sd);

static int cert_callback (gnutls_session_t session,
                          const gnutls_datum_t * req_ca_rdn, int nreqs,
                          const gnutls_pk_algorithm_t * sign_algos,
                          int sign_algos_length, gnutls_retr2_st * st);

gnutls_x509_cert_t crt;
gnutls_pkcs11_privkey_t key;

/* Load the certificate and the private key.
 */
static void
load_keys (void)
{
    int ret;

    gnutls_x509_cert_init (&crt);

    ret = gnutls_x509_cert_import_pkcs11_url (crt, CERT_URL, 0);

    /* some tokens require login to read data */
    if (ret == GNUTLS_E_REQUESTED_DATA_NOT_AVAILABLE)
        ret = gnutls_x509_cert_import_pkcs11_url (crt, CERT_URL,
                                                  GNUTLS_PKCS11_OBJ_FLAG_LOGIN);

    if (ret < 0)
    {
        fprintf (stderr, "*** Error loading key file: %s\n",
                gnutls_strerror (ret));
        exit (1);
    }

    gnutls_pkcs11_privkey_init (&key);

    ret = gnutls_pkcs11_privkey_import_url (key, KEY_URL, 0);
    if (ret < 0)
    {
        fprintf (stderr, "*** Error loading key file: %s\n",
```

```

        gnutls_strerror (ret));
    exit (1);
}

}

static int
pin_callback (void *user, int attempt, const char *token_url,
              const char *token_label, unsigned int flags, char *pin,
              size_t pin_max)
{
    const char *password;
    int len;

    printf ("PIN required for token '%s' with URL '%s'\n", token_label,
            token_url);
    if (flags & GNUTLS_PKCS11_PIN_FINAL_TRY)
        printf ("*** This is the final try before locking!\n");
    if (flags & GNUTLS_PKCS11_PIN_COUNT_LOW)
        printf ("*** Only few tries left before locking!\n");

    password = getpass ("Enter pin: ");
    if (password == NULL || password[0] == 0)
    {
        fprintf (stderr, "No password given\n");
        exit (1);
    }

    len = MIN (pin_max, strlen (password));
    memcpy (pin, password, len);
    pin[len] = 0;

    return 0;
}

int
main (void)
{
    int ret, sd, ii;
    gnutls_session_t session;
    gnutls_priority_t priorities_cache;
    char buffer[MAX_BUF + 1];
    gnutls_certificate_credentials_t xcred;
    /* Allow connections to servers that have OpenPGP keys as well.
     */

    gnutls_global_init ();

```

```
/* PKCS11 private key operations might require PIN.
 * Register a callback.
 */
gnutls_pkcs11_set_pin_function (pin_callback, NULL);

load_keys ();

/* X509 stuff */
gnutls_certificate_allocate_credentials (&xcred);

/* priorities */
gnutls_priority_init (&priorities_cache, "NORMAL", NULL);

/* sets the trusted cas file
 */
gnutls_certificate_set_x509_trust_file (xcred, CAFILE, GNUTLS_X509_FMT_PEM);

gnutls_certificate_set_retrieve_function (xcred, cert_callback);

/* Initialize TLS session
 */
gnutls_init (&session, GNUTLS_CLIENT);

/* Use default priorities */
gnutls_priority_set (session, priorities_cache);

/* put the x509 credentials to the current session
 */
gnutls_credentials_set (session, GNUTLS_CRD_CERTIFICATE, xcred);

/* connect to the peer
 */
sd = tcp_connect ();

gnutls_transport_set_ptr (session, (gnutls_transport_ptr_t) sd);

/* Perform the TLS handshake
 */
ret = gnutls_handshake (session);

if (ret < 0)
{
    fprintf (stderr, "*** Handshake failed\n");
    gnutls_perror (ret);
    goto end;
}
```

```
else
{
    printf ("- Handshake was completed\n");
}

gnutls_record_send (session, MSG, strlen (MSG));

ret = gnutls_record_recv (session, buffer, MAX_BUF);
if (ret == 0)
{
    printf ("- Peer has closed the TLS connection\n");
    goto end;
}
else if (ret < 0)
{
    fprintf (stderr, "*** Error: %s\n", gnutls_strerror (ret));
    goto end;
}

printf ("- Received %d bytes: ", ret);
for (ii = 0; ii < ret; ii++)
{
    fputc (buffer[ii], stdout);
}
fputs ("\n", stdout);

gnutls_bye (session, GNUTLS_SHUT_RDWR);

end:

tcp_close (sd);

gnutls_deinit (session);

gnutls_certificate_free_credentials (xcred);
gnutls_priority_deinit (priorities_cache);

gnutls_global_deinit ();

return 0;
}

/* This callback should be associated with a session by calling
 * gnutls_certificate_client_set_retrieve_function( session, cert_callback),
 * before a handshake.
```

```

*/

static int
cert_callback (gnutls_session_t session,
               const gnutls_datum_t * req_ca_rdn, int nreqs,
               const gnutls_pk_algorithm_t * sign_algos,
               int sign_algos_length, gnutls_retr2_st * st)
{
    char issuer_dn[256];
    int i, ret;
    size_t len;
    gnutls_certificate_type_t type;

    /* Print the server's trusted CAs
    */
    if (nreqs > 0)
        printf ("- Server's trusted authorities:\n");
    else
        printf ("- Server did not send us any trusted authorities names.\n");

    /* print the names (if any) */
    for (i = 0; i < nreqs; i++)
    {
        len = sizeof (issuer_dn);
        ret = gnutls_x509_rdn_get (&req_ca_rdn[i], issuer_dn, &len);
        if (ret >= 0)
        {
            printf (" [%d]: ", i);
            printf ("%s\n", issuer_dn);
        }
    }

    /* Select a certificate and return it.
    * The certificate must be of any of the "sign algorithms"
    * supported by the server.
    */

    type = gnutls_certificate_type_get (session);
    if (type == GNUTLS_CERT_X509)
    {
        /* check if the certificate we are sending is signed
        * with an algorithm that the server accepts */
        gnutls_sign_algorithm_t cert_algo, req_algo;
        int i, match = 0;

        ret = gnutls_x509_cert_get_signature_algorithm (crt);
        if (ret < 0)

```

```
    {
        /* error reading signature algorithm
        */
        return -1;
    }
cert_algo = ret;

i = 0;
do
    {
        ret = gnutls_sign_algorithm_get_requested (session, i, &req_algo);
        if (ret >= 0 && cert_algo == req_algo)
            {
                match = 1;
                break;
            }

        /* server has not requested anything specific */
        if (i == 0 && ret == GNUTLS_E_REQUESTED_DATA_NOT_AVAILABLE)
            {
                match = 1;
                break;
            }
        i++;
    }
while (ret >= 0);

if (match == 0)
    {
        printf
            ("- Could not find a suitable certificate to send to server\n");
        return -1;
    }

st->cert_type = type;
st->ncerts = 1;

st->cert.x509 = &crt;
st->key.pkcs11 = key;
st->key_type = GNUTLS_PRIVKEY_PKCS11;

st->deinit_all = 0;
}
else
    {
        return -1;
    }
}
```

```

    return 0;
}

```

6.2.9 Client with resume capability example

This is a modification of the simple client example. Here we demonstrate the use of session resumption. The client tries to connect once using TLS, close the connection and then try to establish a new connection using the previously negotiated data.

```

/* This example code is placed in the public domain. */

#ifdef HAVE_CONFIG_H
#include <config.h>
#endif

#include <string.h>
#include <stdio.h>
#include <stdlib.h>
#include <gnutls/gnutls.h>

/* Those functions are defined in other examples.
*/
extern void check_alert (gnutls_session_t session, int ret);
extern int tcp_connect (void);
extern void tcp_close (int sd);

#define MAX_BUF 1024
#define CAFILE "ca.pem"
#define MSG "GET / HTTP/1.0\r\n\r\n"

int
main (void)
{
    int ret;
    int sd, ii;
    gnutls_session_t session;
    char buffer[MAX_BUF + 1];
    gnutls_certificate_credentials_t xcred;

    /* variables used in session resuming
    */
    int t;
    char *session_data = NULL;
    size_t session_data_size = 0;

    gnutls_global_init ();

```

```
/* X509 stuff */
gnutls_certificate_allocate_credentials (&xcred);

gnutls_certificate_set_x509_trust_file (xcred, CAFILE, GNUTLS_X509_FMT_PEM);

for (t = 0; t < 2; t++)
{
    /* connect 2 times to the server */

    sd = tcp_connect ();

    gnutls_init (&session, GNUTLS_CLIENT);

    gnutls_priority_set_direct (session, "PERFORMANCE:!ARCFOUR-128", NULL);

    gnutls_credentials_set (session, GNUTLS_CRD_CERTIFICATE, xcred);

    if (t > 0)
    {
        /* if this is not the first time we connect */
        gnutls_session_set_data (session, session_data, session_data_size);
        free (session_data);
    }

    gnutls_transport_set_ptr (session, (gnutls_transport_ptr_t) sd);

    /* Perform the TLS handshake
    */
    ret = gnutls_handshake (session);

    if (ret < 0)
    {
        fprintf (stderr, "*** Handshake failed\n");
        gnutls_perror (ret);
        goto end;
    }
    else
    {
        printf ("- Handshake was completed\n");
    }

    if (t == 0)
    {
        /* the first time we connect */
        /* get the session data size */
        gnutls_session_get_data (session, NULL, &session_data_size);
        session_data = malloc (session_data_size);
    }
}
```

```

        /* put session data to the session variable */
        gnutls_session_get_data (session, session_data, &session_data_size);

    }
else
    {
        /* the second time we connect */

        /* check if we actually resumed the previous session */
        if (gnutls_session_is_resumed (session) != 0)
            {
                printf ("- Previous session was resumed\n");
            }
        else
            {
                fprintf (stderr, "*** Previous session was NOT resumed\n");
            }
    }

/* This function was defined in a previous example
*/
/* print_info(session); */

gnutls_record_send (session, MSG, strlen (MSG));

ret = gnutls_record_recv (session, buffer, MAX_BUF);
if (ret == 0)
    {
        printf ("- Peer has closed the TLS connection\n");
        goto end;
    }
else if (ret < 0)
    {
        fprintf (stderr, "*** Error: %s\n", gnutls_strerror (ret));
        goto end;
    }

printf ("- Received %d bytes: ", ret);
for (ii = 0; ii < ret; ii++)
    {
        fputc (buffer[ii], stdout);
    }
fputs ("\n", stdout);

gnutls_bye (session, GNUTLS_SHUT_RDWR);

end:

```

```

        tcp_close (sd);

        gnutls_deinit (session);

    }                               /* for() */

    gnutls_certificate_free_credentials (xcred);

    gnutls_global_deinit ();

    return 0;
}

```

6.2.10 Simple client example with SRP authentication

The following client is a very simple SRP TLS client which connects to a server and authenticates using a *username* and a *password*. The server may authenticate itself using a certificate, and in that case it has to be verified.

```

/* This example code is placed in the public domain. */

#ifdef HAVE_CONFIG_H
#include <config.h>
#endif

#include <stdio.h>
#include <stdlib.h>
#include <string.h>
#include <gnutls/gnutls.h>
#include <gnutls/extra.h>

/* Those functions are defined in other examples.
*/
extern void check_alert (gnutls_session_t session, int ret);
extern int tcp_connect (void);
extern void tcp_close (int sd);

#define MAX_BUF 1024
#define USERNAME "user"
#define PASSWORD "pass"
#define CAFILE "ca.pem"
#define MSG "GET / HTTP/1.0\r\n\r\n"

int
main (void)
{
    int ret;
    int sd, ii;

```

```
gnutls_session_t session;
char buffer[MAX_BUF + 1];
gnutls_srp_client_credentials_t srp_cred;
gnutls_certificate_credentials_t cert_cred;

gnutls_global_init ();

gnutls_srp_allocate_client_credentials (&srp_cred);
gnutls_certificate_allocate_credentials (&cert_cred);

gnutls_certificate_set_x509_trust_file (cert_cred, CAFILE,
                                       GNUTLS_X509_FMT_PEM);
gnutls_srp_set_client_credentials (srp_cred, USERNAME, PASSWORD);

/* connects to server
 */
sd = tcp_connect ();

/* Initialize TLS session
 */
gnutls_init (&session, GNUTLS_CLIENT);

/* Set the priorities.
 */
gnutls_priority_set_direct (session, "NORMAL:+SRP:+SRP-RSA:+SRP-DSS", NULL);

/* put the SRP credentials to the current session
 */
gnutls_credentials_set (session, GNUTLS_CRD_SRP, srp_cred);
gnutls_credentials_set (session, GNUTLS_CRD_CERTIFICATE, cert_cred);

gnutls_transport_set_ptr (session, (gnutls_transport_ptr_t) sd);

/* Perform the TLS handshake
 */
ret = gnutls_handshake (session);

if (ret < 0)
{
    fprintf (stderr, "*** Handshake failed\n");
    gnutls_perror (ret);
    goto end;
}
else
{
    printf ("- Handshake was completed\n");
}
```

```
    }

    gnutls_record_send (session, MSG, strlen (MSG));

    ret = gnutls_record_recv (session, buffer, MAX_BUF);
    if (gnutls_error_is_fatal (ret) == 1 || ret == 0)
    {
        if (ret == 0)
        {
            printf ("- Peer has closed the GnuTLS connection\n");
            goto end;
        }
        else
        {
            fprintf (stderr, "*** Error: %s\n", gnutls_strerror (ret));
            goto end;
        }
    }
    else
        check_alert (session, ret);

    if (ret > 0)
    {
        printf ("- Received %d bytes: ", ret);
        for (ii = 0; ii < ret; ii++)
        {
            fputc (buffer[ii], stdout);
        }
        fputs ("\n", stdout);
    }
    gnutls_bye (session, GNUTLS_SHUT_RDWR);

end:

    tcp_close (sd);

    gnutls_deinit (session);

    gnutls_srp_free_client_credentials (srp_cred);
    gnutls_certificate_free_credentials (cert_cred);

    gnutls_global_deinit ();

    return 0;
}
```

6.2.11 Simple client example using the C++ API

The following client is a simple example of a client utilizing the GnuTLS C++ API.

```
#include <config.h>
#include <iostream>
#include <stdexcept>
#include <gnutls/gnutls.h>
#include <gnutls/gnutlsxx.h>
#include <cstring> /* for strlen */

/* A very basic TLS client, with anonymous authentication.
 * written by Eduardo Villanueva Che.
 */

#define MAX_BUF 1024
#define SA struct sockaddr

#define CAFILE "ca.pem"
#define MSG "GET / HTTP/1.0\r\n\r\n"

extern "C"
{
    int tcp_connect(void);
    void tcp_close(int sd);
}

int main(void)
{
    int sd = -1;
    gnutls_global_init();

    try
    {
        /* Allow connections to servers that have OpenPGP keys as well.
         */
        gnutls::client_session session;

        /* X509 stuff */
        gnutls::certificate_credentials credentials;

        /* sets the trusted cas file
         */
        credentials.set_x509_trust_file(CAFILE, GNUTLS_X509_FMT_PEM);
        /* put the x509 credentials to the current session
```

```
    */
    session.set_credentials(credentials);

    /* Use default priorities */
    session.set_priority ("NORMAL", NULL);

    /* connect to the peer
    */
    sd = tcp_connect();
    session.set_transport_ptr((gnutls_transport_ptr_t) sd);

    /* Perform the TLS handshake
    */
    int ret = session.handshake();
    if (ret < 0)
    {
        throw std::runtime_error("Handshake failed");
    }
    else
    {
        std::cout << "- Handshake was completed" << std::endl;
    }

    session.send(MSG, strlen(MSG));
    char buffer[MAX_BUF + 1];
    ret = session.recv(buffer, MAX_BUF);
    if (ret == 0)
    {
        throw std::runtime_error("Peer has closed the TLS connection");
    }
    else if (ret < 0)
    {
        throw std::runtime_error(gnutls_strerror(ret));
    }

    std::cout << "- Received " << ret << " bytes:" << std::endl;
    std::cout.write(buffer, ret);
    std::cout << std::endl;

    session.bye(GNUTLS_SHUT_RDWR);
}
catch (std::exception &ex)
{
    std::cerr << "Exception caught: " << ex.what() << std::endl;
}

if (sd != -1)
```

```

        tcp_close(sd);

    gnutls_global_deinit();

    return 0;
}

```

6.2.12 Helper function for TCP connections

This helper function abstracts away TCP connection handling from the other examples. It is required to build some examples.

```

/* This example code is placed in the public domain. */

#ifdef HAVE_CONFIG_H
#include <config.h>
#endif

#include <stdio.h>
#include <stdlib.h>
#include <string.h>
#include <sys/types.h>
#include <sys/socket.h>
#include <arpa/inet.h>
#include <netinet/in.h>
#include <unistd.h>

#define SA struct sockaddr

/* tcp.c */
int tcp_connect (void);
void tcp_close (int sd);

/* Connects to the peer and returns a socket
 * descriptor.
 */
extern int
tcp_connect (void)
{
    const char *PORT = "5556";
    const char *SERVER = "127.0.0.1";
    int err, sd;
    struct sockaddr_in sa;

    /* connects to server
     */
    sd = socket (AF_INET, SOCK_STREAM, 0);

```

```

memset (&sa, '\0', sizeof (sa));
sa.sin_family = AF_INET;
sa.sin_port = htons (atoi (PORT));
inet_pton (AF_INET, SERVER, &sa.sin_addr);

err = connect (sd, (SA *) & sa, sizeof (sa));
if (err < 0)
{
    fprintf (stderr, "Connect error\n");
    exit (1);
}

return sd;
}

/* closes the given socket descriptor.
*/
extern void
tcp_close (int sd)
{
    shutdown (sd, SHUT_RDWR);    /* no more receptions */
    close (sd);
}

```

6.3 Server examples

This section contains examples of TLS and SSL servers, using GnuTLS.

6.3.1 Echo server with X.509 authentication

This example is a very simple echo server which supports X.509 authentication, using the RSA ciphersuites.

```

/* This example code is placed in the public domain. */

#ifdef HAVE_CONFIG_H
#include <config.h>
#endif

#include <stdio.h>
#include <stdlib.h>
#include <errno.h>
#include <sys/types.h>
#include <sys/socket.h>
#include <arpa/inet.h>
#include <netinet/in.h>
#include <string.h>
#include <unistd.h>
#include <gnutls/gnutls.h>

```

```
#define KEYFILE "key.pem"
#define CERTFILE "cert.pem"
#define CAFILE "ca.pem"
#define CRLFILE "crl.pem"

/* This is a sample TLS 1.0 echo server, using X.509 authentication.
*/

#define SA struct sockaddr
#define SOCKET_ERR(err,s) if(err==-1) {perror(s);return(1);}
#define MAX_BUF 1024
#define PORT 5556 /* listen to 5556 port */
#define DH_BITS 1024

/* These are global */
gnutls_certificate_credentials_t x509_cred;
gnutls_priority_t priority_cache;

static gnutls_session_t
initialize_tls_session (void)
{
    gnutls_session_t session;

    gnutls_init (&session, GNUTLS_SERVER);

    gnutls_priority_set (session, priority_cache);

    gnutls_credentials_set (session, GNUTLS_CRD_CERTIFICATE, x509_cred);

    /* request client certificate if any.
    */
    gnutls_certificate_server_set_request (session, GNUTLS_CERT_REQUEST);

    /* Set maximum compatibility mode. This is only suggested on public webservers
    * that need to trade security for compatibility
    */
    gnutls_session_enable_compatibility_mode (session);

    return session;
}

static gnutls_dh_params_t dh_params;

static int
generate_dh_params (void)
```

```
{

/* Generate Diffie-Hellman parameters - for use with DHE
 * kx algorithms.  When short bit length is used, it might
 * be wise to regenerate parameters.
 *
 * Check the ex-serv-export.c example for using static
 * parameters.
 */
gnutls_dh_params_init (&dh_params);
gnutls_dh_params_generate2 (dh_params, DH_BITS);

return 0;
}

int
main (void)
{
    int err, listen_sd;
    int sd, ret;
    struct sockaddr_in sa_serv;
    struct sockaddr_in sa_cli;
    int client_len;
    char topbuf[512];
    gnutls_session_t session;
    char buffer[MAX_BUF + 1];
    int optval = 1;

/* this must be called once in the program
 */
gnutls_global_init ();

gnutls_certificate_allocate_credentials (&x509_cred);
gnutls_certificate_set_x509_trust_file (x509_cred, CAFILE,
                                       GNUTLS_X509_FMT_PEM);

gnutls_certificate_set_x509_crl_file (x509_cred, CRLFILE,
                                       GNUTLS_X509_FMT_PEM);

gnutls_certificate_set_x509_key_file (x509_cred, CERTFILE, KEYFILE,
                                       GNUTLS_X509_FMT_PEM);

generate_dh_params ();

gnutls_priority_init (&priority_cache, "NORMAL", NULL);
```

```

gnutls_certificate_set_dh_params (x509_cred, dh_params);

/* Socket operations
 */
listen_sd = socket (AF_INET, SOCK_STREAM, 0);
SOCKET_ERR (listen_sd, "socket");

memset (&sa_serv, '\0', sizeof (sa_serv));
sa_serv.sin_family = AF_INET;
sa_serv.sin_addr.s_addr = INADDR_ANY;
sa_serv.sin_port = htons (PORT);      /* Server Port number */

setsockopt (listen_sd, SOL_SOCKET, SO_REUSEADDR, (void *) &optval,
            sizeof (int));

err = bind (listen_sd, (SA *) & sa_serv, sizeof (sa_serv));
SOCKET_ERR (err, "bind");
err = listen (listen_sd, 1024);
SOCKET_ERR (err, "listen");

printf ("Server ready.  Listening to port '%d'.\n\n", PORT);

client_len = sizeof (sa_cli);
for (;;)
{
    session = initialize_tls_session ();

    sd = accept (listen_sd, (SA *) & sa_cli, &client_len);

    printf ("- connection from %s, port %d\n",
            inet_ntop (AF_INET, &sa_cli.sin_addr, topbuf,
                      sizeof (topbuf)), ntohs (sa_cli.sin_port));

    gnutls_transport_set_ptr (session, (gnutls_transport_ptr_t) sd);
    ret = gnutls_handshake (session);
    if (ret < 0)
    {
        close (sd);
        gnutls_deinit (session);
        fprintf (stderr, "*** Handshake has failed (%s)\n\n",
                gnutls_strerror (ret));
        continue;
    }
    printf ("- Handshake was completed\n");

    /* see the Getting peer's information example */
    /* print_info(session); */
}

```

```
for (;;)
{
    memset (buffer, 0, MAX_BUF + 1);
    ret = gnutls_record_recv (session, buffer, MAX_BUF);

    if (ret == 0)
    {
        printf ("\n- Peer has closed the GnuTLS connection\n");
        break;
    }
    else if (ret < 0)
    {
        fprintf (stderr, "\n*** Received corrupted "
                "data(%d). Closing the connection.\n\n", ret);
        break;
    }
    else if (ret > 0)
    {
        /* echo data back to the client
        */
        gnutls_record_send (session, buffer, strlen (buffer));
    }
    }
printf ("\n");
/* do not wait for the peer to close the connection.
*/
gnutls_bye (session, GNUTLS_SHUT_WR);

close (sd);
gnutls_deinit (session);

}
close (listen_sd);

gnutls_certificate_free_credentials (x509_cred);
gnutls_priority_deinit (priority_cache);

gnutls_global_deinit ();

return 0;

}
```

6.3.2 Echo server with OpenPGP authentication

The following example is an echo server which supports OpenPGP key authentication. You can easily combine this functionality—that is have a server that supports both X.509 and OpenPGP certificates—but we separated them to keep these examples as simple as possible.

```

/* This example code is placed in the public domain. */

#ifdef HAVE_CONFIG_H
#include <config.h>
#endif

#include <stdio.h>
#include <stdlib.h>
#include <errno.h>
#include <sys/types.h>
#include <sys/socket.h>
#include <arpa/inet.h>
#include <netinet/in.h>
#include <string.h>
#include <unistd.h>
#include <gnutls/gnutls.h>
#include <gnutls/openpgp.h>

#define KEYFILE "secret.asc"
#define CERTFILE "public.asc"
#define RINGFILE "ring.gpg"

/* This is a sample TLS 1.0-OpenPGP echo server.
*/

#define SA struct sockaddr
#define SOCKET_ERR(err,s) if(err==-1) {perror(s);return(1);}
#define MAX_BUF 1024
#define PORT 5556 /* listen to 5556 port */
#define DH_BITS 1024

/* These are global */
gnutls_certificate_credentials_t cred;
gnutls_dh_params_t dh_params;

static int
generate_dh_params (void)
{
    /* Generate Diffie-Hellman parameters - for use with DHE
    * kx algorithms. These should be discarded and regenerated

```

```
    * once a day, once a week or once a month. Depending on the
    * security requirements.
    */
    gnutls_dh_params_init (&dh_params);
    gnutls_dh_params_generate2 (dh_params, DH_BITS);

    return 0;
}

static gnutls_session_t
initialize_tls_session (void)
{
    gnutls_session_t session;

    gnutls_init (&session, GNUTLS_SERVER);

    gnutls_priority_set_direct (session, "NORMAL", NULL);

    /* request client certificate if any.
    */
    gnutls_certificate_server_set_request (session, GNUTLS_CERT_REQUEST);

    gnutls_dh_set_prime_bits (session, DH_BITS);

    return session;
}

int
main (void)
{
    int err, listen_sd;
    int sd, ret;
    struct sockaddr_in sa_serv;
    struct sockaddr_in sa_cli;
    int client_len;
    char topbuf[512];
    gnutls_session_t session;
    char buffer[MAX_BUF + 1];
    int optval = 1;
    char name[256];

    strcpy (name, "Echo Server");

    /* this must be called once in the program
    */
    gnutls_global_init ();
```

```

gnutls_certificate_allocate_credentials (&cred);
gnutls_certificate_set_openpgp_keyring_file (cred, RINGFILE,
                                             GNUTLS_OPENPGP_FMT_BASE64);

gnutls_certificate_set_openpgp_key_file (cred, CERTFILE, KEYFILE,
                                         GNUTLS_OPENPGP_FMT_BASE64);

generate_dh_params ();

gnutls_certificate_set_dh_params (cred, dh_params);

/* Socket operations
*/
listen_sd = socket (AF_INET, SOCK_STREAM, 0);
SOCKET_ERR (listen_sd, "socket");

memset (&sa_serv, '\0', sizeof (sa_serv));
sa_serv.sin_family = AF_INET;
sa_serv.sin_addr.s_addr = INADDR_ANY;
sa_serv.sin_port = htons (PORT);      /* Server Port number */

setsockopt (listen_sd, SOL_SOCKET, SO_REUSEADDR, (void *) &optval,
           sizeof (int));

err = bind (listen_sd, (SA *) & sa_serv, sizeof (sa_serv));
SOCKET_ERR (err, "bind");
err = listen (listen_sd, 1024);
SOCKET_ERR (err, "listen");

printf ("%s ready. Listening to port '%d'.\n\n", name, PORT);

client_len = sizeof (sa_cli);
for (;;)
{
    session = initialize_tls_session ();

    sd = accept (listen_sd, (SA *) & sa_cli, &client_len);

    printf ("- connection from %s, port %d\n",
            inet_ntop (AF_INET, &sa_cli.sin_addr, topbuf,
                      sizeof (topbuf)), ntohs (sa_cli.sin_port));

    gnutls_transport_set_ptr (session, (gnutls_transport_ptr_t) sd);
    ret = gnutls_handshake (session);
    if (ret < 0)
    {
        close (sd);
    }
}

```

```

        gnutls_deinit (session);
        fprintf (stderr, "*** Handshake has failed (%s)\n\n",
                gnutls_strerror (ret));
        continue;
    }
    printf ("- Handshake was completed\n");

    /* see the Getting peer's information example */
    /* print_info(session); */

    for (;;)
    {
        memset (buffer, 0, MAX_BUF + 1);
        ret = gnutls_record_recv (session, buffer, MAX_BUF);

        if (ret == 0)
        {
            printf ("\n- Peer has closed the GnuTLS connection\n");
            break;
        }
        else if (ret < 0)
        {
            fprintf (stderr, "\n*** Received corrupted "
                    "data(%d). Closing the connection.\n\n", ret);
            break;
        }
        else if (ret > 0)
        {
            /* echo data back to the client
             */
            gnutls_record_send (session, buffer, strlen (buffer));
        }
    }
    printf ("\n");
    /* do not wait for the peer to close the connection.
     */
    gnutls_bye (session, GNUTLS_SHUT_WR);

    close (sd);
    gnutls_deinit (session);

}
close (listen_sd);

gnutls_certificate_free_credentials (cred);

gnutls_global_deinit ();

```

```

    return 0;
}

```

6.3.3 Echo server with SRP authentication

This is a server which supports SRP authentication. It is also possible to combine this functionality with a certificate server. Here it is separate for simplicity.

```

/* This example code is placed in the public domain. */

#ifdef HAVE_CONFIG_H
#include <config.h>
#endif

#include <stdio.h>
#include <stdlib.h>
#include <errno.h>
#include <sys/types.h>
#include <sys/socket.h>
#include <arpa/inet.h>
#include <netinet/in.h>
#include <string.h>
#include <unistd.h>
#include <gnutls/gnutls.h>
#include <gnutls/extra.h>

#define SRP_PASSWD "tpasswd"
#define SRP_PASSWD_CONF "tpasswd.conf"

#define KEYFILE "key.pem"
#define CERTFILE "cert.pem"
#define CAFILE "ca.pem"

/* This is a sample TLS-SRP echo server.
 */

#define SA struct sockaddr
#define SOCKET_ERR(err,s) if(err==-1) {perror(s);return(1);}
#define MAX_BUF 1024
#define PORT 5556 /* listen to 5556 port */

/* These are global */
gnutls_srp_server_credentials_t srp_cred;
gnutls_certificate_credentials_t cert_cred;

static gnutls_session_t

```



```

gnutls_certificate_set_x509_key_file (cert_cred, CERTFILE, KEYFILE,
                                     GNUTLS_X509_FMT_PEM);

/* TCP socket operations
 */
listen_sd = socket (AF_INET, SOCK_STREAM, 0);
SOCKET_ERR (listen_sd, "socket");

memset (&sa_serv, '\0', sizeof (sa_serv));
sa_serv.sin_family = AF_INET;
sa_serv.sin_addr.s_addr = INADDR_ANY;
sa_serv.sin_port = htons (PORT);      /* Server Port number */

setsockopt (listen_sd, SOL_SOCKET, SO_REUSEADDR, (void *) &optval,
           sizeof (int));

err = bind (listen_sd, (SA *) & sa_serv, sizeof (sa_serv));
SOCKET_ERR (err, "bind");
err = listen (listen_sd, 1024);
SOCKET_ERR (err, "listen");

printf ("%s ready.  Listening to port '%d'.\n\n", name, PORT);

client_len = sizeof (sa_cli);
for (;;)
{
    session = initialize_tls_session ();

    sd = accept (listen_sd, (SA *) & sa_cli, &client_len);

    printf ("- connection from %s, port %d\n",
           inet_ntop (AF_INET, &sa_cli.sin_addr, topbuf,
                    sizeof (topbuf)), ntohs (sa_cli.sin_port));

    gnutls_transport_set_ptr (session, (gnutls_transport_ptr_t) sd);
    ret = gnutls_handshake (session);
    if (ret < 0)
    {
        close (sd);
        gnutls_deinit (session);
        fprintf (stderr, "*** Handshake has failed (%s)\n\n",
                gnutls_strerror (ret));
        continue;
    }
    printf ("- Handshake was completed\n");

    /* print_info(session); */
}

```

```

for (;;)
{
    memset (buffer, 0, MAX_BUF + 1);
    ret = gnutls_record_recv (session, buffer, MAX_BUF);

    if (ret == 0)
    {
        printf ("\n- Peer has closed the GnuTLS connection\n");
        break;
    }
    else if (ret < 0)
    {
        fprintf (stderr, "\n*** Received corrupted "
                "data(%d). Closing the connection.\n\n", ret);
        break;
    }
    else if (ret > 0)
    {
        /* echo data back to the client
        */
        gnutls_record_send (session, buffer, strlen (buffer));
    }
    }
printf ("\n");
/* do not wait for the peer to close the connection. */
gnutls_bye (session, GNUTLS_SHUT_WR);

close (sd);
gnutls_deinit (session);

}
close (listen_sd);

gnutls_srp_free_server_credentials (srp_cred);
gnutls_certificate_free_credentials (cert_cred);

gnutls_global_deinit ();

return 0;

}

```

6.3.4 Echo Server with anonymous authentication

This example server support anonymous authentication, and could be used to serve the example client for anonymous authentication.

```
/* This example code is placed in the public domain. */

#ifdef HAVE_CONFIG_H
#include <config.h>
#endif

#include <stdio.h>
#include <stdlib.h>
#include <errno.h>
#include <sys/types.h>
#include <sys/socket.h>
#include <arpa/inet.h>
#include <netinet/in.h>
#include <string.h>
#include <unistd.h>
#include <gnutls/gnutls.h>

/* This is a sample TLS 1.0 echo server, for anonymous authentication only.
*/

#define SA struct sockaddr
#define SOCKET_ERR(err,s) if(err==-1) {perror(s);return(1);}
#define MAX_BUF 1024
#define PORT 5556 /* listen to 5556 port */
#define DH_BITS 1024

/* These are global */
gnutls_anon_server_credentials_t anoncred;

static gnutls_session_t
initialize_tls_session (void)
{
    gnutls_session_t session;

    gnutls_init (&session, GNUTLS_SERVER);

    gnutls_priority_set_direct (session, "NORMAL:+ANON-ECDH:+ANON-DH", NULL);

    gnutls_credentials_set (session, GNUTLS_CRD_ANON, anoncred);

    gnutls_dh_set_prime_bits (session, DH_BITS);

    return session;
}

static gnutls_dh_params_t dh_params;
```

```
static int
generate_dh_params (void)
{
    /* Generate Diffie-Hellman parameters - for use with DHE
     * kx algorithms. These should be discarded and regenerated
     * once a day, once a week or once a month. Depending on the
     * security requirements.
     */
    gnutls_dh_params_init (&dh_params);
    gnutls_dh_params_generate2 (dh_params, DH_BITS);

    return 0;
}

int
main (void)
{
    int err, listen_sd;
    int sd, ret;
    struct sockaddr_in sa_serv;
    struct sockaddr_in sa_cli;
    int client_len;
    char topbuf[512];
    gnutls_session_t session;
    char buffer[MAX_BUF + 1];
    int optval = 1;

    /* this must be called once in the program
     */
    gnutls_global_init ();

    gnutls_anon_allocate_server_credentials (&anoncred);

    generate_dh_params ();

    gnutls_anon_set_server_dh_params (anoncred, dh_params);

    /* Socket operations
     */
    listen_sd = socket (AF_INET, SOCK_STREAM, 0);
    SOCKET_ERR (listen_sd, "socket");

    memset (&sa_serv, '\0', sizeof (sa_serv));
    sa_serv.sin_family = AF_INET;
    sa_serv.sin_addr.s_addr = INADDR_ANY;
```

```
sa_serv.sin_port = htons (PORT);      /* Server Port number */

setsockopt (listen_sd, SOL_SOCKET, SO_REUSEADDR, (void *) &optval,
            sizeof (int));

err = bind (listen_sd, (SA *) & sa_serv, sizeof (sa_serv));
SOCKET_ERR (err, "bind");
err = listen (listen_sd, 1024);
SOCKET_ERR (err, "listen");

printf ("Server ready.  Listening to port '%d'.\n\n", PORT);

client_len = sizeof (sa_cli);
for (;;)
{
    session = initialize_tls_session ();

    sd = accept (listen_sd, (SA *) & sa_cli, &client_len);

    printf ("- connection from %s, port %d\n",
            inet_ntop (AF_INET, &sa_cli.sin_addr, topbuf,
                      sizeof (topbuf)), ntohs (sa_cli.sin_port));

    gnutls_transport_set_ptr (session, (gnutls_transport_ptr_t) sd);
    ret = gnutls_handshake (session);
    if (ret < 0)
    {
        close (sd);
        gnutls_deinit (session);
        fprintf (stderr, "*** Handshake has failed (%s)\n\n",
                gnutls_strerror (ret));
        continue;
    }
    printf ("- Handshake was completed\n");

    /* see the Getting peer's information example */
    /* print_info(session); */

    for (;;)
    {
        memset (buffer, 0, MAX_BUF + 1);
        ret = gnutls_record_recv (session, buffer, MAX_BUF);

        if (ret == 0)
        {
            printf ("\n- Peer has closed the GnuTLS connection\n");
            break;
        }
    }
}
```

```

    }
    else if (ret < 0)
    {
        fprintf (stderr, "\n*** Received corrupted "
                "data(%d). Closing the connection.\n\n", ret);
        break;
    }
    else if (ret > 0)
    {
        /* echo data back to the client
         */
        gnutls_record_send (session, buffer, strlen (buffer));
    }
}
printf ("\n");
/* do not wait for the peer to close the connection.
 */
gnutls_bye (session, GNUTLS_SHUT_WR);

close (sd);
gnutls_deinit (session);

}
close (listen_sd);

gnutls_anon_free_server_credentials (anoncred);

gnutls_global_deinit ();

return 0;

}

```

6.4 Miscellaneous examples

6.4.1 Checking for an alert

This is a function that checks if an alert has been received in the current session.

/ This example code is placed in the public domain. */*

```

#ifdef HAVE_CONFIG_H
#include <config.h>
#endif

#include <stdio.h>
#include <stdlib.h>
#include <gnutls/gnutls.h>

```

```

#include "examples.h"

/* This function will check whether the given return code from
 * a gnutls function (recv/send), is an alert, and will print
 * that alert.
 */
void
check_alert (gnutls_session_t session, int ret)
{
    int last_alert;

    if (ret == GNUTLS_E_WARNING_ALERT_RECEIVED
        || ret == GNUTLS_E_FATAL_ALERT_RECEIVED)
    {
        last_alert = gnutls_alert_get (session);

        /* The check for renegotiation is only useful if we are
         * a server, and we had requested a rehandshake.
         */
        if (last_alert == GNUTLS_A_NO_RENEGOTIATION &&
            ret == GNUTLS_E_WARNING_ALERT_RECEIVED)
            printf ("* Received NO_RENEGOTIATION alert.  "
                    "Client Does not support renegotiation.\n");
        else
            printf ("* Received alert '%d':  %s.\n", last_alert,
                    gnutls_alert_get_name (last_alert));
    }
}

```

6.4.2 X.509 certificate parsing example

To demonstrate the X.509 parsing capabilities an example program is listed below. That program reads the peer's certificate, and prints information about it.

```

/* This example code is placed in the public domain. */

#ifdef HAVE_CONFIG_H
#include <config.h>
#endif

#include <stdio.h>
#include <stdlib.h>
#include <gnutls/gnutls.h>
#include <gnutls/x509.h>

#include "examples.h"

```

```
static const char *
bin2hex (const void *bin, size_t bin_size)
{
    static char printable[110];
    const unsigned char *_bin = bin;
    char *print;
    size_t i;

    if (bin_size > 50)
        bin_size = 50;

    print = printable;
    for (i = 0; i < bin_size; i++)
    {
        sprintf (print, "%.2x ", _bin[i]);
        print += 2;
    }

    return printable;
}

/* This function will print information about this session's peer
 * certificate.
 */
void
print_x509_certificate_info (gnutls_session_t session)
{
    char serial[40];
    char dn[256];
    size_t size;
    unsigned int algo, bits;
    time_t expiration_time, activation_time;
    const gnutls_datum_t *cert_list;
    unsigned int cert_list_size = 0;
    gnutls_x509_crt_t cert;
    gnutls_datum_t cinfo;

    /* This function only works for X.509 certificates.
     */
    if (gnutls_certificate_type_get (session) != GNUTLS_CERT_X509)
        return;

    cert_list = gnutls_certificate_get_peers (session, &cert_list_size);

    printf ("Peer provided %d certificates.\n", cert_list_size);

    if (cert_list_size > 0)
```

```
{
    int ret;

    /* we only print information about the first certificate.
     */
    gnutls_x509_cert_init (&cert);

    gnutls_x509_cert_import (cert, &cert_list[0], GNUTLS_X509_FMT_DER);

    printf ("Certificate info:\n");

    /* This is the preferred way of printing short information about
     a certificate. */

    ret = gnutls_x509_cert_print (cert, GNUTLS_CERT_PRINT_ONELINE, &cinfo);
    if (ret == 0)
    {
        printf ("\t%s\n", cinfo.data);
        gnutls_free (cinfo.data);
    }

    /* If you want to extract fields manually for some other reason,
     below are popular example calls. */

    expiration_time = gnutls_x509_cert_get_expiration_time (cert);
    activation_time = gnutls_x509_cert_get_activation_time (cert);

    printf ("\tCertificate is valid since: %s", ctime (&activation_time));
    printf ("\tCertificate expires: %s", ctime (&expiration_time));

    /* Print the serial number of the certificate.
     */
    size = sizeof (serial);
    gnutls_x509_cert_get_serial (cert, serial, &size);

    printf ("\tCertificate serial number: %s\n", bin2hex (serial, size));

    /* Extract some of the public key algorithm's parameters
     */
    algo = gnutls_x509_cert_get_pk_algorithm (cert, &bits);

    printf ("Certificate public key: %s",
            gnutls_pk_algorithm_get_name (algo));

    /* Print the version of the X.509
     * certificate.
     */
}
```

```
    printf ("\tCertificate version:  %#d\n",
           gnutls_x509_cert_get_version (cert));

    size = sizeof (dn);
    gnutls_x509_cert_get_dn (cert, dn, &size);
    printf ("\tDN:  %s\n", dn);

    size = sizeof (dn);
    gnutls_x509_cert_get_issuer_dn (cert, dn, &size);
    printf ("\tIssuer's DN:  %s\n", dn);

    gnutls_x509_cert_deinit (cert);

}
}
```

6.5 Advanced and other topics

6.5.1 Parameter generation

Several TLS ciphersuites require additional parameters that need to be generated or provided by the application. The Diffie-Hellman based ciphersuites (ANON-DH or DHE), require the group information to be provided. This information can be either be generated on the fly using [\[gnutls_dh_params_generate2\]](#), page 179 or imported from some pregenerated value using [\[gnutls_dh_params_import_pkcs3\]](#), page 179. The parameters can be used in a session by calling [\[gnutls_certificate_set_dh_params\]](#), page 160 or [\[gnutls_anon_set_server_dh_params\]](#), page 154 for anonymous sessions.

- [\[gnutls_dh_params_generate2\]](#), page 179
- [\[gnutls_dh_params_import_pkcs3\]](#), page 179
- [\[gnutls_certificate_set_dh_params\]](#), page 160
- [\[gnutls_anon_set_server_dh_params\]](#), page 154

Due to the time-consuming calculations required for the generation of Diffie-Hellman parameters we suggest against performing generation of them within an application. The `certtool` tool can be used to generate or export known safe values that can be stored in code or in a configuration file to provide the ability to replace. We also recommend the usage of [\[gnutls_sec_param_to_pk_bits\]](#), page 229 (see [Section 3.7 \[Selecting cryptographic key sizes\]](#), page 19) to determine the bit size of the parameters to be generated.

The ciphersuites that involve the RSA-EXPORT key exchange require additional parameters. Those ciphersuites are rarely used today because they are by design insecure, thus if you have no requirement for them, this section should be skipped. The RSA-EXPORT key exchange requires 512-bit RSA keys to be generated. It is recommended those parameters to be refreshed (regenerated) in short intervals. The following functions can be used for these parameters.

- [\[gnutls_rsa_params_generate2\]](#), page 228
- [\[gnutls_certificate_set_rsa_export_params\]](#), page 161

- [\[gnutls_rsa_params_import_pkcs1\]](#), page 228
- [\[gnutls_rsa_params_export_pkcs1\]](#), page 227

6.5.2 Keying material exporters

The TLS PRF can be used by other protocols to derive data. The API to use is [\[gnutls_prf\]](#), page 207. The function needs to be provided with the label in the parameter `label`, and the extra data to mix in the `extra` parameter. Depending on whether you want to mix in the client or server random data first, you can set the `server_random_first` parameter.

For example, after establishing a TLS session using [\[gnutls_handshake\]](#), page 188, you can invoke the TLS PRF with this call:

```
#define MYLABEL "EXPORTER-FOO"
#define MYCONTEXT "some context data"
char out[32];
rc = gnutls_prf (session, strlen (MYLABEL), MYLABEL, 0,
                strlen (MYCONTEXT), MYCONTEXT, 32, out);
```

If you don't want to mix in the client/server random, there is a more low-level TLS PRF interface called [\[gnutls_prf_raw\]](#), page 206.

6.5.3 Channel bindings

In user authentication protocols (e.g., EAP or SASL mechanisms) it is useful to have a unique string that identifies the secure channel that is used, to bind together the user authentication with the secure channel. This can protect against man-in-the-middle attacks in some situations. The unique strings is a “channel bindings”. For background and more discussion see [\[RFC5056\]](#) .

You can extract a channel bindings using the [\[gnutls_session_channel_binding\]](#), page 230 function. Currently only the `GNUTLS_CB_TLS_UNIQUE` type is supported, which corresponds to the `tls-unique` channel bindings for TLS defined in [\[RFC5929\]](#) .

The following example describes how to print the channel binding data. Note that it must be run after a successful TLS handshake.

```
{
    gnutls_datum_t cb;
    int rc;

    rc = gnutls_session_channel_binding (session,
                                        GNUTLS_CB_TLS_UNIQUE,
                                        &cb);

    if (rc)
        fprintf (stderr, "Channel binding error: %s\n",
                gnutls_strerror (rc));
    else
    {
        size_t i;
        printf ("- Channel binding 'tls-unique': ");
        for (i = 0; i < cb.size; i++)
            printf ("%02x", cb.data[i]);
        printf ("\n");
    }
}
```

6.5.4 Compatibility with the OpenSSL library

To ease GnuTLS' integration with existing applications, a compatibility layer with the widely used OpenSSL library is included in the `gnutls-openssl` library. This compatibility layer is not complete and it is not intended to completely re-implement the OpenSSL API with GnuTLS. It only provides limited source-level compatibility. There is currently no attempt to make it binary-compatible with OpenSSL.

The prototypes for the compatibility functions are in the `'gnutls/openssl.h'` header file.

Current limitations imposed by the compatibility layer include:

- Error handling is not thread safe.

7 How to use TLS in application protocols

This chapter is intended to provide some hints on how to use the TLS over simple custom made application protocols. The discussion below mainly refers to the TCP/IP transport layer but may be extended to other ones too.

7.1 Separate ports

Traditionally SSL was used in application protocols by assigning a new port number for the secure services. That way two separate ports were assigned, one for the non secure sessions, and one for the secured ones. This has the benefit that if a user requests a secure session then the client will try to connect to the secure port and fail otherwise. The only possible attack with this method is a denial of service one. The most famous example of this method is the famous “HTTP over TLS” or HTTPS protocol [*RFC2818*].

Despite its wide use, this method is not as good as it seems. This approach starts the TLS Handshake procedure just after the client connects on the —so called— secure port. That way the TLS protocol does not know anything about the client, and popular methods like the host advertising in HTTP do not work¹. There is no way for the client to say “I connected to YYY server” before the Handshake starts, so the server cannot possibly know which certificate to use.

Other than that it requires two separate ports to run a single service, which is unnecessary complication. Due to the fact that there is a limitation on the available privileged ports, this approach was soon obsolete.

7.2 Upward negotiation

Other application protocols² use a different approach to enable the secure layer. They use something called the “TLS upgrade” method. This method is quite tricky but it is more flexible. The idea is to extend the application protocol to have a “STARTTLS” request, whose purpose it to start the TLS protocols just after the client requests it. This approach does not require an extra port and is used by almost all modern protocols. There is even an extension to HTTP protocol to support that method [*RFC2817*].

The tricky part, in this method, is that the “STARTTLS” request is sent in the clear, thus is vulnerable to modifications. A typical attack is to modify the messages in a way that the client is fooled and thinks that the server does not have the “STARTTLS” capability. See a typical conversation of a hypothetical protocol:

```
(client connects to the server)
CLIENT: HELLO I'M MR. XXX
SERVER: NICE TO MEET YOU XXX
CLIENT: PLEASE START TLS
SERVER: OK
*** TLS STARTS
CLIENT: HERE ARE SOME CONFIDENTIAL DATA
```

¹ See also the Server Name Indication extension on [*serverind*], page 17.

² See LDAP, IMAP etc.

And see an example of a conversation where someone is acting in between:

```
(client connects to the server)
CLIENT: HELLO I'M MR. XXX
SERVER: NICE TO MEET YOU XXX
CLIENT: PLEASE START TLS
(here someone inserts this message)
SERVER: SORRY I DON'T HAVE THIS CAPABILITY
CLIENT: HERE ARE SOME CONFIDENTIAL DATA
```

As you can see above the client was fooled, and was dummy enough to send the confidential data in the clear.

How to avoid the above attack? As you may have already thought this one is easy to avoid. The client has to ask the user before it connects whether the user requests TLS or not. If the user answered that he certainly wants the secure layer the last conversation should be:

```
(client connects to the server)
CLIENT: HELLO I'M MR. XXX
SERVER: NICE TO MEET YOU XXX
CLIENT: PLEASE START TLS
(here someone inserts this message)
SERVER: SORRY I DON'T HAVE THIS CAPABILITY
CLIENT: BYE
```

(the client notifies the user that the secure connection was not possible)

This method, if implemented properly, is far better than the traditional method, and the security properties remain the same, since only denial of service is possible. The benefit is that the server may request additional data before the TLS Handshake protocol starts, in order to send the correct certificate, use the correct password file³, or anything else!

³ in SRP authentication

8 Included programs

Included with GnuTLS are also a few command line tools that let you use the library for common tasks without writing an application. The applications are discussed in this chapter.

8.1 Invoking certtool

This is a program to generate X.509 certificates, certificate requests, CRLs and private keys.

```

Certtool help
Usage: certtool [options]
  -s, --generate-self-signed          Generate a self-signed certificate.
  -c, --generate-certificate          Generate a signed certificate.
  --generate-proxy                    Generate a proxy certificate.
  --generate-crl                      Generate a CRL.
  -u, --update-certificate            Update a signed certificate.
  -p, --generate-privkey              Generate a private key.
  -q, --generate-request              Generate a PKCS #10 certificate
  request.
  -e, --verify-chain                  Verify a PEM encoded certificate chain.
  The last certificate in the chain must
  be a self signed one.
  --verify                             Verify a PEM encoded certificate chain.
  CA certificates must be loaded with
  --load-ca-certificate.
  --verify-crl                        Verify a CRL.
  --generate-dh-params                Generate PKCS #3 encoded Diffie-Hellman
  parameters.
  --get-dh-params                      Get the included PKCS #3 encoded
  Diffie-Hellman parameters.
  --load-privkey FILE                 Private key file to use.
  --load-pubkey FILE                  Private key file to use.
  --load-request FILE                 Certificate request file to use.
  --load-certificate FILE              Certificate file to use.
  --load-ca-privkey FILE              Certificate authority's private key
  file to use.
  --load-ca-certificate FILE          Certificate authority's certificate
  file to use.
  --password PASSWORD                Password to use.
  -i, --certificate-info              Print information on a certificate.
  --certificate-pubkey                Print certificate public key.
  --pgp-certificate-info              Print information on a OpenPGP

```

```

certificate.
--pgp-ring-info      Print information on a keyring
                    structure.
-l, --crl-info       Print information on a CRL.
--crl-info           Print information on a Certificate
                    Request.
--no-crl-extensions Do not use extensions in certificate
                    requests.
--p12-info           Print information on a PKCS #12
                    structure.
--p7-info            Print information on a PKCS #7
                    structure.
--smime-to-p7        Convert S/MIME to PKCS #7 structure.
-k, --key-info       Print information on a private key.
--pgp-key-info       Print information on a OpenPGP private
                    key.
--pubkey-info        Print information on a public key.
--fix-key            Regenerate the parameters in a private
                    key.
--v1                 Generate an X.509 version 1 certificate
                    (no extensions).
--to-p12             Generate a PKCS #12 structure.
--to-p8             Generate a PKCS #8 key structure.
-8, --pkcs8         Use PKCS #8 format for private keys.
--dsa               Use DSA keys.
--ecc               Use ECC (ECDSA) keys.
--hash STR          Hash algorithm to use for signing
                    (MD5,SHA1,RMD160,SHA256,SHA384,SHA512).
--export-ciphers     Use weak encryption algorithms.
--inder            Use DER format for input certificates
                    and private keys.
--inraw            Use RAW/DER format for input
                    certificates and private keys.
--outder           Use DER format for output certificates
                    and private keys.
--outraw          Use RAW/DER format for output
                    certificates and private keys.
--bits BITS        specify the number of bits for key
                    generation.
--sec-param PARAM  specify the security level
                    [low|normal|high|ultra].
--disable-quick-random Use /dev/random for key generationg,
                    thus increasing the quality of
                    randomness used.
--outfile FILE     Output file.
--infile FILE      Input file.
--template FILE    Template file to use for non

```

	interactive operation.
<code>--pkcs-cipher CIPHER</code>	Cipher to use for pkcs operations (3des,3des-pkcs12,aes-128,aes-192,aes-256,rc2-40,arcfour).
<code>-d, --debug LEVEL</code>	specify the debug level. Default is 1.
<code>-h, --help</code>	shows this help text
<code>-v, --version</code>	shows the program's version

The program can be used interactively or non interactively by specifying the `--template` command line option. See below for an example of a template file.

8.1.1 Diffie-Hellman parameter generation

To generate parameters for Diffie-Hellman key exchange, use the command:

```
$ certtool --generate-dh-params --outfile dh.pem
```

8.1.2 Self-signed certificate generation

To create a self signed certificate, use the command:

```
$ certtool --generate-privkey --outfile ca-key.pem
$ certtool --generate-self-signed --load-privkey ca-key.pem \
--outfile ca-cert.pem
```

Note that a self-signed certificate usually belongs to a certificate authority, that signs other certificates.

8.1.3 Private key generation

To create a private key (RSA by default), run:

```
$ certtool --generate-privkey --outfile key.pem
```

To create a DSA private key, run:

```
$ certtool --dsa --generate-privkey --outfile key-dsa.pem
```

8.1.4 Certificate generation

To generate a certificate using the private key, use the command:

```
$ certtool --generate-certificate --load-privkey key.pem \
--outfile cert.pem --load-ca-certificate ca-cert.pem \
--load-ca-privkey ca-key.pem
```

Alternatively you may create a certificate request, which is needed when the certificate will be signed by a third party authority.

```
$ certtool --generate-request --load-privkey key.pem \
--outfile request.pem
```

To generate a certificate using the previous request, use the command:

```
$ certtool --generate-certificate --load-request request.pem \
--outfile cert.pem \
--load-ca-certificate ca-cert.pem --load-ca-privkey ca-key.pem
```

8.1.5 Certificate information

To view the certificate information, use:

```
$ certtool --certificate-info --infile cert.pem
```

8.1.6 PKCS #12 structure generation

To generate a PKCS #12 structure using the previous key and certificate, use the command:

```
$ certtool --load-certificate cert.pem --load-privkey key.pem \
  --to-p12 --outder --outfile key.p12
```

Some tools (reportedly web browsers) have problems with that file because it does not contain the CA certificate for the certificate. To work around that problem in the tool, you can use the `--load-ca-certificate` parameter as follows:

```
$ certtool --load-ca-certificate ca.pem \
  --load-certificate cert.pem --load-privkey key.pem \
  --to-p12 --outder --outfile key.p12
```

8.1.7 Proxy certificate generation

Proxy certificate can be used to delegate your credential to a temporary, typically short-lived, certificate. To create one from the previously created certificate, first create a temporary key and then generate a proxy certificate for it, using the commands:

```
$ certtool --generate-privkey > proxy-key.pem
$ certtool --generate-proxy --load-ca-privkey key.pem \
  --load-privkey proxy-key.pem --load-certificate cert.pem \
  --outfile proxy-cert.pem
```

8.1.8 Certificate revocation list generation

To create an empty Certificate Revocation List (CRL) do:

```
$ certtool --generate-crl --load-ca-privkey x509-ca-key.pem \
  --load-ca-certificate x509-ca.pem
```

To create a CRL that contains some revoked certificates, place the certificates in a file and use `--load-certificate` as follows:

```
$ certtool --generate-crl --load-ca-privkey x509-ca-key.pem \
  --load-ca-certificate x509-ca.pem --load-certificate revoked-certs.pem
```

To verify a Certificate Revocation List (CRL) do:

```
$ certtool --verify-crl --load-ca-certificate x509-ca.pem < crl.pem
```

8.1.9 Certtool's template file format:

A template file can be used to avoid the interactive questions of certtool. Initially create a file named 'cert.cfg' that contains the information about the certificate. The template can be used as below:

```
$ certtool --generate-certificate cert.pem --load-privkey key.pem \
  --template cert.cfg \
  --load-ca-certificate ca-cert.pem --load-ca-privkey ca-key.pem
```

An example certtool template file:

```
# X.509 Certificate options
#
# DN options

# The organization of the subject.
organization = "Koko inc."

# The organizational unit of the subject.
```

```
unit = "sleeping dept."

# The locality of the subject.
# locality =

# The state of the certificate owner.
state = "Attiki"

# The country of the subject. Two letter code.
country = GR

# The common name of the certificate owner.
cn = "Cindy Lauper"

# A user id of the certificate owner.
#uid = "clauper"

# If the supported DN OIDs are not adequate you can set
# any OID here.
# For example set the X.520 Title and the X.520 Pseudonym
# by using OID and string pairs.
#dn_oid = "2.5.4.12" "Dr." "2.5.4.65" "jackal"

# This is deprecated and should not be used in new
# certificates.
# pkcs9_email = "none@none.org"

# The serial number of the certificate
serial = 007

# In how many days, counting from today, this certificate will expire.
expiration_days = 700

# X.509 v3 extensions

# A dnsname in case of a WWW server.
#dns_name = "www.none.org"
#dns_name = "www.morethanone.org"

# An IP address in case of a server.
#ip_address = "192.168.1.1"

# An email in case of a person
email = "none@none.org"

# An URL that has CRLs (certificate revocation lists)
# available. Needed in CA certificates.
```

```
#crl_dist_points = "http://www.getcrl.crl/getcrl/"

# Whether this is a CA certificate or not
#ca

# Whether this certificate will be used for a TLS client
#tls_www_client

# Whether this certificate will be used for a TLS server
#tls_www_server

# Whether this certificate will be used to sign data (needed
# in TLS DHE ciphersuites).
signing_key

# Whether this certificate will be used to encrypt data (needed
# in TLS RSA ciphersuites). Note that it is preferred to use different
# keys for encryption and signing.
#encryption_key

# Whether this key will be used to sign other certificates.
#cert_signing_key

# Whether this key will be used to sign CRLs.
#crl_signing_key

# Whether this key will be used to sign code.
#code_signing_key

# Whether this key will be used to sign OCSP data.
#ocsp_signing_key

# Whether this key will be used for time stamping.
#time_stamping_key

# Whether this key will be used for IPsec IKE operations.
#ipsec_ike_key
```

8.2 Invoking gnutls-cli

Simple client program to set up a TLS connection to some other computer. It sets up a TLS connection and forwards data from the standard input to the secured socket and vice versa.

```
GnuTLS test client
Usage:  gnutls-cli [options] hostname

        -d, --debug integer      Enable debugging
```

```

-r, --resume          Connect, establish a session. Connect
                    again and resume this session.
-s, --starttls       Connect, establish a plain session and
                    start TLS when EOF or a SIGALRM is
                    received.
--crlf              Send CR LF instead of LF.
--x509fmtder        Use DER format for certificates to read
                    from.
-f, --fingerprint   Send the openpgp fingerprint, instead
                    of the key.
--disable-extensions Disable all the TLS extensions.
--print-cert        Print the certificate in PEM format.
--recordsize integer The maximum record size to advertize.
-V, --verbose       More verbose output.
--ciphers cipher1 cipher2...
                    Ciphers to enable.
--protocols protocol1 protocol2...
                    Protocols to enable.
--comp comp1 comp2... Compression methods to enable.
--macs mac1 mac2...  MACs to enable.
--kx kx1 kx2...     Key exchange methods to enable.
--ctypes certType1 certType2...
                    Certificate types to enable.
--priority PRIORITY STRING
                    Priorities string.
--x509cafile FILE   Certificate file to use.
--x509crlfile FILE  CRL file to use.
--pgpkeyfile FILE   PGP Key file to use.
--pgpkeyring FILE   PGP Key ring file to use.
--pgpcertfile FILE  PGP Public Key (certificate) file to
                    use.
--pgpsubkey HEX|auto PGP subkey to use.
--x509keyfile FILE  X.509 key file to use.
--x509certfile FILE X.509 Certificate file to use.
--srpusername NAME  SRP username to use.
--srppasswd PASSWD  SRP password to use.
--pskusername NAME  PSK username to use.
--pskkey KEY        PSK key (in hex) to use.
--opaque-prf-input DATA
                    Use Opaque PRF Input DATA.
-p, --port PORT     The port to connect to.
--insecure          Don't abort program if server
                    certificate can't be validated.
-l, --list          Print a list of the supported
                    algorithms and modes.
-h, --help          prints this help
-v, --version       prints the program's version number

```

To connect to a server using PSK authentication, you may use something like:

```
$ gnutls-cli -p 5556 test.gnutls.org --pskusername jas \
--pskkey 9e32cf7786321a828ef7668f09fb35db \
--priority NORMAL:-KX-ALL:+ECDHE-PSK:DHE-PSK:+PSK
```

8.2.1 Example client PSK connection

If your server only supports the PSK ciphersuite, connecting to it should be as simple as connecting to the server:

```
$ ./gnutls-cli -p 5556 localhost
Resolving 'localhost'...
Connecting to '127.0.0.1:5556'...
- PSK client callback.
Enter PSK identity: psk_identity
Enter password:
- PSK authentication.
- Version: TLS1.1
- Key Exchange: PSK
- Cipher: AES-128-CBC
- MAC: SHA1
- Compression: NULL
- Handshake was completed

- Simple Client Mode:
```

If the server supports several cipher suites, you may need to force it to chose PSK by using a cipher priority parameter such as in the example below:

```
$ ./gnutls-cli -p 5556 localhost --pskusername psk_identity \
--pskkey 88f3824b3e5659f52d00e959bacab954b6540344 \
--priority NORMAL:-KX-ALL:+ECDHE-PSK:+DHE-PSK:+PSK
Resolving 'localhost'...
Connecting to '127.0.0.1:5556'...
- PSK authentication.
- Version: TLS1.1
- Key Exchange: PSK
- Cipher: AES-128-CBC
- MAC: SHA1
- Compression: NULL
- Handshake was completed

- Simple Client Mode:
```

By keeping the `--pskusername` parameter and removing the `--pskkey` parameter, it will query only for the password during the handshake.

8.3 Invoking gnutls-cli-debug

This program was created to assist in debugging GnuTLS, but it might be useful to extract a TLS server's capabilities. It's purpose is to connect onto a TLS server, perform some tests and print the server's capabilities. If called with the `-v` parameter a more checks will be performed. An example output is:

```
crystal:/cvs/gnutls/src$ ./gnutls-cli-debug localhost -p 5556
Resolving 'localhost'...
Connecting to '127.0.0.1:5556'...
Checking for TLS 1.1 support... yes
```

```

Checking fallback from TLS 1.1 to... N/A
Checking for TLS 1.0 support... yes
Checking for SSL 3.0 support... yes
Checking for version rollback bug in RSA PMS... no
Checking for version rollback bug in Client Hello... no
Checking whether we need to disable TLS 1.0... N/A
Checking whether the server ignores the RSA PMS version... no
Checking whether the server can accept Hello Extensions... yes
Checking whether the server can accept cipher suites not in SSL 3.0 spec... yes
Checking for certificate information... N/A
Checking for trusted CAs... N/A
Checking whether the server understands TLS closure alerts... yes
Checking whether the server supports session resumption... yes
Checking for export-grade ciphersuite support... no
Checking RSA-export ciphersuite info... N/A
Checking for anonymous authentication support... no
Checking anonymous Diffie-Hellman group info... N/A
Checking for ephemeral Diffie-Hellman support... no
Checking ephemeral Diffie-Hellman group info... N/A
Checking for AES cipher support (TLS extension)... yes
Checking for 3DES cipher support... yes
Checking for ARCFOUR 128 cipher support... yes
Checking for ARCFOUR 40 cipher support... no
Checking for MD5 MAC support... yes
Checking for SHA1 MAC support... yes
Checking for ZLIB compression support (TLS extension)... yes
Checking for max record size (TLS extension)... yes
Checking for SRP authentication support (TLS extension)... yes
Checking for OpenPGP authentication support (TLS extension)... no

```

8.4 Invoking gnutls-serv

Simple server program that listens to incoming TLS connections.

GnuTLS test server

Usage: gnutls-serv [options]

-d, --debug integer	Enable debugging
-g, --generate	Generate Diffie-Hellman Parameters.
-p, --port integer	The port to connect to.
-q, --quiet	Suppress some messages.
--nodb	Does not use the resume database.
--http	Act as an HTTP Server.
--echo	Act as an Echo Server.
--dhparams FILE	DH params file to use.
--x509fmtder	Use DER format for certificates
--x509cafile FILE	Certificate file to use.
--x509crlfile FILE	CRL file to use.

```

--pgpkeyring FILE          PGP Key ring file to use.
--pgpkeyfile FILE         PGP Key file to use.
--pgpcertfile FILE        PGP Public Key (certificate) file to
                           use.
--pgpsubkey HEX|auto      PGP subkey to use.
--x509keyfile FILE        X.509 key file to use.
--x509certfile FILE       X.509 Certificate file to use.
--x509dsakeyfile FILE     Alternative X.509 key file to use.
--x509dsacertfile FILE   Alternative X.509 certificate file to
                           use.
-r, --require-cert        Require a valid certificate.
-a, --disable-client-cert
                           Disable request for a client
                           certificate.
--pskpasswd FILE          PSK password file to use.
--pskhint HINT            PSK identity hint to use.
--srppasswd FILE          SRP password file to use.
--srppasswdconf FILE     SRP password conf file to use.
--opaque-prf-input DATA
                           Use Opaque PRF Input DATA.
--ciphers cipher1 cipher2...
                           Ciphers to enable.
--protocols protocol1 protocol2...
                           Protocols to enable.
--comp comp1 comp2...    Compression methods to enable.
--macs mac1 mac2...      MACs to enable.
--kx kx1 kx2...          Key exchange methods to enable.
--ctypes certType1 certType2...
                           Certificate types to enable.
--priority PRIORITY STRING
                           Priorities string.
-l, --list                Print a list of the supported
                           algorithms and modes.
-h, --help                prints this help
-v, --version             prints the program's version number

```

8.4.1 Setting up a test HTTPS server

Running your own TLS server based on GnuTLS can be useful when debugging clients and/or GnuTLS itself. This section describes how to use `gnutls-serv` as a simple HTTPS server.

The most basic server can be started as:

```
gnutls-serv --http
```

It will only support anonymous ciphersuites, which many TLS clients refuse to use.

The next step is to add support for X.509. First we generate a CA:

```
$ certtool --generate-privkey > x509-ca-key.pem
$ echo 'cn = GnuTLS test CA' > ca.tmpl
```

```
$ echo 'ca' >> ca.tpl
$ echo 'cert_signing_key' >> ca.tpl
$ certtool --generate-self-signed --load-privkey x509-ca-key.pem \
  --template ca.tpl --outfile x509-ca.pem
...
```

Then generate a server certificate. Remember to change the `dns_name` value to the name of your server host, or skip that command to avoid the field.

```
$ certtool --generate-privkey > x509-server-key.pem
$ echo 'organization = GnuTLS test server' > server.tpl
$ echo 'cn = test.gnutls.org' >> server.tpl
$ echo 'tls_www_server' >> server.tpl
$ echo 'encryption_key' >> server.tpl
$ echo 'signing_key' >> server.tpl
$ echo 'dns_name = test.gnutls.org' >> server.tpl
$ certtool --generate-certificate --load-privkey x509-server-key.pem \
  --load-ca-certificate x509-ca.pem --load-ca-privkey x509-ca-key.pem \
  --template server.tpl --outfile x509-server.pem
...
```

For use in the client, you may want to generate a client certificate as well.

```
$ certtool --generate-privkey > x509-client-key.pem
$ echo 'cn = GnuTLS test client' > client.tpl
$ echo 'tls_www_client' >> client.tpl
$ echo 'encryption_key' >> client.tpl
$ echo 'signing_key' >> client.tpl
$ certtool --generate-certificate --load-privkey x509-client-key.pem \
  --load-ca-certificate x509-ca.pem --load-ca-privkey x509-ca-key.pem \
  --template client.tpl --outfile x509-client.pem
...
```

To be able to import the client key/certificate into some applications, you will need to convert them into a PKCS#12 structure. This also encrypts the security sensitive key with a password.

```
$ certtool --to-p12 --load-ca-certificate x509-ca.pem \
  --load-privkey x509-client-key.pem --load-certificate x509-client.pem \
  --outder --outfile x509-client.p12
```

For icing, we'll create a proxy certificate for the client too.

```
$ certtool --generate-privkey > x509-proxy-key.pem
$ echo 'cn = GnuTLS test client proxy' > proxy.tpl
$ certtool --generate-proxy --load-privkey x509-proxy-key.pem \
  --load-ca-certificate x509-client.pem --load-ca-privkey x509-client-key.pem \
  --load-certificate x509-client.pem --template proxy.tpl \
  --outfile x509-proxy.pem
...
```

Then start the server again:

```
$ gnutls-serv --http \
  --x509cafile x509-ca.pem \
  --x509keyfile x509-server-key.pem \
  --x509certfile x509-server.pem
```

Try connecting to the server using your web browser. Note that the server listens to port 5556 by default.

While you are at it, to allow connections using DSA, you can also create a DSA key and certificate for the server. These credentials will be used in the final example below.

```
$ certtool --generate-privkey --dsa > x509-server-key-dsa.pem
$ certtool --generate-certificate --load-privkey x509-server-key-dsa.pem \
  --load-ca-certificate x509-ca.pem --load-ca-privkey x509-ca-key.pem \
  --template server.tmpl --outfile x509-server-dsa.pem
...
```

The next step is to create OpenPGP credentials for the server.

```
gpg --gen-key
...enter whatever details you want, use 'test.gnutls.org' as name...
```

Make a note of the OpenPGP key identifier of the newly generated key, here it was 5D1D14D8. You will need to export the key for GnuTLS to be able to use it.

```
gpg -a --export 5D1D14D8 > openpgp-server.txt
gpg --export 5D1D14D8 > openpgp-server.bin
gpg --export-secret-keys 5D1D14D8 > openpgp-server-key.bin
gpg -a --export-secret-keys 5D1D14D8 > openpgp-server-key.txt
```

Let's start the server with support for OpenPGP credentials:

```
gnutls-serv --http \
  --pgpkeyfile openpgp-server-key.txt \
  --pgpcertfile openpgp-server.txt
```

The next step is to add support for SRP authentication.

```
srptool --create-conf srp-tpasswd.conf
srptool --passwd-conf srp-tpasswd.conf --username jas --passwd srp-passwd.txt
Enter password: [TYPE "foo"]
```

Start the server with SRP support:

```
gnutls-serv --http \
  --srpasswdconf srp-tpasswd.conf \
  --srpasswd srp-passwd.txt
```

Let's also add support for PSK.

```
$ psktool --passwd psk-passwd.txt
```

Start the server with PSK support:

```
gnutls-serv --http \
  --pskpasswd psk-passwd.txt
```

Finally, we start the server with all the earlier parameters and you get this command:

```
gnutls-serv --http \
  --x509cafile x509-ca.pem \
  --x509keyfile x509-server-key.pem \
  --x509certfile x509-server.pem \
  --x509dsakeyfile x509-server-key-dsa.pem \
  --x509dsacertfile x509-server-dsa.pem \
  --pgpkeyfile openpgp-server-key.txt \
  --pgpcertfile openpgp-server.txt \
  --srpasswdconf srp-tpasswd.conf \
  --srpasswd srp-passwd.txt \
  --pskpasswd psk-passwd.txt
```

8.4.2 Example server PSK connection

To set up a PSK server with `gnutls-serv` you need to create PSK password file. This is illustrated in the example below, where a password is provided at the prompt.

```
$ ./psktool -u psk_identity -p psks.txt
Enter password:
Key stored to psks.txt
$ cat psks.txt
psk_identity:88f3824b3e5659f52d00e959bacab954b6540344
$
```

After this, start the server pointing to the password file. We disable DHE-PSK.

```
$ ./gnutls-serv --pskpasswd psks.txt --pskhint psk_identity_hint \
--priority NORMAL:-DHE-PSK
Set static Diffie-Hellman parameters, consider --dhparams.
Echo Server ready. Listening to port '5556'.
```

You can now connect to the server using a PSK client as in [Section 8.2.1 \[Example client PSK connection\]](#), page 122.

8.5 Invoking psktool

This is a program to manage PSK username and keys.

```
PSKtool help
Usage : psktool [options]
    -u, --username username      specify username.
    -p, --passwd FILE            specify a password file.
    -s, --keysize SIZE           specify the key size in bytes.
    -v, --version                prints the program's version number
    -h, --help                   shows this help text
```

Normally the file will generate random keys for the indicated username.

8.6 Invoking srptool

The 'srptool' is a very simple program that emulates the programs in the *Stanford SRP libraries*, see <http://srp.stanford.edu/>. It is intended for use in places where you don't expect SRP authentication to be the used for system users.

Traditionally *libsrp* used two files. One called `tpasswd` which holds usernames and verifiers, and `tpasswd.conf` which holds generators and primes.

8.6.1 How to use srptool

To create `tpasswd.conf` which holds the `g` and `n` values for SRP protocol (generator and a large prime), run:

```
$ srptool --create-conf /etc/tpasswd.conf
```

This command will create `/etc/tpasswd` and will add user 'test' (you will also be prompted for a password). Verifiers are stored by default in the way `libsrp` expects.

```
$ srptool --passwd /etc/tpasswd \
--passwd-conf /etc/tpasswd.conf -u test
```

This command will check against a password. If the password matches the one in `/etc/tpasswd` you will get an ok.

```
$ srptool --passwd /etc/tpasswd \
--passwd-conf /etc/tpasswd.conf --verify -u test
```

8.7 Invoking p11tool

The ‘p11tool’ is a program that helps with accessing tokens and security modules that support the PKCS #11 API. It requires the individual PKCS #11 modules to be loaded either with the `--provider` option, or by setting up the GnuTLS configuration file for PKCS #11 as in [Section 5.3 \[Hardware tokens\]](#), page 41.

```
p11tool help
Usage: p11tool [options]

--export URL           Export an object specified by a pkcs11
                       URL
--list-tokens          List all available tokens
--list-mechanisms URL  List all available mechanisms in token.
--list-all            List all objects specified by a PKCS#11
                       URL
--list-all-certs     List all certificates specified by a
                       PKCS#11 URL
--list-certs          List certificates that have a private
                       key specified by a PKCS#11 URL
--list-privkeys       List private keys specified by a
                       PKCS#11 URL
--list-trusted        List certificates marked as trusted,
                       specified by a PKCS#11 URL
--initialize URL      Initializes a PKCS11 token.
--write URL           Writes loaded certificates, private or
                       secret keys to a PKCS11 token.
--delete URL          Deletes objects matching the URL.
--label label         Sets a label for the write operation.
--trusted             Marks the certificate to be imported as
                       trusted.
--login               Force login to token
--detailed-url        Export detailed URLs.
--no-detailed-url     Export less detailed URLs.
--secret-key HEX_KEY Provide a hex encoded secret key.
--load-privkey FILE   Private key file to use.
--load-pubkey FILE    Private key file to use.
--load-certificate FILE Certificate file to use.
-8, --pkcs8          Use PKCS #8 format for private keys.
--inder              Use DER format for input certificates
                       and private keys.
--inraw              Use RAW/DER format for input
                       certificates and private keys.
--provider Library    Specify the pkcs11 provider library
--outfile FILE        Output file.
-d, --debug LEVEL    specify the debug level. Default is 1.
-h, --help           shows this help text
```

After being provided the available PKCS #11 modules, it can list all tokens available in your system, the objects on the tokens, and perform operations on them.

Some examples on how to use p11tool are illustrated in the following paragraphs.

8.7.1 List all tokens

```
$ p11tool --list-tokens
```

8.7.2 List all objects

```
$ p11tool --login --list-all
```

8.7.3 Exporting an object

```
$ p11tool --login --export pkcs11:(OBJECT URL)
```

Note however that typically PKCS #11 private key objects are not allowed to be extracted from the token.

8.7.4 Copy an object to a token

```
$ p11tool --login --write pkcs11:(TOKEN URL) \  
--load-certificate cert.pem --label "my_cert"
```

9 Internal Architecture of GnuTLS

This chapter is to give a brief description of the way GnuTLS works. The focus is to give an idea to potential developers and those who want to know what happens inside the black box.

9.1 The TLS Protocol

The main use case for the TLS protocol is shown in [Figure 9.1](#). A user of a library implementing the protocol expects no less than this functionality, i.e., to be able to set parameters such as the accepted security level, perform a negotiation with the peer and be able to exchange data.

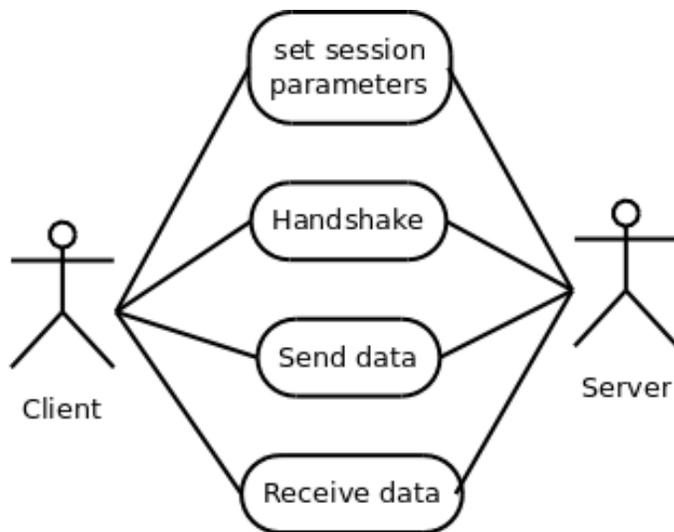


Figure 9.1: TLS protocol use case.

This in GnuTLS is being accomplished by an object-oriented architecture as shown in [Figure 9.2](#). Note that since GnuTLS is being developed in C object are just structures with attributes. The operations listed are functions that require the first parameter to be that object.

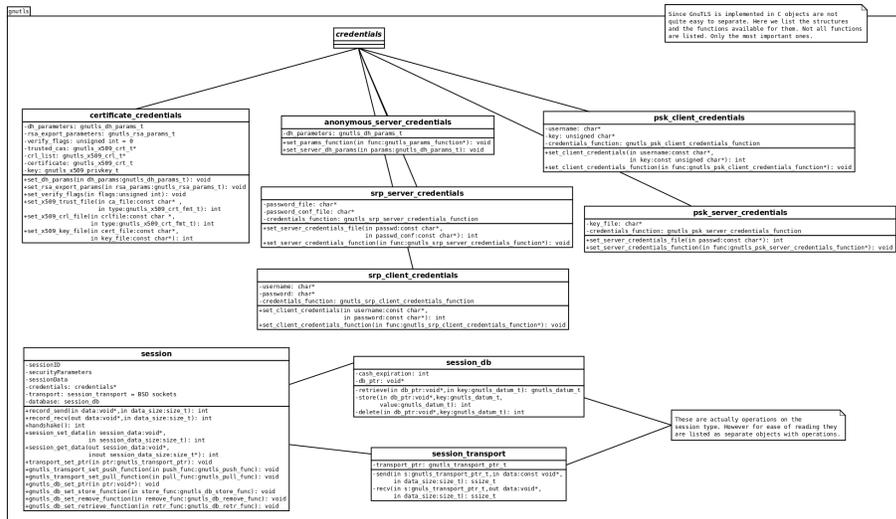


Figure 9.2: GnuTLS objects.

9.2 TLS Handshake Protocol

The GnuTLS handshake protocol is implemented as a state machine that waits for input or returns immediately when the non-blocking transport layer functions are used. The main idea is shown in [Figure 9.3](#).

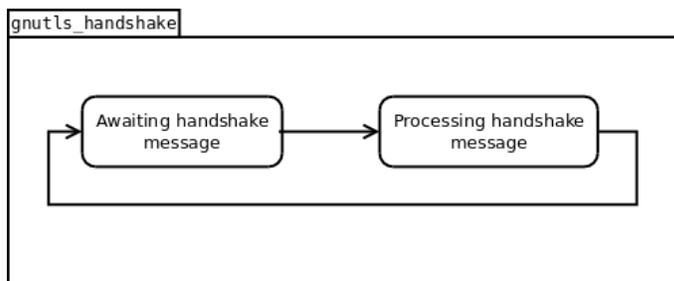


Figure 9.3: GnuTLS handshake state machine.

Also the way the input is processed varies per ciphersuite. Several implementations of the internal handlers are available and [\[gnutls_handshake\]](#), page 188 only multiplexes the input to the appropriate handler. For example a PSK ciphersuite has a different implementation of the `process_client_key_exchange` than a certificate ciphersuite. We illustrate the idea in [Figure 9.4](#).

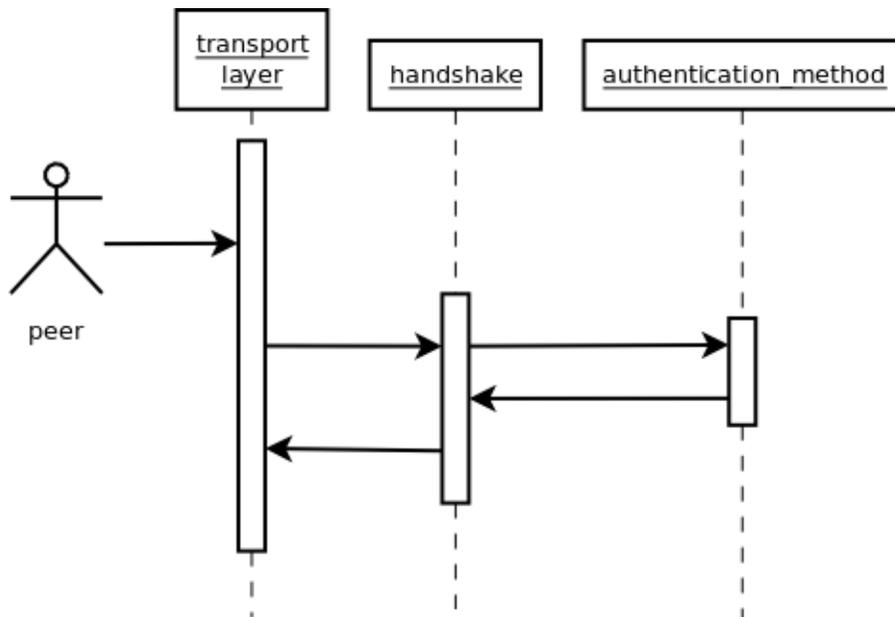


Figure 9.4: GnuTLS handshake process sequence.

9.3 TLS Authentication Methods

In GnuTLS authentication methods can be implemented quite easily. Since the required changes to add a new authentication method affect only the handshake protocol, a simple interface is used. An authentication method needs only to implement the functions as seen in [Figure 9.5](#). The functions that need to be implemented are the ones responsible for interpreting the handshake protocol messages. It is common for such functions to read data from one or more `credentials_t` structures¹ and write data, such as certificates, usernames etc. to `auth_info_t` structures.

¹ such as the `gnutls_certificate_credentials_t` structures

mod_auth_st
<pre> generate_server_certificate(in session:gnutls_session_t,out data:opaque**): int generate_client_certificate(in session:gnutls_session_t,out data:opaque**): int generate_server_kx(in session:gnutls_session_t,out data:opaque**): int generate_client_kx(in session:gnutls_session_t,out data:opaque**): int generate_client_cert_vrfy(in session:gnutls_session_t,out data:opaque**): int generate_server_certificate_request(in session:gnutls_session_t, out data:opaque**): int process_server_certificate(in session:gnutls_session_t,in data:opaque*, in data_size:size_t): int process_client_certificate(in session:gnutls_session_t,in data:opaque*, in data_size:size_t): int process_server_kx(in session:gnutls_session_t,in data:opaque*, in data_size:size_t): int process_client_kx(in session:gnutls_session_t,in data:opaque*, in data_size:size_t): int process_client_cert_vrfy(in session:gnutls_session_t,in data:opaque*, in data_size:size_t): int process_server_certificate_request(in session:gnutls_session_t, in data:opaque*,in data_size:size_t): int </pre>

Figure 9.5: GnuTLS authentication method structure.

Simple examples of existing authentication methods can be seen in `auth_psk.c` for PSK ciphersuites and `auth_srp.c` for SRP ciphersuites. After implementing these functions the structure holding its pointers has to be registered in `gnutls_algorithms.c` in the `_gnutls_kx_algorithms` structure.

9.4 TLS Extension Handling

As with authentication methods, the TLS extensions handlers can be implemented using the interface shown in [Figure 9.6](#).

extensions_st
<pre> ext_rcv_func(in session:gnutls_session_t,in data:const opaque*, in data_size:size_t): int ext_send_func(in session:gnutls_session_t,out data:opaque*, in data_size:size_t): int </pre>

Figure 9.6: GnuTLS extensions structure.

Here there are two functions, one for receiving the extension data and one for sending. These functions have to check internally whether they operate in client or server side.

A simple example of an extension handler can be seen in `ext_srp.c`. After implementing these functions, together with the extension number they handle, they have to be registered in `gnutls_extensions.c` in the `_gnutls_extensions` structure.

9.4.1 Adding a New TLS Extension

Adding support for a new TLS extension is done from time to time, and the process to do so is not difficult. Here are the steps you need to follow if you wish to do this yourself. For sake of discussion, let's consider adding support for the hypothetical TLS extension `foobar`.

1. Add `configure` option like `--enable-foobar` or `--disable-foobar`.

This step is useful when the extension code is large and it might be desirable to disable the extension under some circumstances. Otherwise it can be safely skipped.

Whether to chose enable or disable depends on whether you intend to make the extension be enabled by default. Look at existing checks (i.e., SRP, authz) for how to model the code. For example:

```
AC_MSG_CHECKING([whether to disable foobar support])
AC_ARG_ENABLE(foobar,
AS_HELP_STRING([--disable-foobar],
[disable foobar support]),
ac_enable_foobar=no)
if test x$ac_enable_foobar != xno; then
  AC_MSG_RESULT(no)
  AC_DEFINE(ENABLE_FOOBAR, 1, [enable foobar])
else
  ac_full=0
  AC_MSG_RESULT(yes)
fi
AM_CONDITIONAL(ENABLE_FOOBAR, test "$ac_enable_foobar" != "no")
```

These lines should go in `lib/m4/hooks.m4`.

2. Add IANA extension value to `extensions_t` in `gnutls_int.h`.

A good name for the value would be `GNUTLS_EXTENSION_FOOBAR`. Check with <http://www.iana.org/assignments/tls-extensiontype-values> for allocated values. For experiments, you could pick a number but remember that some consider it a bad idea to deploy such modified version since it will lead to interoperability problems in the future when the IANA allocates that number to someone else, or when the foobar protocol is allocated another number.

3. Add an entry to `_gnutls_extensions` in `gnutls_extensions.c`.

A typical entry would be:

```
int ret;

/* ...
*/

#if ENABLE_FOOBAR

ret = _gnutls_ext_register (&foobar_ext);
if (ret != GNUTLS_E_SUCCESS)
return ret;
#endif
```

Most likely you'll need to add an `#include "ext_foobar.h"`, that will contain something like like:

```
extension_entry_st foobar_ext = {
.name = "FOOBAR",
.type = GNUTLS_EXTENSION_FOOBAR,
```

```

        .parse_type = GNUTLS_EXT_TLS,
        .recv_func = _foobar_recv_params,
        .send_func = _foobar_send_params,
        .pack_func = _foobar_pack,
        .unpack_func = _foobar_unpack,
        .deinit_func = NULL
    }

```

The `GNUTLS_EXTENSION_FOOBAR` is the integer value you added to `gnutls_int.h` earlier. In this structure you specify the functions to read the extension from the hello message, the function to send the reply to, and two more functions to pack and unpack from stored session data (e.g. when resuming a session). The `deinit` function will be called to deinitialize the extension's private parameters, if any.

Note that the conditional `ENABLE_FOOBAR` definition should only be used if step 1 with the `configure` options has taken place.

4. Add new files `ext_foobar.c` and `ext_foobar.h` that implement the extension.

The functions you are responsible to add are those mentioned in the previous step. As a starter, you could add this:

```

int
_foobar_recv_params (gnutls_session_t session,
                    const opaque * data,
                    size_t data_size)
{
    return 0;
}

int
_foobar_send_params (gnutls_session_t session,
                    gnutls_buffer_st* data)
{
    return 0;
}

int
_foobar_pack (extension_priv_data_t epriv, gnutls_buffer_st * ps)
{
    /* Append the extension's internal state to buffer */
    return 0;
}

int
_foobar_unpack (gnutls_buffer_st * ps, extension_priv_data_t * epriv)
{
    /* Read the internal state from buffer */
    return 0;
}

```

The `_foobar_recv_params` function is responsible for parsing incoming extension data (both in the client and server).

The `_foobar_send_params` function is responsible for sending extension data (both in the client and server).

The `_foobar_pack` function is responsible for packing internal extension data to save them in the session storage.

The `_foobar_unpack` function is responsible for restoring session data from the session storage.

If you receive length fields that doesn't match, return `GNUTLS_E_UNEXPECTED_PACKET_LENGTH`. If you receive invalid data, return `GNUTLS_E_RECEIVED_ILLEGAL_PARAMETER`. You can use other error codes too. Return 0 on success.

The function could store some information in the `session` variable for later usage. That can be done using the functions `_gnutls_ext_set_session_data` and `_gnutls_ext_get_session_data`. You can check simple examples at `ext_max_record.c` and `ext_server_name.c` extensions.

Recall that both the client and server both send and receives parameters, and your code most likely will need to do different things depending on which mode it is in. It may be useful to make this distinction explicit in the code. Thus, for example, a better template than above would be:

```
int
_gnutls_foobar_recv_params (gnutls_session_t session,
                           const opaque * data,
                           size_t data_size)
{
    if (session->security_parameters.entity == GNUTLS_CLIENT)
        return foobar_recv_client (session, data, data_size);
    else
        return foobar_recv_server (session, data, data_size);
}

int
_gnutls_foobar_send_params (gnutls_session_t session,
                           gnutls_buffer_st * data)
{
    if (session->security_parameters.entity == GNUTLS_CLIENT)
        return foobar_send_client (session, data);
    else
        return foobar_send_server (session, data);
}
```

The functions used would be declared as `static` functions, of the appropriate prototype, in the same file.

When adding the files, you'll need to add them to `Makefile.am` as well, for example:

```
if ENABLE_FOOBAR
OBJECTS += ext_foobar.c
HFILES += ext_foobar.h
```

```
endif
```

5. Add API functions to enable/disable the extension.

Normally the client will have one API to request use of the extension, and setting some extension specific data. The server will have one API to let the library know that it is willing to accept the extension, often this is implemented through a callback but it doesn't have to.

The APIs need to be added to `includes/gnutls/gnutls.h` or `includes/gnutls/extra.h` as appropriate. It is recommended that if you don't have a requirement to use the LGPLv2.1+ license for your extension, that you place your work under the GPLv3+ license and thus in the `libgnutls-extra` library.

You can implement the API function in the `ext_foobar.c` file, or if that file ends up becoming rather larger, add a `gnutls_foobar.c` file.

To make the API available in the shared library you need to add the symbol in `lib/libgnutls.map` or `libextra/libgnutls-extra.map` as appropriate, so that the symbol is exported properly.

When writing GTK-DOC style documentation for your new APIs, don't forget to add `Since:` tags to indicate the GnuTLS version the API was introduced in.

9.5 Certificate Handling

What is provided by the certificate handling functions is summarized in [Figure 9.7](#).

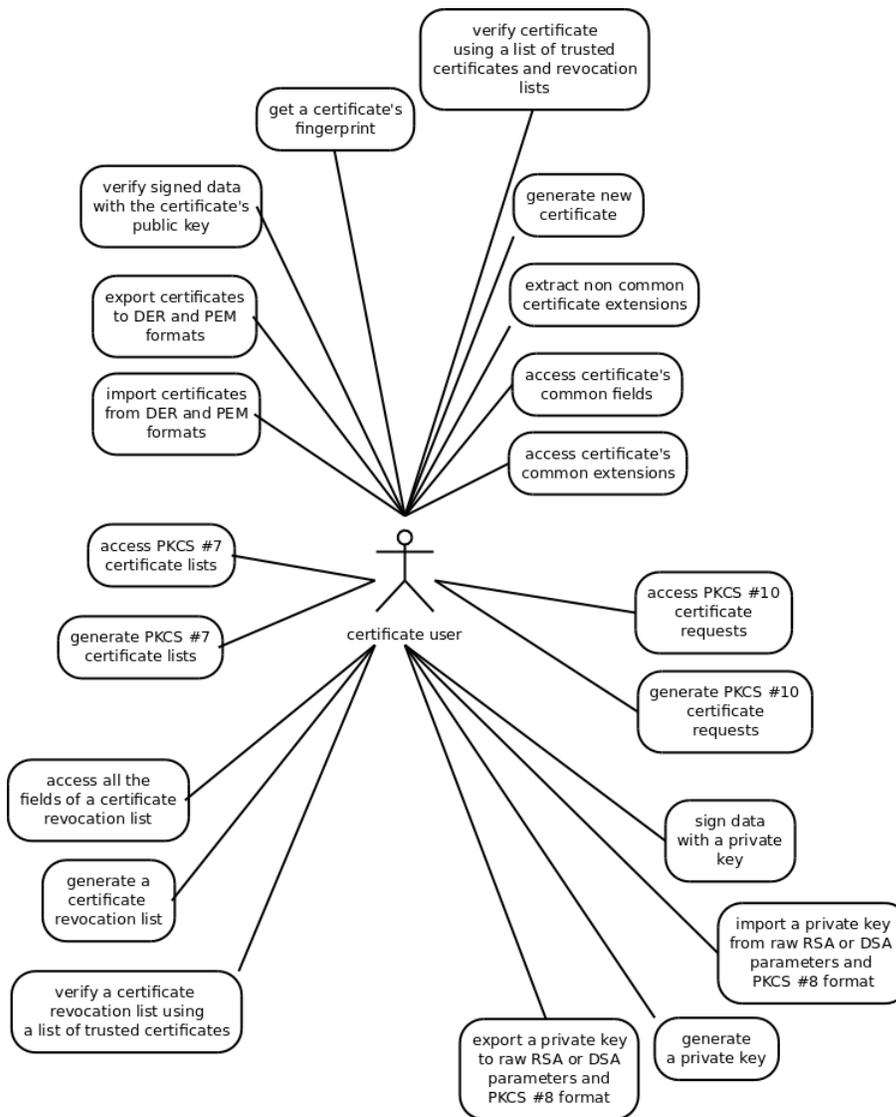


Figure 9.7: GnuTLS certificate subsystem use cases.

9.6 Cryptographic Backend

Today most new processors, either for embedded or desktop systems include either instructions intended to speed up cryptographic operations, or a co-processor with cryptographic capabilities. Taking advantage of those is a challenging task for every cryptographic application or library. Unfortunately the cryptographic libraries that GnuTLS is based on take no advantage of these properties. For this reason GnuTLS handles this internally by following a layered approach to accessing cryptographic operations as in [Figure 9.8](#).

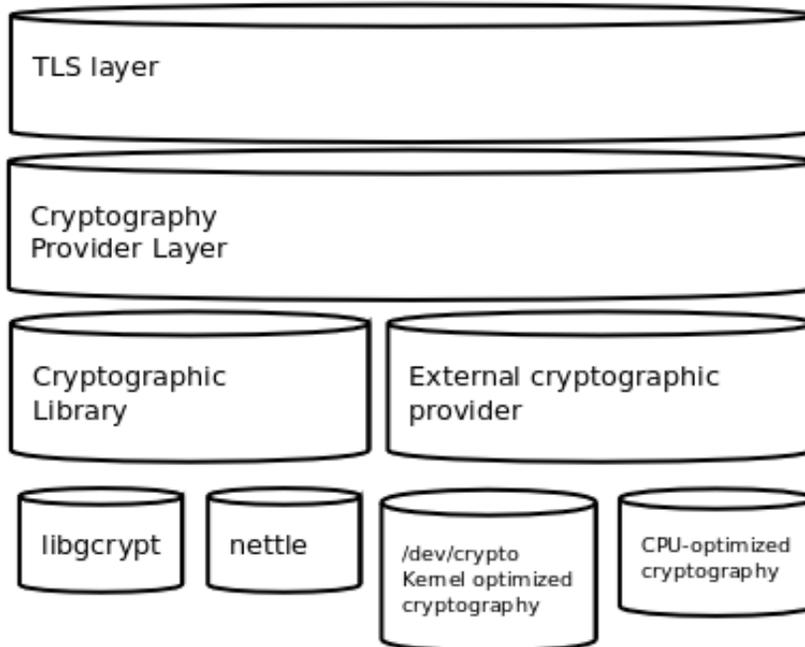


Figure 9.8: GnuTLS cryptographic back-end design.

The TLS layer uses a cryptographic provider layer, that will in turn either use the default crypto provider - a crypto library, or use an external crypto provider, if available.

9.6.1 Cryptographic Library layer

The Cryptographic Library layer, can currently be used either with `libgcrypt` or `libnettle`, each of one has its advantages and some disadvantages. `libgcrypt` is a self-contained library, pretty broad in scope that supports many algorithms. In some processors like VIA, it will also use the available crypto instruction set hence providing performance benefit comparing to plain software implementation. `libnettle` provides only software implementation of the basic algorithms required in TLS, and is on average 30% faster than `libgcrypt` on almost all algorithms. For this reason `libnettle` is library used by default in GnuTLS.

9.6.2 External cryptography provider

Systems that include a cryptographic co-processor, typically come with kernel drivers to utilize the operations from software. For this reason GnuTLS provides a layer where each individual algorithm used can be replaced by another implementation, i.e. the one provided by the driver. The FreeBSD, OpenBSD and Linux kernels² include already a number of hardware assisted implementations, and also provide an interface to access them, called `/dev/crypto`. GnuTLS will take advantage of this interface if compiled with special options.

² Check <http://home.gna.org/cryptodev-linux/> for the Linux kernel implementation of `/dev/crypto`.

That is because in most systems where hardware-assisted cryptographic operations are not available, using this interface might actually reduce performance.

In systems that include cryptographic instructions with the CPU's instructions set, using the kernel interface will introduce an unneeded layer. For this reason GnuTLS includes such optimizations found in popular processors such as the AES-NI instruction set. This is achieved using a mechanism that overrides parts of crypto backend at runtime, once the cryptographic instructions are detected.

The next section discusses the runtime possibility. The API available for this functionality is in `gnutls/crypto.h` header file.

9.6.2.1 Override specific algorithms

When an optimized implementation of a single algorithm is available, say a hardware assisted version of AES-CBC then the following functions can be used to register those algorithms.

- `gnutls_crypto_single_cipher_register` To register a cipher algorithm.
- `gnutls_crypto_single_digest_register` To register a hash (digest) or MAC algorithm.

Those registration functions will only replace the specified algorithm and leave the rest of subsystem intact.

9.6.2.2 Override parts of the backend

In some systems, such as embedded ones, it might be desirable to override big parts of the cryptographic backend, or even all of them. For this reason the following functions are provided.

- `gnutls_crypto_cipher_register` To override the cryptographic algorithms backend.
- `gnutls_crypto_digest_register` To override the digest algorithms backend.
- `gnutls_crypto_rnd_register` To override the random number generator backend.
- `gnutls_crypto_bigint_register` To override the big number number operations backend.
- `gnutls_crypto_pk_register` To override the public key encryption backend. This is tight to the big number operations so either both of them should be updated or care must be taken to use the same format.

If all of them are used then GnuTLS will no longer use libcrypto.

Appendix A Support

A.1 Getting Help

A mailing list where users may help each other exists, and you can reach it by sending e-mail to help-gnutls@gnu.org. Archives of the mailing list discussions, and an interface to manage subscriptions, is available through the World Wide Web at <http://lists.gnu.org/mailman/listinfo/help-gnutls>.

A mailing list for developers are also available, see <http://www.gnu.org/software/gnutls/lists.html>. Bug reports should be sent to bug-gnutls@gnu.org, see Section A.4 [Bug Reports], page 142.

A.2 Commercial Support

Commercial support is available for users of GnuTLS. The kind of support that can be purchased may include:

- Implement new features. Such as a new TLS extension.
- Port GnuTLS to new platforms. This could include porting to an embedded platforms that may need memory or size optimization.
- Integrating TLS as a security environment in your existing project.
- System design of components related to TLS.

If you are interested, please write to:

Simon Josefsson Datakonsult
Hagagatan 24
113 47 Stockholm
Sweden

E-mail: simon@josefsson.org

If your company provides support related to GnuTLS and would like to be mentioned here, contact the authors using the address at Section A.4 [Bug Reports], page 142.

A.3 Downloading and Installing

GnuTLS is available for download at: <http://www.gnutls.org/download.html>

GnuTLS uses a Linux-like development cycle: even minor version numbers indicate a stable release and a odd minor version number indicates a development release. For example, GnuTLS 1.6.3 denote a stable release since 6 is even, and GnuTLS 1.7.11 denote a development release since 7 is odd.

GnuTLS depends on Libnettle, and you will need to install it before installing GnuTLS. Libnettle is available from <http://www.lysator.liu.se/~nisse/nettle/>. Don't forget to verify the cryptographic signature after downloading source code packages.

The package is then extracted, configured and built like many other packages that use Autoconf. For detailed information on configuring and building it, refer to the 'INSTALL' file that is part of the distribution archive. Typically you invoke `./configure` and then `make check install`. There are a number of compile-time parameters, as discussed below.

The compression library, `libz`, is an optional dependency. You can get `libz` from <http://www.zlib.net/>.

The X.509 part of GnuTLS needs ASN.1 functionality, from a library called `libtasn1`. A copy of `libtasn1` is included in GnuTLS. If you want to install it separately (e.g., to make it possible to use `libtasn1` in other programs), you can get it from <http://www.gnu.org/software/gnutls/download.html>.

A few `configure` options may be relevant, summarized below. They disable or enable particular features.

```
--disable-srp-authentication
--disable-psk-authentication
--disable-anon-authentication
--disable-extra-pki
--disable-openpgp-authentication
--disable-openssl-compatibility
--without-p11-kit
```

For the complete list, refer to the output from `configure --help`.

A.4 Bug Reports

If you think you have found a bug in GnuTLS, please investigate it and report it.

- Please make sure that the bug is really in GnuTLS, and preferably also check that it hasn't already been fixed in the latest version.
- You have to send us a test case that makes it possible for us to reproduce the bug.
- You also have to explain what is wrong; if you get a crash, or if the results printed are not good and in that case, in what way. Make sure that the bug report includes all information you would need to fix this kind of bug for someone else.

Please make an effort to produce a self-contained report, with something definite that can be tested or debugged. Vague queries or piecemeal messages are difficult to act on and don't help the development effort.

If your bug report is good, we will do our best to help you to get a corrected version of the software; if the bug report is poor, we won't do anything about it (apart from asking you to send better bug reports).

If you think something in this manual is unclear, or downright incorrect, or if the language needs to be improved, please also send a note.

Send your bug report to:

`'bug-gnutls@gnu.org'`

A.5 Contributing

If you want to submit a patch for inclusion – from solve a typo you discovered, up to adding support for a new feature – you should submit it as a bug report, using the process in [Section A.4 \[Bug Reports\], page 142](#). There are some things that you can do to increase the chances for it to be included in the official package.

Unless your patch is very small (say, under 10 lines) we require that you assign the copyright of your work to the Free Software Foundation. This is to protect the freedom of the project.

If you have not already signed papers, we will send you the necessary information when you submit your contribution.

For contributions that doesn't consist of actual programming code, the only guidelines are common sense. Use it.

For code contributions, a number of style guides will help you:

- Coding Style. Follow the GNU Standards document.
If you normally code using another coding standard, there is no problem, but you should use `'indent'` to reformat the code before submitting your work.
- Use the unified diff format `'diff -u'`.
- Return errors. No reason whatsoever should abort the execution of the library. Even memory allocation errors, e.g. when malloc return NULL, should work although result in an error code.
- Design with thread safety in mind. Don't use global variables. Don't even write to per-handle global variables unless the documented behaviour of the function you write is to write to the per-handle global variable.
- Avoid using the C math library. It causes problems for embedded implementations, and in most situations it is very easy to avoid using it.
- Document your functions. Use comments before each function headers, that, if properly formatted, are extracted into Texinfo manuals and GTK-DOC web pages.
- Supply a ChangeLog and NEWS entries, where appropriate.

Appendix B Error Codes and Descriptions

The error codes used throughout the library are described below. The return code `GNUTLS_E_SUCCESS` indicate successful operation, and is guaranteed to have the value 0, so you can use it in logical expressions.

`GNUTLS_E_AGAIN:`

Resource temporarily unavailable, try again.

`GNUTLS_E_ASN1_DER_ERROR:`

ASN1 parser: Error in DER parsing.

`GNUTLS_E_ASN1_DER_OVERFLOW:`

ASN1 parser: Overflow in DER parsing.

`GNUTLS_E_ASN1_ELEMENT_NOT_FOUND:`

ASN1 parser: Element was not found.

`GNUTLS_E_ASN1_GENERIC_ERROR:`

ASN1 parser: Generic parsing error.

`GNUTLS_E_ASN1_IDENTIFIER_NOT_FOUND:`

ASN1 parser: Identifier was not found

`GNUTLS_E_ASN1_SYNTAX_ERROR:`

ASN1 parser: Syntax error.

`GNUTLS_E_ASN1_TAG_ERROR:`

ASN1 parser: Error in TAG.

`GNUTLS_E_ASN1_TAG_IMPLICIT:`

ASN1 parser: error in implicit tag

`GNUTLS_E_ASN1_TYPE_ANY_ERROR:`

ASN1 parser: Error in type 'ANY'.

`GNUTLS_E_ASN1_VALUE_NOT_FOUND:`

ASN1 parser: Value was not found.

`GNUTLS_E_ASN1_VALUE_NOT_VALID:`

ASN1 parser: Value is not valid.

`GNUTLS_E_BAD_COOKIE:`

The cookie was bad.

`GNUTLS_E_BASE64_DECODING_ERROR:`

Base64 decoding error.

`GNUTLS_E_BASE64_ENCODING_ERROR:`

Base64 encoding error.

`GNUTLS_E_BASE64_UNEXPECTED_HEADER_ERROR:`

Base64 unexpected header error.

`GNUTLS_E_CERTIFICATE_ERROR:`

Error in the certificate.

- GNUTLS_E_CERTIFICATE_KEY_MISMATCH:**
The certificate and the given key do not match.
- GNUTLS_E_CHANNEL_BINDING_NOT_AVAILABLE:**
Channel binding data not available
- GNUTLS_E_COMPRESSION_FAILED:**
Compression of the TLS record packet has failed.
- GNUTLS_E_CONSTRAINT_ERROR:**
Some constraint limits were reached.
- GNUTLS_E_CRYPTODEV_DEVICE_ERROR:**
Error opening /dev/crypto
- GNUTLS_E_CRYPTODEV_IOCTL_ERROR:**
Error interfacing with /dev/crypto
- GNUTLS_E_CRYPTO_ALREADY_REGISTERED:**
There is already a crypto algorithm with lower priority.
- GNUTLS_E_CRYPTO_INIT_FAILED:**
The initialization of crypto backend has failed.
- GNUTLS_E_DB_ERROR:**
Error in Database backend.
- GNUTLS_E_DECOMPRESSION_FAILED:**
Decompression of the TLS record packet has failed.
- GNUTLS_E_DECRYPTION_FAILED:**
Decryption has failed.
- GNUTLS_E_DH_PRIME_UNACCEPTABLE:**
The Diffie-Hellman prime sent by the server is not acceptable (not long enough).
- GNUTLS_E_ECC_NO_SUPPORTED_CURVES:**
No supported ECC curves were found
- GNUTLS_E_ECC_UNSUPPORTED_CURVE:**
The curve is unsupported
- GNUTLS_E_ENCRYPTION_FAILED:**
Encryption has failed.
- GNUTLS_E_ERROR_IN_FINISHED_PACKET:**
An error was encountered at the TLS Finished packet calculation.
- GNUTLS_E_EXPIRED:**
The requested session has expired.
- GNUTLS_E_FATAL_ALERT_RECEIVED:**
A TLS fatal alert has been received.
- GNUTLS_E_FILE_ERROR:**
Error while reading file.

- GNUTLS_E_GOT_APPLICATION_DATA:**
TLS Application data were received, while expecting handshake data.
- GNUTLS_E_HANDSHAKE_TOO_LARGE:**
The handshake data size is too large.
- GNUTLS_E_HASH_FAILED:**
Hashing has failed.
- GNUTLS_E_IA_VERIFY_FAILED:**
Verifying TLS/IA phase checksum failed
- GNUTLS_E_ILLEGAL_SRP_USERNAME:**
The SRP username supplied is illegal.
- GNUTLS_E_INCOMPATIBLE_GCRYPT_LIBRARY:**
The crypto library version is too old.
- GNUTLS_E_INCOMPATIBLE_LIBTASN1_LIBRARY:**
The tasn1 library version is too old.
- GNUTLS_E_INCOMPAT_DSA_KEY_WITH_TLS_PROTOCOL:**
The given DSA key is incompatible with the selected TLS protocol.
- GNUTLS_E_INIT_LIBEXTRA:**
The initialization of GnuTLS-extra has failed.
- GNUTLS_E_INSUFFICIENT_CREDENTIALS:**
Insufficient credentials for that request.
- GNUTLS_E_INTERNAL_ERROR:**
GnuTLS internal error.
- GNUTLS_E_INTERRUPTED:**
Function was interrupted.
- GNUTLS_E_INVALID_PASSWORD:**
The given password contains invalid characters.
- GNUTLS_E_INVALID_REQUEST:**
The request is invalid.
- GNUTLS_E_INVALID_SESSION:**
The specified session has been invalidated for some reason.
- GNUTLS_E_KEY_USAGE_VIOLATION:**
Key usage violation in certificate has been detected.
- GNUTLS_E_LARGE_PACKET:**
A large TLS record packet was received.
- GNUTLS_E_LIBRARY_VERSION_MISMATCH:**
The GnuTLS library version does not match the GnuTLS-extra library version.
- GNUTLS_E_LOCKING_ERROR:**
Thread locking error

GNUTLS_E_MAC_VERIFY_FAILED:
The Message Authentication Code verification failed.

GNUTLS_E_MEMORY_ERROR:
Internal error in memory allocation.

GNUTLS_E_MPI_PRINT_FAILED:
Could not export a large integer.

GNUTLS_E_MPI_SCAN_FAILED:
The scanning of a large integer has failed.

GNUTLS_E_NO_CERTIFICATE_FOUND:
The peer did not send any certificate.

GNUTLS_E_NO_CIPHER_SUITES:
No supported cipher suites have been found.

GNUTLS_E_NO_COMPRESSION_ALGORITHMS:
No supported compression algorithms have been found.

GNUTLS_E_NO_TEMPORARY_DH_PARAMS:
No temporary DH parameters were found.

GNUTLS_E_NO_TEMPORARY_RSA_PARAMS:
No temporary RSA parameters were found.

GNUTLS_E_OPENPGP_FINGERPRINT_UNSUPPORTED:
The OpenPGP fingerprint is not supported.

GNUTLS_E_OPENPGP_GETKEY_FAILED:
Could not get OpenPGP key.

GNUTLS_E_OPENPGP_KEYRING_ERROR:
Error loading the keyring.

GNUTLS_E_OPENPGP_PREFERRED_KEY_ERROR:
The OpenPGP key has not a preferred key set.

GNUTLS_E_OPENPGP_SUBKEY_ERROR:
Could not find OpenPGP subkey.

GNUTLS_E_OPENPGP_UID_REVOKED:
The OpenPGP User ID is revoked.

GNUTLS_E_PARSING_ERROR:
Error in parsing.

GNUTLS_E_PKCS11_ATTRIBUTE_ERROR:
PKCS #11 error in attribute

GNUTLS_E_PKCS11_DATA_ERROR:
PKCS #11 error in data

GNUTLS_E_PKCS11_DEVICE_ERROR:
PKCS #11 error in device

GNUTLS_E_PKCS11_ERROR:
PKCS #11 error.

GNUTLS_E_PKCS11_KEY_ERROR:
PKCS #11 error in key

GNUTLS_E_PKCS11_LOAD_ERROR:
PKCS #11 initialization error.

GNUTLS_E_PKCS11_PIN_ERROR:
PKCS #11 error in PIN.

GNUTLS_E_PKCS11_PIN_EXPIRED:
PKCS #11 PIN expired

GNUTLS_E_PKCS11_PIN_LOCKED:
PKCS #11 PIN locked

GNUTLS_E_PKCS11_REQUESTED_OBJECT_NOT_AVAILABLE:
The requested PKCS #11 object is not available

GNUTLS_E_PKCS11_SESSION_ERROR:
PKCS #11 error in session

GNUTLS_E_PKCS11_SIGNATURE_ERROR:
PKCS #11 error in signature

GNUTLS_E_PKCS11_SLOT_ERROR:
PKCS #11 error in slot

GNUTLS_E_PKCS11_TOKEN_ERROR:
PKCS #11 error in token

GNUTLS_E_PKCS11_UNSUPPORTED_FEATURE_ERROR:
PKCS #11 unsupported feature

GNUTLS_E_PKCS11_USER_ERROR:
PKCS #11 user error

GNUTLS_E_PKCS1_WRONG_PAD:
Wrong padding in PKCS1 packet.

GNUTLS_E_PK_DECRYPTION_FAILED:
Public key decryption has failed.

GNUTLS_E_PK_ENCRYPTION_FAILED:
Public key encryption has failed.

GNUTLS_E_PK_SIGN_FAILED:
Public key signing has failed.

GNUTLS_E_PK_SIG_VERIFY_FAILED:
Public key signature verification has failed.

GNUTLS_E_PREMATURE_TERMINATION:
The TLS connection was non-properly terminated.

GNUTLS_E_PULL_ERROR:
Error in the pull function.

GNUTLS_E_PUSH_ERROR:
Error in the push function.

GNUTLS_E_RANDOM_FAILED:
Failed to acquire random data.

GNUTLS_E_RECEIVED_ILLEGAL_EXTENSION:
An illegal TLS extension was received.

GNUTLS_E_RECEIVED_ILLEGAL_PARAMETER:
An illegal parameter has been received.

GNUTLS_E_RECORD_LIMIT_REACHED:
The upper limit of record packet sequence numbers has been reached. Wow!

GNUTLS_E_REHANDSHAKE:
Rehandshake was requested by the peer.

GNUTLS_E_REQUESTED_DATA_NOT_AVAILABLE:
The requested data were not available.

GNUTLS_E_SAFE_RENEGOTIATION_FAILED:
Safe renegotiation failed.

GNUTLS_E_SHORT_MEMORY_BUFFER:
The given memory buffer is too short to hold parameters.

GNUTLS_E_SRP_PWD_ERROR:
Error in password file.

GNUTLS_E_SRP_PWD_PARSING_ERROR:
Parsing error in password file.

GNUTLS_E_SUCCESS:
Success.

GNUTLS_E_TIMEDOUT:
The operation timed out

GNUTLS_E_TOO_MANY_EMPTY_PACKETS:
Too many empty record packets have been received.

GNUTLS_E_TOO_MANY_HANDSHAKE_PACKETS:
Too many handshake packets have been received.

GNUTLS_E_UNEXPECTED_HANDSHAKE_PACKET:
An unexpected TLS handshake packet was received.

GNUTLS_E_UNEXPECTED_PACKET:
An unexpected TLS packet was received.

GNUTLS_E_UNEXPECTED_PACKET_LENGTH:
A TLS packet with unexpected length was received.

GNUTLS_E_UNKNOWN_ALGORITHM:	The specified algorithm or protocol is unknown.
GNUTLS_E_UNKNOWN_CIPHER_SUITE:	Could not negotiate a supported cipher suite.
GNUTLS_E_UNKNOWN_CIPHER_TYPE:	The cipher type is unsupported.
GNUTLS_E_UNKNOWN_COMPRESSION_ALGORITHM:	Could not negotiate a supported compression method.
GNUTLS_E_UNKNOWN_HASH_ALGORITHM:	The hash algorithm is unknown.
GNUTLS_E_UNKNOWN_PKCS_BAG_TYPE:	The PKCS structure's bag type is unknown.
GNUTLS_E_UNKNOWN_PKCS_CONTENT_TYPE:	The PKCS structure's content type is unknown.
GNUTLS_E_UNKNOWN_PK_ALGORITHM:	An unknown public key algorithm was encountered.
GNUTLS_E_UNKNOWN_SRP_USERNAME:	The SRP username supplied is unknown.
GNUTLS_E_UNSAFE_RENEGOTIATION_DENIED:	Unsafe renegotiation denied.
GNUTLS_E_UNSUPPORTED_CERTIFICATE_TYPE:	The certificate type is not supported.
GNUTLS_E_UNSUPPORTED_SIGNATURE_ALGORITHM:	The signature algorithm is not supported.
GNUTLS_E_UNSUPPORTED_VERSION_PACKET:	A record packet with illegal version was received.
GNUTLS_E_UNWANTED_ALGORITHM:	An algorithm that is not enabled was negotiated.
GNUTLS_E_USER_ERROR:	The operation was cancelled due to user error
GNUTLS_E_WARNING_ALERT_RECEIVED:	A TLS warning alert has been received.
GNUTLS_E_WARNING_IA_FPHF_RECEIVED:	Received a TLS/IA Final Phase Finished message
GNUTLS_E_WARNING_IA_IPHF_RECEIVED:	Received a TLS/IA Intermediate Phase Finished message
GNUTLS_E_X509_UNKNOWN_SAN:	Unknown Subject Alternative name in X.509 certificate.

`GNUTLS_E_X509_UNSUPPORTED_ATTRIBUTE:`

The certificate has unsupported attributes.

`GNUTLS_E_X509_UNSUPPORTED_CRITICAL_EXTENSION:`

Unsupported critical extension in X.509 certificate.

`GNUTLS_E_X509_UNSUPPORTED_OID:`

The OID is not supported.

Appendix C Function Reference

C.1 Core Functions

The prototypes for the following functions lie in ‘gnutls/gnutls.h’.

gnutls_alert_get_name

```
const char * gnutls_alert_get_name (gnutls_alert_description_t      [Function]
    alert)
```

alert: is an alert number.

This function will return a string that describes the given alert number, or NULL. See `gnutls_alert_get()`.

Returns: string corresponding to `gnutls_alert_description_t` value.

gnutls_alert_get_strname

```
const char * gnutls_alert_get_strname (gnutls_alert_description_t  [Function]
    alert)
```

alert: is an alert number.

This function will return a string of the name of the alert.

Returns: string corresponding to `gnutls_alert_description_t` value.

gnutls_alert_get

```
gnutls_alert_description_t gnutls_alert_get (gnutls_session_t      [Function]
    session)
```

session: is a `gnutls_session_t` structure.

This function will return the last alert number received. This function should be called when `GNUTLS_E_WARNING_ALERT_RECEIVED` or `GNUTLS_E_FATAL_ALERT_RECEIVED` errors are returned by a gnutls function. The peer may send alerts if he encounters an error. If no alert has been received the returned value is undefined.

Returns: the last alert received, a `gnutls_alert_description_t` value.

gnutls_alert_send_appropriate

```
int gnutls_alert_send_appropriate (gnutls_session_t session, int   [Function]
    err)
```

session: is a `gnutls_session_t` structure.

err: is an integer

Sends an alert to the peer depending on the error code returned by a gnutls function. This function will call `gnutls_error_to_alert()` to determine the appropriate alert to send.

This function may also return `GNUTLS_E_AGAIN`, or `GNUTLS_E_INTERRUPTED`.

If the return value is `GNUTLS_E_INVALID_REQUEST`, then no alert has been sent to the peer.

Returns: On success, `GNUTLS_E_SUCCESS` (0) is returned, otherwise an error code is returned.

gnutls_alert_send

`int gnutls_alert_send (gnutls_session_t session, gnutls_alert_level_t level, gnutls_alert_description_t desc)` [Function]

session: is a `gnutls_session_t` structure.

level: is the level of the alert

desc: is the alert description

This function will send an alert to the peer in order to inform him of something important (eg. his Certificate could not be verified). If the alert level is Fatal then the peer is expected to close the connection, otherwise he may ignore the alert and continue.

The error code of the underlying record send function will be returned, so you may also receive `GNUTLS_E_INTERRUPTED` or `GNUTLS_E_AGAIN` as well.

Returns: On success, `GNUTLS_E_SUCCESS` (0) is returned, otherwise an error code is returned.

gnutls_anon_allocate_client_credentials

`int gnutls_anon_allocate_client_credentials (gnutls_anon_client_credentials_t * sc)` [Function]

sc: is a pointer to a `gnutls_anon_client_credentials_t` structure.

This structure is complex enough to manipulate directly thus this helper function is provided in order to allocate it.

Returns: `GNUTLS_E_SUCCESS` on success, or an error code.

gnutls_anon_allocate_server_credentials

`int gnutls_anon_allocate_server_credentials (gnutls_anon_server_credentials_t * sc)` [Function]

sc: is a pointer to a `gnutls_anon_server_credentials_t` structure.

This structure is complex enough to manipulate directly thus this helper function is provided in order to allocate it.

Returns: `GNUTLS_E_SUCCESS` on success, or an error code.

gnutls_anon_free_client_credentials

`void gnutls_anon_free_client_credentials (gnutls_anon_client_credentials_t sc)` [Function]

sc: is a `gnutls_anon_client_credentials_t` structure.

This structure is complex enough to manipulate directly thus this helper function is provided in order to free (deallocate) it.

gnutls_anon_free_server_credentials

`void gnutls_anon_free_server_credentials (gnutls_anon_server_credentials_t sc)` [Function]

sc: is a `gnutls_anon_server_credentials_t` structure.

This structure is complex enough to manipulate directly thus this helper function is provided in order to free (deallocate) it.

gnutls_anon_set_params_function

```
void gnutls_anon_set_params_function [Function]
    (gnutls_anon_server_credentials_t res, gnutls_params_function * func)
```

res: is a *gnutls_anon_server_credentials_t* structure

func: is the function to be called

This function will set a callback in order for the server to get the Diffie-Hellman or RSA parameters for anonymous authentication. The callback should return `GNUTLS_E_SUCCESS (0)` on success.

gnutls_anon_set_server_dh_params

```
void gnutls_anon_set_server_dh_params [Function]
    (gnutls_anon_server_credentials_t res, gnutls_dh_params_t dh_params)
```

res: is a *gnutls_anon_server_credentials_t* structure

dh_params: is a structure that holds Diffie-Hellman parameters.

This function will set the Diffie-Hellman parameters for an anonymous server to use. These parameters will be used in Anonymous Diffie-Hellman cipher suites.

gnutls_anon_set_server_params_function

```
void gnutls_anon_set_server_params_function [Function]
    (gnutls_anon_server_credentials_t res, gnutls_params_function * func)
```

res: is a *gnutls_certificate_credentials_t* structure

func: is the function to be called

This function will set a callback in order for the server to get the Diffie-Hellman parameters for anonymous authentication. The callback should return `GNUTLS_E_SUCCESS (0)` on success.

gnutls_auth_client_get_type

```
gnutls_credentials_type_t gnutls_auth_client_get_type [Function]
    (gnutls_session_t session)
```

session: is a *gnutls_session_t* structure.

Returns the type of credentials that were used for client authentication. The returned information is to be used to distinguish the function used to access authentication data.

Returns: The type of credentials for the client authentication schema, a *gnutls_credentials_type_t* type.

gnutls_auth_get_type

```
gnutls_credentials_type_t gnutls_auth_get_type [Function]
    (gnutls_session_t session)
```

session: is a *gnutls_session_t* structure.

Returns type of credentials for the current authentication schema. The returned information is to be used to distinguish the function used to access authentication data.

Eg. for CERTIFICATE ciphersuites (key exchange algorithms: GNUTLS_KX_RSA, GNUTLS_KX_DHE_RSA), the same function are to be used to access the authentication data.

Returns: The type of credentials for the current authentication schema, a `gnutls_credentials_type_t` type.

gnutls_auth_server_get_type

`gnutls_credentials_type_t gnutls_auth_server_get_type` [Function]
(*gnutls_session_t session*)

session: is a `gnutls_session_t` structure.

Returns the type of credentials that were used for server authentication. The returned information is to be used to distinguish the function used to access authentication data.

Returns: The type of credentials for the server authentication schema, a `gnutls_credentials_type_t` type.

gnutls_bye

`int gnutls_bye` (*gnutls_session_t session*, *gnutls_close_request_t how*) [Function]
session: is a `gnutls_session_t` structure.

how: is an integer

Terminates the current TLS/SSL connection. The connection should have been initiated using `gnutls_handshake()`. *how* should be one of GNUTLS_SHUT_RDWR, GNUTLS_SHUT_WR.

In case of GNUTLS_SHUT_RDWR then the TLS connection gets terminated and further receives and sends will be disallowed. If the return value is zero you may continue using the connection. GNUTLS_SHUT_RDWR actually sends an alert containing a close request and waits for the peer to reply with the same message.

In case of GNUTLS_SHUT_WR then the TLS connection gets terminated and further sends will be disallowed. In order to reuse the connection you should wait for an EOF from the peer. GNUTLS_SHUT_WR sends an alert containing a close request.

Note that not all implementations will properly terminate a TLS connection. Some of them, usually for performance reasons, will terminate only the underlying transport layer, thus causing a transmission error to the peer. This error cannot be distinguished from a malicious party prematurely terminating the session, thus this behavior is not recommended.

This function may also return GNUTLS_E_AGAIN or GNUTLS_E_INTERRUPTED; cf. `gnutls_record_get_direction()`.

Returns: GNUTLS_E_SUCCESS on success, or an error code, see function documentation for entire semantics.

gnutls_certificate_activation_time_peers

`time_t gnutls_certificate_activation_time_peers` [Function]
 (`gnutls_session_t session`)

session: is a gnutls session

This function will return the peer's certificate activation time. This is the creation time for openpgp keys.

Returns: (time_t)-1 on error.

Deprecated: `gnutls_certificate_verify_peers2()` now verifies activation times.

gnutls_certificate_allocate_credentials

`int gnutls_certificate_allocate_credentials` [Function]
 (`gnutls_certificate_credentials_t * res`)

res: is a pointer to a `gnutls_certificate_credentials_t` structure.

This structure is complex enough to manipulate directly thus this helper function is provided in order to allocate it.

Returns: `GNUTLS_E_SUCCESS` on success, or an error code.

gnutls_certificate_client_get_request_status

`int gnutls_certificate_client_get_request_status` [Function]
 (`gnutls_session_t session`)

session: is a gnutls session

Get whether client certificate is requested or not.

Returns: 0 if the peer (server) did not request client authentication or 1 otherwise, or a negative error code in case of error.

gnutls_certificate_client_set_retrieve_function

`void gnutls_certificate_client_set_retrieve_function` [Function]
 (`gnutls_certificate_credentials_t cred`, `gnutls_certificate_client_retrieve_function * func`)

cred: is a `gnutls_certificate_credentials_t` structure.

func: is the callback function

This function sets a callback to be called in order to retrieve the certificate to be used in the handshake. You are advised to use `gnutls_certificate_set_retrieve_function2()` because it is much more efficient in the processing it requires from gnutls.

The callback's function prototype is: `int (*callback)(gnutls_session_t, const gnutls_datum_t* req_ca_dn, int nreqs, const gnutls_pk_algorithm_t* pk_algos, int pk_algos_length, gnutls_retr_st* st);`

`req_ca_cert` is only used in X.509 certificates. Contains a list with the CA names that the server considers trusted. Normally we should send a certificate that is signed by one of these CAs. These names are DER encoded. To get a more meaningful value use the function `gnutls_x509_rdn_get()`.

`pk_algos` contains a list with server's acceptable signature algorithms. The certificate returned should support the server's given algorithms.

`st` should contain the certificates and private keys.

If the callback function is provided then `gnutls` will call it, in the handshake, after the certificate request message has been received.

The callback function should set the certificate list to be sent, and return 0 on success.

If no certificate was selected then the number of certificates should be set to zero.

The value (-1) indicates error and the handshake will be terminated.

`gnutls_certificate_expiration_time_peers`

`time_t gnutls_certificate_expiration_time_peers` [Function]
 (`gnutls_session_t session`)

`session`: is a `gnutls_session`

This function will return the peer's certificate expiration time.

Returns: (time_t)-1 on error.

Deprecated: `gnutls_certificate_verify_peers2()` now verifies expiration times.

`gnutls_certificate_free_ca_names`

`void gnutls_certificate_free_ca_names` [Function]
 (`gnutls_certificate_credentials_t sc`)

`sc`: is a `gnutls_certificate_credentials_t` structure.

This function will delete all the CA name in the given credentials. Clients may call this to save some memory since in client side the CA names are not used. Servers might want to use this function if a large list of trusted CAs is present and sending the names of it would just consume bandwidth without providing information to client.

CA names are used by servers to advertize the CAs they support to clients.

`gnutls_certificate_free_cas`

`void gnutls_certificate_free_cas` (`gnutls_certificate_credentials_t` [Function]
`sc`)

`sc`: is a `gnutls_certificate_credentials_t` structure.

This function will delete all the CAs associated with the given credentials. Servers that do not use `gnutls_certificate_verify_peers2()` may call this to save some memory.

`gnutls_certificate_free_credentials`

`void gnutls_certificate_free_credentials` [Function]
 (`gnutls_certificate_credentials_t sc`)

`sc`: is a `gnutls_certificate_credentials_t` structure.

This structure is complex enough to manipulate directly thus this helper function is provided in order to free (deallocate) it.

This function does not free any temporary parameters associated with this structure (ie RSA and DH parameters are not freed by this function).

gnutls_certificate_free_crls

```
void gnutls_certificate_free_crls (gnutls_certificate_credentials_t [Function]
    sc)
```

sc: is a `gnutls_certificate_credentials_t` structure.

This function will delete all the CRLs associated with the given credentials.

gnutls_certificate_free_keys

```
void gnutls_certificate_free_keys (gnutls_certificate_credentials_t [Function]
    sc)
```

sc: is a `gnutls_certificate_credentials_t` structure.

This function will delete all the keys and the certificates associated with the given credentials. This function must not be called when a TLS negotiation that uses the credentials is in progress.

gnutls_certificate_get_issuer

```
int gnutls_certificate_get_issuer (gnutls_certificate_credentials_t [Function]
    sc, gnutls_x509_cert_t cert, gnutls_x509_cert_t* issuer, unsigned int flags)
```

sc: is a `gnutls_certificate_credentials_t` structure.

cert: is the certificate to find issuer for

issuer: Will hold the issuer if any. Should be treated as constant.

flags: Use zero.

This function will return the issuer of a given certificate.

Returns: On success, `GNUTLS_E_SUCCESS (0)` is returned, otherwise a negative error value.

gnutls_certificate_get_ours

```
const gnutls_datum_t * gnutls_certificate_get_ours [Function]
    (gnutls_session_t session)
```

session: is a gnutls session

Get the certificate as sent to the peer, in the last handshake. These certificates are in raw format. In X.509 this is a certificate list. In OpenPGP this is a single certificate.

Returns: return a pointer to a `gnutls_datum_t` containing our certificates, or `NULL` in case of an error or if no certificate was used.

gnutls_certificate_get_peers

```
const gnutls_datum_t * gnutls_certificate_get_peers [Function]
    (gnutls_session_t session, unsigned int * list_size)
```

session: is a gnutls session

list_size: is the length of the certificate list

Get the peer's raw certificate (chain) as sent by the peer. These certificates are in raw format (DER encoded for X.509). In case of a X.509 then a certificate list may be

present. The first certificate in the list is the peer's certificate, following the issuer's certificate, then the issuer's issuer etc.

In case of OpenPGP keys a single key will be returned in raw format.

Returns: return a pointer to a `gnutls_datum_t` containing our certificates, or NULL in case of an error or if no certificate was used.

`gnutls_certificate_send_x509_rdn_sequence`

`void gnutls_certificate_send_x509_rdn_sequence` [Function]
 (`gnutls_session_t session`, `int status`)

`session`: is a pointer to a `gnutls_session_t` structure.

`status`: is 0 or 1

If `status` is non zero, this function will order gnutls not to send the `rdnSequence` in the certificate request message. That is the server will not advertize it's trusted CAs to the peer. If `status` is zero then the default behaviour will take effect, which is to advertize the server's trusted CAs.

This function has no effect in clients, and in authentication methods other than certificate with X.509 certificates.

`gnutls_certificate_server_set_request`

`void gnutls_certificate_server_set_request` (`gnutls_session_t` [Function]
 `session`, `gnutls_certificate_request_t req`)

`session`: is a `gnutls_session_t` structure.

`req`: is one of `GNUTLS_CERT_REQUEST`, `GNUTLS_CERT_REQUIRE`

This function specifies if we (in case of a server) are going to send a certificate request message to the client. If `req` is `GNUTLS_CERT_REQUIRE` then the server will return an error if the peer does not provide a certificate. If you do not call this function then the client will not be asked to send a certificate.

`gnutls_certificate_server_set_retrieve_function`

`void gnutls_certificate_server_set_retrieve_function` [Function]
 (`gnutls_certificate_credentials_t cred`,
 `gnutls_certificate_server_retrieve_function * func`)

`cred`: is a `gnutls_certificate_credentials_t` structure.

`func`: is the callback function

This function sets a callback to be called in order to retrieve the certificate to be used in the handshake. You are advised to use `gnutls_certificate_set_retrieve_function2()` because it is much more efficient in the processing it requires from gnutls.

The callback's function prototype is: `int (*callback)(gnutls_session_t, gnutls_retr_st* st);`

`st` should contain the certificates and private keys.

If the callback function is provided then gnutls will call it, in the handshake, after the certificate request message has been received.

The callback function should set the certificate list to be sent, and return 0 on success. The value (-1) indicates error and the handshake will be terminated.

gnutls_certificate_set_dh_params

void gnutls_certificate_set_dh_params [Function]
 (*gnutls_certificate_credentials_t res, gnutls_dh_params_t dh_params*)

res: is a `gnutls_certificate_credentials_t` structure

dh_params: is a structure that holds Diffie-Hellman parameters.

This function will set the Diffie-Hellman parameters for a certificate server to use. These parameters will be used in Ephemeral Diffie-Hellman cipher suites. Note that only a pointer to the parameters are stored in the certificate handle, so if you deallocate the parameters before the certificate is deallocated, you must change the parameters stored in the certificate first.

gnutls_certificate_set_params_function

void gnutls_certificate_set_params_function [Function]
 (*gnutls_certificate_credentials_t res, gnutls_params_function * func*)

res: is a `gnutls_certificate_credentials_t` structure

func: is the function to be called

This function will set a callback in order for the server to get the Diffie-Hellman or RSA parameters for certificate authentication. The callback should return `GNUTLS_E_SUCCESS (0)` on success.

gnutls_certificate_set_retrieve_function2

void gnutls_certificate_set_retrieve_function2 [Function]
 (*gnutls_certificate_credentials_t cred, gnutls_certificate_retrieve_function2 * func*)

cred: is a `gnutls_certificate_credentials_t` structure.

func: is the callback function

This function sets a callback to be called in order to retrieve the certificate to be used in the handshake.

The callback's function prototype is: `int (*callback)(gnutls_session_t, const gnutls_datum_t* req_ca_dn, int nreqs, const gnutls_pk_algorithm_t* pk_algos, int pk_algos_length, gnutls_pcert_st* st);`

`req_ca_cert` is only used in X.509 certificates. Contains a list with the CA names that the server considers trusted. Normally we should send a certificate that is signed by one of these CAs. These names are DER encoded. To get a more meaningful value use the function `gnutls_x509_rdn_get()`.

`pk_algos` contains a list with server's acceptable signature algorithms. The certificate returned should support the server's given algorithms.

`st` should contain the certificates and private keys.

If the callback function is provided then `gnutls` will call it, in the handshake, after the certificate request message has been received.

In server side `pk_algos` and `req_ca_dn` are NULL.

The callback function should set the certificate list to be sent, and return 0 on success. If no certificate was selected then the number of certificates should be set to zero. The value (-1) indicates error and the handshake will be terminated.

gnutls_certificate_set_retrieve_function

```
void gnutls_certificate_set_retrieve_function          [Function]
      (gnutls_certificate_credentials_t cred, gnutls_certificate_retrieve_function *
      func)
```

cred: is a `gnutls_certificate_credentials_t` structure.

func: is the callback function

This function sets a callback to be called in order to retrieve the certificate to be used in the handshake. You are advised to use `gnutls_certificate_set_retrieve_function2()` because it is much more efficient in the processing it requires from gnutls.

The callback's function prototype is: `int (*callback)(gnutls_session_t, const gnutls_datum_t* req_ca_dn, int nreqs, const gnutls_pk_algorithm_t* pk_algos, int pk_algos_length, gnutls_retr2_st* st);`

`req_ca_cert` is only used in X.509 certificates. Contains a list with the CA names that the server considers trusted. Normally we should send a certificate that is signed by one of these CAs. These names are DER encoded. To get a more meaningful value use the function `gnutls_x509_rdn_get()`.

`pk_algos` contains a list with server's acceptable signature algorithms. The certificate returned should support the server's given algorithms.

`st` should contain the certificates and private keys.

If the callback function is provided then gnutls will call it, in the handshake, after the certificate request message has been received.

In server side `pk_algos` and `req_ca_dn` are NULL.

The callback function should set the certificate list to be sent, and return 0 on success. If no certificate was selected then the number of certificates should be set to zero. The value (-1) indicates error and the handshake will be terminated.

gnutls_certificate_set_rsa_export_params

```
void gnutls_certificate_set_rsa_export_params        [Function]
      (gnutls_certificate_credentials_t res, gnutls_rsa_params_t rsa_params)
```

res: is a `gnutls_certificate_credentials_t` structure

rsa_params: is a structure that holds temporary RSA parameters.

This function will set the temporary RSA parameters for a certificate server to use. These parameters will be used in RSA-EXPORT cipher suites.

gnutls_certificate_set_verify_flags

`void gnutls_certificate_set_verify_flags` [Function]

(*gnutls_certificate_credentials_t res*, *unsigned int flags*)

res: is a `gnutls_certificate_credentials_t` structure

flags: are the flags

This function will set the flags to be used at verification of the certificates. Flags must be OR of the `gnutls_certificate_verify_flags` enumerations.

gnutls_certificate_set_verify_function

`void gnutls_certificate_set_verify_function` [Function]

(*gnutls_certificate_credentials_t cred*, *gnutls_certificate_verify_function * func*)

cred: is a `gnutls_certificate_credentials_t` structure.

func: is the callback function

This function sets a callback to be called when peer's certificate has been received in order to verify it on receipt rather than doing after the handshake is completed.

The callback's function prototype is: `int (*callback)(gnutls_session_t);`

If the callback function is provided then gnutls will call it, in the handshake, just after the certificate message has been received. To verify or obtain the certificate the `gnutls_certificate_verify_peers2()`, `gnutls_certificate_type_get()`, `gnutls_certificate_get_peers()` functions can be used.

The callback function should return 0 for the handshake to continue or non-zero to terminate.

Since: 2.10.0

gnutls_certificate_set_verify_limits

`void gnutls_certificate_set_verify_limits` [Function]

(*gnutls_certificate_credentials_t res*, *unsigned int max_bits*, *unsigned int max_depth*)

res: is a `gnutls_certificate_credentials_t` structure

max_bits: is the number of bits of an acceptable certificate (default 8200)

max_depth: is maximum depth of the verification of a certificate chain (default 5)

This function will set some upper limits for the default verification function, `gnutls_certificate_verify_peers2()`, to avoid denial of service attacks. You can set them to zero to disable limits.

gnutls_certificate_set_x509_crl_file

`int gnutls_certificate_set_x509_crl_file` [Function]

(*gnutls_certificate_credentials_t res*, *const char * crlfile*, *gnutls_x509_crt_fmt_t type*)

res: is a `gnutls_certificate_credentials_t` structure.

crlfile: is a file containing the list of verified CRLs (DER or PEM list)

type: is PEM or DER

This function adds the trusted CRLs in order to verify client or server certificates. In case of a client this is not required to be called if the certificates are not verified using `gnutls_certificate_verify_peers2()`. This function may be called multiple times.

Returns: number of CRLs processed or a negative error code on error.

`gnutls_certificate_set_x509_crl_mem`

```
int gnutls_certificate_set_x509_crl_mem [Function]
    (gnutls_certificate_credentials_t res, const gnutls_datum_t * CRL,
     gnutls_x509_crt_fmt_t type)
```

res: is a `gnutls_certificate_credentials_t` structure.

CRL: is a list of trusted CRLs. They should have been verified before.

type: is DER or PEM

This function adds the trusted CRLs in order to verify client or server certificates. In case of a client this is not required to be called if the certificates are not verified using `gnutls_certificate_verify_peers2()`. This function may be called multiple times.

Returns: number of CRLs processed, or a negative error code on error.

`gnutls_certificate_set_x509_crl`

```
int gnutls_certificate_set_x509_crl [Function]
    (gnutls_certificate_credentials_t res, gnutls_x509_crl_t * crl_list, int
     crl_list_size)
```

res: is a `gnutls_certificate_credentials_t` structure.

crl_list: is a list of trusted CRLs. They should have been verified before.

crl_list_size: holds the size of the *crl_list*

This function adds the trusted CRLs in order to verify client or server certificates. In case of a client this is not required to be called if the certificates are not verified using `gnutls_certificate_verify_peers2()`. This function may be called multiple times.

Returns: GNUTLS_E_SUCCESS (0) on success, or a negative error code.

Since: 2.4.0

`gnutls_certificate_set_x509_key_file`

```
int gnutls_certificate_set_x509_key_file [Function]
    (gnutls_certificate_credentials_t res, const char * certfile, const char *
     keyfile, gnutls_x509_crt_fmt_t type)
```

res: is a `gnutls_certificate_credentials_t` structure.

certfile: is a file that containing the certificate list (path) for the specified private key, in PKCS7 format, or a list of certificates

keyfile: is a file that contains the private key

type: is PEM or DER

This function sets a certificate/private key pair in the `gnutls_certificate_credentials_t` structure. This function may be called more than once, in case multiple keys/certificates exist for the server. For clients that need to send more than its own end entity certificate, e.g., also an intermediate CA cert, then the `certfile` must contain the ordered certificate chain.

This function can also accept PKCS 11 URLs at `keyfile` and `certfile`. In that case it will import the private key and certificate indicated by the URLs.

Returns: `GNUTLS_E_SUCCESS` (0) on success, or a negative error code.

`gnutls_certificate_set_x509_key_mem`

```
int gnutls_certificate_set_x509_key_mem [Function]
    (gnutls_certificate_credentials_t res, const gnutls_datum_t * cert, const
     gnutls_datum_t * key, gnutls_x509_cert_fmt_t type)
```

res: is a `gnutls_certificate_credentials_t` structure.

cert: contains a certificate list (path) for the specified private key

key: is the private key, or NULL

type: is PEM or DER

This function sets a certificate/private key pair in the `gnutls_certificate_credentials_t` structure. This function may be called more than once, in case multiple keys/certificates exist for the server.

Note that the `keyUsage` (2.5.29.15) PKIX extension in X.509 certificates is supported. This means that certificates intended for signing cannot be used for ciphersuites that require encryption.

If the certificate and the private key are given in PEM encoding then the strings that hold their values must be null terminated.

The `key` may be NULL if you are using a sign callback, see `gnutls_sign_callback_set()`.

Returns: `GNUTLS_E_SUCCESS` (0) on success, or a negative error code.

`gnutls_certificate_set_x509_key`

```
int gnutls_certificate_set_x509_key [Function]
    (gnutls_certificate_credentials_t res, gnutls_x509_cert_t * cert_list, int
     cert_list_size, gnutls_x509_privkey_t key)
```

res: is a `gnutls_certificate_credentials_t` structure.

cert_list: contains a certificate list (path) for the specified private key

cert_list_size: holds the size of the certificate list

key: is a `gnutls_x509_privkey_t` key

This function sets a certificate/private key pair in the `gnutls_certificate_credentials_t` structure. This function may be called more than once, in case multiple keys/certificates exist for the server. For clients that wants to send more than its own end entity certificate (e.g., also an intermediate CA cert) then put the certificate chain in `cert_list`.

Returns: GNUTLS_E_SUCCESS (0) on success, or a negative error code.

Since: 2.4.0

gnutls_certificate_set_x509_simple_pkcs12_file

```
int gnutls_certificate_set_x509_simple_pkcs12_file           [Function]
    (gnutls_certificate_credentials_t res, const char * pkcs12file,
     gnutls_x509_cert_fmt_t type, const char * password)
```

res: is a `gnutls_certificate_credentials_t` structure.

pkcs12file: filename of file containing PKCS12 blob.

type: is PEM or DER of the `pkcs12file`.

password: optional password used to decrypt PKCS12 file, bags and keys.

This function sets a certificate/private key pair and/or a CRL in the `gnutls_certificate_credentials_t` structure. This function may be called more than once (in case multiple keys/certificates exist for the server).

MAC: ed PKCS12 files are supported. Encrypted PKCS12 bags are supported. Encrypted PKCS8 private keys are supported. However, only password based security, and the same password for all operations, are supported.

PKCS12 file may contain many keys and/or certificates, and there is no way to identify which key/certificate pair you want. You should make sure the PKCS12 file only contain one key/certificate pair and/or one CRL.

It is believed that the limitations of this function is acceptable for most usage, and that any more flexibility would introduce complexity that would make it harder to use this functionality at all.

Returns: GNUTLS_E_SUCCESS (0) on success, or a negative error code.

gnutls_certificate_set_x509_simple_pkcs12_mem

```
int gnutls_certificate_set_x509_simple_pkcs12_mem           [Function]
    (gnutls_certificate_credentials_t res, const gnutls_datum_t * p12blob,
     gnutls_x509_cert_fmt_t type, const char * password)
```

res: is a `gnutls_certificate_credentials_t` structure.

p12blob: the PKCS12 blob.

type: is PEM or DER of the `pkcs12file`.

password: optional password used to decrypt PKCS12 file, bags and keys.

This function sets a certificate/private key pair and/or a CRL in the `gnutls_certificate_credentials_t` structure. This function may be called more than once (in case multiple keys/certificates exist for the server).

MAC: ed PKCS12 files are supported. Encrypted PKCS12 bags are supported. Encrypted PKCS8 private keys are supported. However, only password based security, and the same password for all operations, are supported.

PKCS12 file may contain many keys and/or certificates, and there is no way to identify which key/certificate pair you want. You should make sure the PKCS12 file only contain one key/certificate pair and/or one CRL.

It is believed that the limitations of this function is acceptable for most usage, and that any more flexibility would introduce complexity that would make it harder to use this functionality at all.

Returns: GNUTLS_E_SUCCESS (0) on success, or a negative error code.

Since: 2.8.0

gnutls_certificate_set_x509_trust_file

int gnutls_certificate_set_x509_trust_file [Function]

(*gnutls_certificate_credentials_t res*, *const char * cafile*,
gnutls_x509_cert_fmt_t type)

res: is a `gnutls_certificate_credentials_t` structure.

cafile: is a file containing the list of trusted CAs (DER or PEM list)

type: is PEM or DER

This function adds the trusted CAs in order to verify client or server certificates. In case of a client this is not required to be called if the certificates are not verified using `gnutls_certificate_verify_peers2()`. This function may be called multiple times.

In case of a server the names of the CAs set here will be sent to the client if a certificate request is sent. This can be disabled using `gnutls_certificate_send_x509_rdn_sequence()`.

This function can also accept PKCS 11 URLs. In that case it will import all certificates that are marked as trusted.

Returns: number of certificates processed, or a negative error code on error.

gnutls_certificate_set_x509_trust_mem

int gnutls_certificate_set_x509_trust_mem [Function]

(*gnutls_certificate_credentials_t res*, *const gnutls_datum_t * ca*,
gnutls_x509_cert_fmt_t type)

res: is a `gnutls_certificate_credentials_t` structure.

ca: is a list of trusted CAs or a DER certificate

type: is DER or PEM

This function adds the trusted CAs in order to verify client or server certificates. In case of a client this is not required to be called if the certificates are not verified using `gnutls_certificate_verify_peers2()`. This function may be called multiple times.

In case of a server the CAs set here will be sent to the client if a certificate request is sent. This can be disabled using `gnutls_certificate_send_x509_rdn_sequence()`.

Returns: the number of certificates processed or a negative error code on error.

gnutls_certificate_set_x509_trust

int gnutls_certificate_set_x509_trust [Function]

(*gnutls_certificate_credentials_t res*, *gnutls_x509_cert_t * ca_list*, *int ca_list_size*)

res: is a `gnutls_certificate_credentials_t` structure.

ca_list: is a list of trusted CAs

ca_list_size: holds the size of the CA list

This function adds the trusted CAs in order to verify client or server certificates. In case of a client this is not required to be called if the certificates are not verified using `gnutls_certificate_verify_peers2()`. This function may be called multiple times.

In case of a server the CAs set here will be sent to the client if a certificate request is sent. This can be disabled using `gnutls_certificate_send_x509_rdn_sequence()`.

Returns: `GNUTLS_E_SUCCESS` (0) on success, or a negative error code.

Since: 2.4.0

`gnutls_certificate_type_get_id`

`gnutls_certificate_type_t gnutls_certificate_type_get_id` [Function]
(*const char * name*)

name: is a certificate type name

The names are compared in a case insensitive way.

Returns: a `gnutls_certificate_type_t` for the specified in a string certificate type, or `GNUTLS_CERT_UNKNOWN` on error.

`gnutls_certificate_type_get_name`

`const char * gnutls_certificate_type_get_name` [Function]
(*gnutls_certificate_type_t type*)

type: is a certificate type

Convert a `gnutls_certificate_type_t` type to a string.

Returns: a string that contains the name of the specified certificate type, or `NULL` in case of unknown types.

`gnutls_certificate_type_get`

`gnutls_certificate_type_t gnutls_certificate_type_get` [Function]
(*gnutls_session_t session*)

session: is a `gnutls_session_t` structure.

The certificate type is by default X.509, unless it is negotiated as a TLS extension.

Returns: the currently used `gnutls_certificate_type_t` certificate type.

`gnutls_certificate_type_list`

`const gnutls_certificate_type_t *` [Function]
`gnutls_certificate_type_list (void)`

Get a list of certificate types. Note that to be able to use OpenPGP certificates, you must link to `libgnutls-extra` and call `gnutls_global_init_extra()`.

Returns: a (0)-terminated list of `gnutls_certificate_type_t` integers indicating the available certificate types.

gnutls_certificate_type_set_priority

`int gnutls_certificate_type_set_priority (gnutls_session_t session, const int * list)` [Function]

session: is a `gnutls_session_t` structure.

list: is a 0 terminated list of `gnutls_certificate_type_t` elements.

Sets the priority on the certificate types supported by gnutls. Priority is higher for elements specified before others. After specifying the types you want, you must append a 0. Note that the certificate type priority is set on the client. The server does not use the cert type priority except for disabling types that were not specified.

Returns: `GNUTLS_E_SUCCESS` on success, or an error code.

gnutls_certificate_verify_peers2

`int gnutls_certificate_verify_peers2 (gnutls_session_t session, unsigned int * status)` [Function]

session: is a gnutls session

status: is the output of the verification

This function will try to verify the peer's certificate and return its status (trusted, invalid etc.). The value of `status` should be one or more of the `gnutls_certificate_status_t` enumerated elements bitwise or'd. To avoid denial of service attacks some default upper limits regarding the certificate key size and chain size are set. To override them use `gnutls_certificate_set_verify_limits()`.

Note that you must also check the peer's name in order to check if the verified certificate belongs to the actual peer.

This function uses `gnutls_x509_crt_list_verify()` with the CAs in the credentials as trusted CAs.

Returns: a negative error code on error and `GNUTLS_E_SUCCESS` (0) on success.

gnutls_check_version

`const char * gnutls_check_version (const char * req_version)` [Function]

req_version: version string to compare with, or NULL.

Check GnuTLS Library version.

See `GNUTLS_VERSION` for a suitable `req_version` string.

Returns: Check that the version of the library is at minimum the one given as a string in `req_version` and return the actual version string of the library; return NULL if the condition is not met. If NULL is passed to this function no check is done and only the version string is returned.

gnutls_cipher_add_auth

`int gnutls_cipher_add_auth (gnutls_cipher_hd_t handle, const void * text, size_t text_size)` [Function]

handle: is a `gnutls_cipher_hd_t` structure.

text: the data to be authenticated

text_size: The length of the data

This function operates on authenticated encryption with associated data (AEAD) ciphers and authenticate the input data. This function can only be called once and before any encryption operations.

Returns: Zero or a negative error code on error.

Since: 2.99.0

gnutls_cipher_decrypt2

```
int gnutls_cipher_decrypt2 (gnutls_cipher_hd_t handle, const void [Function]
                          * ciphertext, size_t ciphertextlen, void * text, size_t textlen)
```

handle: is a `gnutls_cipher_hd_t` structure.

ciphertext: the data to encrypt

ciphertextlen: The length of data to encrypt

text: the decrypted data

textlen: The available length for decrypted data

This function will decrypt the given data using the algorithm specified by the context.

Returns: Zero or a negative error code on error.

Since: 2.10.0

gnutls_cipher_decrypt

```
int gnutls_cipher_decrypt (gnutls_cipher_hd_t handle, void * [Function]
                          ciphertext, size_t ciphertextlen)
```

handle: is a `gnutls_cipher_hd_t` structure.

ciphertext: the data to encrypt

ciphertextlen: The length of data to encrypt

This function will decrypt the given data using the algorithm specified by the context.

Returns: Zero or a negative error code on error.

Since: 2.10.0

gnutls_cipher_deinit

```
void gnutls_cipher_deinit (gnutls_cipher_hd_t handle) [Function]
```

handle: is a `gnutls_cipher_hd_t` structure.

This function will deinitialize all resources occupied by the given encryption context.

Since: 2.10.0

gnutls_cipher_encrypt2

```
int gnutls_cipher_encrypt2 (gnutls_cipher_hd_t handle, const void [Function]
                          * text, size_t textlen, void * ciphertext, size_t ciphertextlen)
```

handle: is a `gnutls_cipher_hd_t` structure.

text: the data to encrypt

textlen: The length of data to encrypt

ciphertext: the encrypted data

ciphertextlen: The available length for encrypted data

This function will encrypt the given data using the algorithm specified by the context.

Returns: Zero or a negative error code on error.

Since: 2.10.0

gnutls_cipher_encrypt

`int gnutls_cipher_encrypt (gnutls_cipher_hd_t handle, void * text, size_t textlen)` [Function]

handle: is a `gnutls_cipher_hd_t` structure.

text: the data to encrypt

textlen: The length of data to encrypt

This function will encrypt the given data using the algorithm specified by the context.

Returns: Zero or a negative error code on error.

Since: 2.10.0

gnutls_cipher_get_block_size

`int gnutls_cipher_get_block_size (gnutls_cipher_algorithm_t algorithm)` [Function]

algorithm: is an encryption algorithm

Get block size for encryption algorithm.

Returns: block size for encryption algorithm.

Since: 2.10.0

gnutls_cipher_get_id

`gnutls_cipher_algorithm_t gnutls_cipher_get_id (const char * name)` [Function]

name: is a MAC algorithm name

The names are compared in a case insensitive way.

Returns: return a `gnutls_cipher_algorithm_t` value corresponding to the specified cipher, or `GNUTLS_CIPHER_UNKNOWN` on error.

gnutls_cipher_get_key_size

`size_t gnutls_cipher_get_key_size (gnutls_cipher_algorithm_t algorithm)` [Function]

algorithm: is an encryption algorithm

Get key size for cipher.

Returns: length (in bytes) of the given cipher's key size, or 0 if the given cipher is invalid.

gnutls_cipher_get_name

`const char * gnutls_cipher_get_name (gnutls_cipher_algorithm_t algorithm)` [Function]

algorithm: is an encryption algorithm

Convert a `gnutls_cipher_algorithm_t` type to a string.

Returns: a pointer to a string that contains the name of the specified cipher, or `NULL`.

gnutls_cipher_get

`gnutls_cipher_algorithm_t gnutls_cipher_get (gnutls_session_t session)` [Function]

session: is a `gnutls_session_t` structure.

Get currently used cipher.

Returns: the currently used cipher, a `gnutls_cipher_algorithm_t` type.

gnutls_cipher_init

`int gnutls_cipher_init (gnutls_cipher_hd_t * handle, gnutls_cipher_algorithm_t cipher, const gnutls_datum_t * key, const gnutls_datum_t * iv)` [Function]

handle: is a `gnutls_cipher_hd_t` structure.

cipher: the encryption algorithm to use

key: The key to be used for encryption

iv: The IV to use (if not applicable set `NULL`)

This function will initialize an context that can be used for encryption/decryption of data. This will effectively use the current crypto backend in use by gnutls or the cryptographic accelerator in use.

Returns: Zero or a negative error code on error.

Since: 2.10.0

gnutls_cipher_list

`const gnutls_cipher_algorithm_t * gnutls_cipher_list (void)` [Function]

Get a list of supported cipher algorithms. Note that not necessarily all ciphers are supported as TLS cipher suites. For example, DES is not supported as a cipher suite, but is supported for other purposes (e.g., PKCS8 or similar).

This function is not thread safe.

Returns: a (0)-terminated list of `gnutls_cipher_algorithm_t` integers indicating the available ciphers.

gnutls_cipher_set_iv

```
void gnutls_cipher_set_iv (gnutls_cipher_hd_t handle, void * iv,      [Function]
                          size_t ivlen)
```

handle: is a `gnutls_cipher_hd_t` structure.

iv: the IV to set

ivlen: The length of the IV

This function will set the IV to be used for the next encryption block.

Since: 2.99.0

gnutls_cipher_set_priority

```
int gnutls_cipher_set_priority (gnutls_session_t session, const    [Function]
                               int * list)
```

session: is a `gnutls_session_t` structure.

list: is a 0 terminated list of `gnutls_cipher_algorithm_t` elements.

Sets the priority on the ciphers supported by gnutls. Priority is higher for elements specified before others. After specifying the ciphers you want, you must append a 0. Note that the priority is set on the client. The server does not use the algorithm's priority except for disabling algorithms that were not specified.

Returns: `GNUTLS_E_SUCCESS` (0) on success, or a negative error code.

gnutls_cipher_suite_get_name

```
const char * gnutls_cipher_suite_get_name                          [Function]
              (gnutls_kx_algorithm_t kx_algorithm, gnutls_cipher_algorithm_t
              cipher_algorithm, gnutls_mac_algorithm_t mac_algorithm)
```

kx_algorithm: is a Key exchange algorithm

cipher_algorithm: is a cipher algorithm

mac_algorithm: is a MAC algorithm

Note that the full cipher suite name must be prepended by TLS or SSL depending of the protocol in use.

Returns: a string that contains the name of a TLS cipher suite, specified by the given algorithms, or `NULL`.

gnutls_cipher_suite_info

```
const char * gnutls_cipher_suite_info (size_t idx, char *         [Function]
                                       cs_id, gnutls_kx_algorithm_t * kx, gnutls_cipher_algorithm_t * cipher,
                                       gnutls_mac_algorithm_t * mac, gnutls_protocol_t * min_version)
```

idx: index of cipher suite to get information about, starts on 0.

cs_id: output buffer with room for 2 bytes, indicating cipher suite value

kx: output variable indicating key exchange algorithm, or `NULL`.

cipher: output variable indicating cipher, or `NULL`.

mac: output variable indicating MAC algorithm, or `NULL`.

min_version: output variable indicating TLS protocol version, or NULL.

Get information about supported cipher suites. Use the function iteratively to get information about all supported cipher suites. Call with *idx*=0 to get information about first cipher suite, then *idx*=1 and so on until the function returns NULL.

Returns: the name of *idx* cipher suite, and set the information about the cipher suite in the output variables. If *idx* is out of bounds, NULL is returned.

gnutls_cipher_tag

`int gnutls_cipher_tag (gnutls_cipher_hd_t handle, void * tag, size_t tag_size)` [Function]

handle: is a `gnutls_cipher_hd_t` structure.

tag: will hold the tag

tag_size: The length of the tag to return

This function operates on authenticated encryption with associated data (AEAD) ciphers and will return the output tag.

Returns: Zero or a negative error code on error.

Since: 2.99.0

gnutls_compression_get_id

`gnutls_compression_method_t gnutls_compression_get_id (const char * name)` [Function]

name: is a compression method name

The names are compared in a case insensitive way.

Returns: an id of the specified in a string compression method, or `GNUTLS_COMP_UNKNOWN` on error.

gnutls_compression_get_name

`const char * gnutls_compression_get_name (gnutls_compression_method_t algorithm)` [Function]

algorithm: is a Compression algorithm

Convert a `gnutls_compression_method_t` value to a string.

Returns: a pointer to a string that contains the name of the specified compression algorithm, or NULL.

gnutls_compression_get

`gnutls_compression_method_t gnutls_compression_get (gnutls_session_t session)` [Function]

session: is a `gnutls_session_t` structure.

Get currently used compression algorithm.

Returns: the currently used compression method, a `gnutls_compression_method_t` value.

gnutls_compression_list

`const gnutls_compression_method_t *` [Function]
`gnutls_compression_list (void)`

Get a list of compression methods.

Returns: a zero-terminated list of `gnutls_compression_method_t` integers indicating the available compression methods.

gnutls_compression_set_priority

`int gnutls_compression_set_priority (gnutls_session_t session,` [Function]
`const int * list)`

session: is a `gnutls_session_t` structure.

list: is a 0 terminated list of `gnutls_compression_method_t` elements.

Sets the priority on the compression algorithms supported by gnutls. Priority is higher for elements specified before others. After specifying the algorithms you want, you must append a 0. Note that the priority is set on the client. The server does not use the algorithm's priority except for disabling algorithms that were not specified.

TLS 1.0 does not define any compression algorithms except NULL. Other compression algorithms are to be considered as gnutls extensions.

Returns: `GNUTLS_E_SUCCESS` on success, or an error code.

gnutls_credentials_clear

`void gnutls_credentials_clear (gnutls_session_t session)` [Function]

session: is a `gnutls_session_t` structure.

Clears all the credentials previously set in this session.

gnutls_credentials_set

`int gnutls_credentials_set (gnutls_session_t session,` [Function]
`gnutls_credentials_type_t type, void * cred)`

session: is a `gnutls_session_t` structure.

type: is the type of the credentials

cred: is a pointer to a structure.

Sets the needed credentials for the specified type. Eg username, password - or public and private keys etc. The `cred` parameter is a structure that depends on the specified type and on the current session (client or server).

In order to minimize memory usage, and share credentials between several threads gnutls keeps a pointer to `cred`, and not the whole `cred` structure. Thus you will have to keep the structure allocated until you call `gnutls_deinit()`.

For `GNUTLS_CRD_ANON`, `cred` should be `gnutls_anon_client_credentials_t` in case of a client. In case of a server it should be `gnutls_anon_server_credentials_t`.

For `GNUTLS_CRD_SRP`, `cred` should be `gnutls_srp_client_credentials_t` in case of a client, and `gnutls_srp_server_credentials_t`, in case of a server.

For `GNUTLS_CRD_CERTIFICATE`, `cred` should be `gnutls_certificate_credentials_t`.

Returns: On success, `GNUTLS_E_SUCCESS` (0) is returned, otherwise a negative error code is returned.

gnutls_db_check_entry

`int gnutls_db_check_entry (gnutls_session_t session, gnutls_datum_t session_entry)` [Function]

`session`: is a `gnutls_session_t` structure.

`session_entry`: is the session data (not key)

Check if database entry has expired. This function is to be used when you want to clear unnecessary session which occupy space in your backend.

Returns: Returns `GNUTLS_E_EXPIRED`, if the database entry has expired or 0 otherwise.

gnutls_db_get_ptr

`void * gnutls_db_get_ptr (gnutls_session_t session)` [Function]

`session`: is a `gnutls_session_t` structure.

Get db function pointer.

Returns: the pointer that will be sent to db store, retrieve and delete functions, as the first argument.

gnutls_db_remove_session

`void gnutls_db_remove_session (gnutls_session_t session)` [Function]

`session`: is a `gnutls_session_t` structure.

This function will remove the current session data from the session database. This will prevent future handshakes reusing these session data. This function should be called if a session was terminated abnormally, and before `gnutls_deinit()` is called.

Normally `gnutls_deinit()` will remove abnormally terminated sessions.

gnutls_db_set_cache_expiration

`void gnutls_db_set_cache_expiration (gnutls_session_t session, int seconds)` [Function]

`session`: is a `gnutls_session_t` structure.

`seconds`: is the number of seconds.

Set the expiration time for resumed sessions. The default is 3600 (one hour) at the time writing this.

gnutls_db_set_ptr

`void gnutls_db_set_ptr (gnutls_session_t session, void * ptr)` [Function]

`session`: is a `gnutls_session_t` structure.

`ptr`: is the pointer

Sets the pointer that will be provided to db store, retrieve and delete functions, as the first argument.

gnutls_db_set_remove_function

```
void gnutls_db_set_remove_function (gnutls_session_t session, [Function]
    gnutls_db_remove_func rem_func)
```

session: is a `gnutls_session_t` structure.

rem_func: is the function.

Sets the function that will be used to remove data from the resumed sessions database. This function must return 0 on success.

The first argument to `rem_func` will be null unless `gnutls_db_set_ptr()` has been called.

gnutls_db_set_retrieve_function

```
void gnutls_db_set_retrieve_function (gnutls_session_t session, [Function]
    gnutls_db_retr_func retr_func)
```

session: is a `gnutls_session_t` structure.

retr_func: is the function.

Sets the function that will be used to retrieve data from the resumed sessions database. This function must return a `gnutls_datum_t` containing the data on success, or a `gnutls_datum_t` containing null and 0 on failure.

The datum's data must be allocated using the function `gnutls_malloc()`.

The first argument to `retr_func` will be null unless `gnutls_db_set_ptr()` has been called.

gnutls_db_set_store_function

```
void gnutls_db_set_store_function (gnutls_session_t session, [Function]
    gnutls_db_store_func store_func)
```

session: is a `gnutls_session_t` structure.

store_func: is the function

Sets the function that will be used to store data from the resumed sessions database. This function must return 0 on success.

The first argument to `store_func()` will be null unless `gnutls_db_set_ptr()` has been called.

gnutls_deinit

```
void gnutls_deinit (gnutls_session_t session) [Function]
```

session: is a `gnutls_session_t` structure.

This function clears all buffers associated with the `session`. This function will also remove session data from the session database if the session was terminated abnormally.

gnutls_dh_get_group

`int gnutls_dh_get_group (gnutls_session_t session, gnutls_datum_t [Function]
* raw_gen, gnutls_datum_t * raw_prime)`

session: is a gnutls session

raw_gen: will hold the generator.

raw_prime: will hold the prime.

This function will return the group parameters used in the last Diffie-Hellman key exchange with the peer. These are the prime and the generator used. This function should be used for both anonymous and ephemeral Diffie-Hellman. The output parameters must be freed with `gnutls_free()`.

Returns: On success, `GNUTLS_E_SUCCESS` (0) is returned, otherwise an error code is returned.

gnutls_dh_get_peers_public_bits

`int gnutls_dh_get_peers_public_bits (gnutls_session_t session) [Function]`

session: is a gnutls session

Get the Diffie-Hellman public key bit size. Can be used for both anonymous and ephemeral Diffie-Hellman.

Returns: the public key bit size used in the last Diffie-Hellman key exchange with the peer, or a negative error code in case of error.

gnutls_dh_get_prime_bits

`int gnutls_dh_get_prime_bits (gnutls_session_t session) [Function]`

session: is a gnutls session

This function will return the bits of the prime used in the last Diffie-Hellman key exchange with the peer. Should be used for both anonymous and ephemeral Diffie-Hellman. Note that some ciphers, like RSA and DSA without DHE, does not use a Diffie-Hellman key exchange, and then this function will return 0.

Returns: The Diffie-Hellman bit strength is returned, or 0 if no Diffie-Hellman key exchange was done, or a negative error code on failure.

gnutls_dh_get_pubkey

`int gnutls_dh_get_pubkey (gnutls_session_t session, gnutls_datum_t [Function]
* raw_key)`

session: is a gnutls session

raw_key: will hold the public key.

This function will return the peer's public key used in the last Diffie-Hellman key exchange. This function should be used for both anonymous and ephemeral Diffie-Hellman. The output parameters must be freed with `gnutls_free()`.

Returns: On success, `GNUTLS_E_SUCCESS` (0) is returned, otherwise an error code is returned.

gnutls_dh_get_secret_bits

int `gnutls_dh_get_secret_bits` (*gnutls_session_t session*) [Function]
session: is a gnutls session

This function will return the bits used in the last Diffie-Hellman key exchange with the peer. Should be used for both anonymous and ephemeral Diffie-Hellman.

Returns: On success, GNUTLS_E_SUCCESS (0) is returned, otherwise an error code is returned.

gnutls_dh_params_cpy

int `gnutls_dh_params_cpy` (*gnutls_dh_params_t dst*, [Function]
gnutls_dh_params_t src)

dst: Is the destination structure, which should be initialized.

src: Is the source structure

This function will copy the DH parameters structure from source to destination.

Returns: On success, GNUTLS_E_SUCCESS (0) is returned, otherwise a negative error code is returned.

gnutls_dh_params_deinit

void `gnutls_dh_params_deinit` (*gnutls_dh_params_t dh_params*) [Function]
dh_params: Is a structure that holds the prime numbers

This function will deinitialize the DH parameters structure.

gnutls_dh_params_export_pkcs3

int `gnutls_dh_params_export_pkcs3` (*gnutls_dh_params_t params*, [Function]
gnutls_x509_cert_fmt_t format, *unsigned char * params_data*, *size_t *
params_data_size*)

params: Holds the DH parameters

format: the format of output params. One of PEM or DER.

params_data: will contain a PKCS3 DHParams structure PEM or DER encoded

params_data_size: holds the size of *params_data* (and will be replaced by the actual size of parameters)

This function will export the given dh parameters to a PKCS3 DHParams structure. This is the format generated by "openssl dhparam" tool. If the buffer provided is not long enough to hold the output, then GNUTLS_E_SHORT_MEMORY_BUFFER will be returned.

If the structure is PEM encoded, it will have a header of "BEGIN DH PARAMETERS".

Returns: On success, GNUTLS_E_SUCCESS (0) is returned, otherwise a negative error code is returned.

gnutls_dh_params_export_raw

`int gnutls_dh_params_export_raw (gnutls_dh_params_t params, [Function]
 gnutls_datum_t * prime, gnutls_datum_t * generator, unsigned int * bits)`

params: Holds the DH parameters

prime: will hold the new prime

generator: will hold the new generator

bits: if non null will hold is the prime's number of bits

This function will export the pair of prime and generator for use in the Diffie-Hellman key exchange. The new parameters will be allocated using `gnutls_malloc()` and will be stored in the appropriate datum.

Returns: On success, `GNUTLS_E_SUCCESS` (0) is returned, otherwise a negative error code is returned.

gnutls_dh_params_generate2

`int gnutls_dh_params_generate2 (gnutls_dh_params_t params, [Function]
 unsigned int bits)`

params: Is the structure that the DH parameters will be stored

bits: is the prime's number of bits

This function will generate a new pair of prime and generator for use in the Diffie-Hellman key exchange. The new parameters will be allocated using `gnutls_malloc()` and will be stored in the appropriate datum. This function is normally slow.

Do not set the number of bits directly, use `gnutls_sec_param_to_pk_bits()` to get bits for `GNUTLS_PK_DSA`. Also note that the DH parameters are only useful to servers. Since clients use the parameters sent by the server, it's of no use to call this in client side.

Returns: On success, `GNUTLS_E_SUCCESS` (0) is returned, otherwise a negative error code is returned.

gnutls_dh_params_import_pkcs3

`int gnutls_dh_params_import_pkcs3 (gnutls_dh_params_t params, [Function]
 const gnutls_datum_t * pkcs3_params, gnutls_x509_crt_fmt_t format)`

params: A structure where the parameters will be copied to

pkcs3_params: should contain a PKCS3 DHParams structure PEM or DER encoded

format: the format of params. PEM or DER.

This function will extract the DHParams found in a PKCS3 formatted structure. This is the format generated by "openssl dhparam" tool.

If the structure is PEM encoded, it should have a header of "BEGIN DH PARAMETERS".

Returns: On success, `GNUTLS_E_SUCCESS` (0) is returned, otherwise a negative error code is returned.

gnutls_dh_params_import_raw

```
int gnutls_dh_params_import_raw (gnutls_dh_params_t dh_params, [Function]
    const gnutls_datum_t * prime, const gnutls_datum_t * generator)
```

dh_params: Is a structure that will hold the prime numbers

prime: holds the new prime

generator: holds the new generator

This function will replace the pair of prime and generator for use in the Diffie-Hellman key exchange. The new parameters should be stored in the appropriate `gnutls_datum`.

Returns: On success, `GNUTLS_E_SUCCESS (0)` is returned, otherwise a negative error code is returned.

gnutls_dh_params_init

```
int gnutls_dh_params_init (gnutls_dh_params_t * dh_params) [Function]
    dh_params: Is a structure that will hold the prime numbers
```

This function will initialize the DH parameters structure.

Returns: On success, `GNUTLS_E_SUCCESS (0)` is returned, otherwise a negative error code is returned.

gnutls_dh_set_prime_bits

```
void gnutls_dh_set_prime_bits (gnutls_session_t session, unsigned [Function]
    int bits)
```

session: is a `gnutls_session_t` structure.

bits: is the number of bits

This function sets the number of bits, for use in an Diffie-Hellman key exchange. This is used both in DH ephemeral and DH anonymous cipher suites. This will set the minimum size of the prime that will be used for the handshake.

In the client side it sets the minimum accepted number of bits. If a server sends a prime with less bits than that `GNUTLS_E_DH_PRIME_UNACCEPTABLE` will be returned by the handshake.

This function has no effect in server side.

gnutls_dtls_cookie_send

```
int gnutls_dtls_cookie_send (gnutls_datum_t* key, void* [Function]
    client_data, size_t client_data_size, gnutls_dtls_pstate_st*
    prestate, gnutls_transport_ptr_t ptr, gnutls_push_func push_func)
```

key: is a random key to be used at cookie generation

client_data: contains data identifying the client (i.e. address)

client_data_size: The size of client's data

prestate: The previous cookie returned by `gnutls_dtls_cookie_verify()`

ptr: A transport pointer to be used by `push_func`

push_func: A function that will be used to reply

This function can be used to prevent denial of service attacks to a DTLS server by requiring the client to reply using a cookie sent by this function. That way it can be ensured that a client we allocated resources for (i.e. `gnutls_session_t`) is the one that the original incoming packet was originated from.

Returns: the number of bytes sent, or a negative error code.

`gnutls_dtls_cookie_verify`

```
int gnutls_dtls_cookie_verify (gnutls_datum_t* key, void* [Function]
    client_data, size_t client_data_size, void* _msg, size_t msg_size,
    gnutls_dtls_prestate_st* prestate)
```

key: is a random key to be used at cookie generation

client_data: contains data identifying the client (i.e. address)

client_data_size: The size of client's data

_msg: An incoming message that initiates a connection.

msg_size: The size of the message.

prestate: The cookie of this client.

This function will verify an incoming message for a valid cookie. If a valid cookie is returned then it should be associated with the session using `gnutls_dtls_prestate_set()`;

Returns: `GNUTLS_E_SUCCESS` (0) on success, or a negative error code.

`gnutls_dtls_get_data_mtu`

```
unsigned int gnutls_dtls_get_data_mtu (gnutls_session_t [Function]
    session)
```

session: is a `gnutls_session_t` structure.

This function will return the actual maximum transfer unit for application data. I.e. DTLS headers are subtracted from the actual MTU.

Returns: the maximum allowed transfer unit.

`gnutls_dtls_get_mtu`

```
unsigned int gnutls_dtls_get_mtu (gnutls_session_t session) [Function]
```

session: is a `gnutls_session_t` structure.

This function will return the MTU size as set with `gnutls_dtls_set_mtu()`. This is not the actual MTU of data you can transmit. Use `gnutls_dtls_get_data_mtu()` for that reason.

Returns: the set maximum transfer unit.

`gnutls_dtls_prestate_set`

```
void gnutls_dtls_prestate_set (gnutls_session_t session, [Function]
    gnutls_dtls_prestate_st* prestate)
```

session: a new session

prestate: contains the client's prestate

This function will associate the prestate acquired by the cookie authentication with the client, with the newly established session.

Returns: GNUTLS_E_SUCCESS (0) on success, or a negative error code.

gnutls_dtls_set_mtu

```
void gnutls_dtls_set_mtu (gnutls_session_t session, unsigned int mtu) [Function]
```

session: is a `gnutls_session_t` structure.

mtu: The maximum transfer unit of the interface

This function will set the maximum transfer unit of the interface that DTLS packets are expected to leave from.

gnutls_dtls_set_timeouts

```
void gnutls_dtls_set_timeouts (gnutls_session_t session, unsigned int retrans_timeout, unsigned int total_timeout) [Function]
```

session: is a `gnutls_session_t` structure.

retrans_timeout: The time at which a retransmission will occur in milliseconds

total_timeout: The time at which the connection will be aborted, in milliseconds.

This function will set the timeouts required for the DTLS handshake protocol. The retransmission timeout is the time after which a message from the peer is not received, the previous messages will be retransmitted. The total timeout is the time after which the handshake will be aborted with GNUTLS_E_TIMEDOUT.

The DTLS protocol recommends the values of 1 sec and 60 seconds respectively.

If the retransmission timeout is zero then the handshake will operate in a non-blocking way, i.e., return GNUTLS_E_AGAIN.

gnutls_ecc_curve_get_name

```
const char * gnutls_ecc_curve_get_name (gnutls_ecc_curve_t curve) [Function]
```

curve: is an ECC curve

Convert a `gnutls_ecc_curve_t` value to a string.

Returns: a string that contains the name of the specified curve or NULL.

gnutls_ecc_curve_get_size

```
int gnutls_ecc_curve_get_size (gnutls_ecc_curve_t curve) [Function]
```

curve: is an ECC curve

Returns the size in bytes of the curve.

Returns: a the size or (0).

gnutls_ecc_curve_get

`gnutls_ecc_curve_t gnutls_ecc_curve_get (gnutls_session_t session)` [Function]

session: is a `gnutls_session_t` structure.

Returns the currently used elliptic curve. Only valid when using an elliptic curve ciphersuite.

Returns: the currently used curve, a `gnutls_ecc_curve_t` type.

gnutls_error_is_fatal

`int gnutls_error_is_fatal (int error)` [Function]

error: is a GnuTLS error code, a negative error code

If a GnuTLS function returns a negative error code you may feed that value to this function to see if the error condition is fatal.

Note that you may want to check the error code manually, since some non-fatal errors to the protocol may be fatal for you program.

This function is only useful if you are dealing with errors from the record layer or the handshake layer.

Returns: 1 if the error code is fatal, for positive `error` values, 0 is returned. For unknown `error` values, -1 is returned.

gnutls_error_to_alert

`int gnutls_error_to_alert (int err, int * level)` [Function]

err: is a negative integer

level: the alert level will be stored there

Get an alert depending on the error code returned by a `gnutls` function. All alerts sent by this function should be considered fatal. The only exception is when `err` is `GNUTLS_E_REHANDSHAKE`, where a warning alert should be sent to the peer indicating that no renegotiation will be performed.

If there is no mapping to a valid alert the alert to indicate internal error is returned.

Returns: the alert code to use for a particular error code.

gnutls_fingerprint

`int gnutls_fingerprint (gnutls_digest_algorithm_t algo, const gnutls_datum_t * data, void * result, size_t * result_size)` [Function]

algo: is a digest algorithm

data: is the data

result: is the place where the result will be copied (may be null).

result_size: should hold the size of the result. The actual size of the returned result will also be copied there.

This function will calculate a fingerprint (actually a hash), of the given data. The result is not printable data. You should convert it to hex, or to something else printable.

This is the usual way to calculate a fingerprint of an X.509 DER encoded certificate. Note however that the fingerprint of an OpenPGP is not just a hash and cannot be calculated with this function.

Returns: On success, `GNUTLS_E_SUCCESS` (0) is returned, otherwise an error code is returned.

gnutls_free

`void gnutls_free (void * ptr)` [Function]
ptr: pointer to memory

This function will free data pointed by *ptr*.

The deallocation function used is the one set by `gnutls_global_set_mem_functions()`.

gnutls_global_deinit

`void gnutls_global_deinit (void)` [Function]
 This function deinitializes the global data, that were initialized using `gnutls_global_init()`.

Note! This function is not thread safe. See the discussion for `gnutls_global_init()` for more information.

gnutls_global_init

`int gnutls_global_init (void)` [Function]

This function initializes the global data to defaults. Every gnutls application has a global data which holds common parameters shared by gnutls session structures. You should call `gnutls_global_deinit()` when gnutls usage is no longer needed

Note that this function will also initialize the underlying crypto backend, if it has not been initialized before.

This function increment a global counter, so that `gnutls_global_deinit()` only releases resources when it has been called as many times as `gnutls_global_init()`. This is useful when GnuTLS is used by more than one library in an application. This function can be called many times, but will only do something the first time.

Note! This function is not thread safe. If two threads call this function simultaneously, they can cause a race between checking the global counter and incrementing it, causing both threads to execute the library initialization code. That would lead to a memory leak. To handle this, your application could invoke this function after acquiring a thread mutex. To ignore the potential memory leak is also an option.

Returns: On success, `GNUTLS_E_SUCCESS` (0) is returned, otherwise a negative error code is returned.

gnutls_global_set_audit_log_function

`void gnutls_global_set_audit_log_function` [Function]
 (*gnutls_audit_log_func log_func*)
log_func: it is the audit log function

This is the function where you set the logging function gnutls is going to use. This is different from `gnutls_global_set_log_function()` because it will report the session of the event if any. Note that that session might be null if there is no corresponding TLS session.

`gnutls_audit_log_func` is of the form, `void (*gnutls_audit_log_func)(gnutls_session_t, int level, const char*)`;

gnutls_global_set_log_function

`void gnutls_global_set_log_function (gnutls_log_func log_func) [Function]`
log_func: it's a log function

This is the function where you set the logging function gnutls is going to use. This function only accepts a character array. Normally you may not use this function since it is only used for debugging purposes.

`gnutls_log_func` is of the form, `void (*gnutls_log_func)(int level, const char*)`;

gnutls_global_set_log_level

`void gnutls_global_set_log_level (int level) [Function]`
level: it's an integer from 0 to 9.

This is the function that allows you to set the log level. The level is an integer between 0 and 9. Higher values mean more verbosity. The default value is 0. Larger values should only be used with care, since they may reveal sensitive information.

Use a log level over 10 to enable all debugging options.

gnutls_global_set_mem_functions

`void gnutls_global_set_mem_functions (gnutls_alloc_function alloc_func, gnutls_alloc_function secure_alloc_func, gnutls_is_secure_function is_secure_func, gnutls_realloc_function realloc_func, gnutls_free_function free_func) [Function]`

alloc_func: it's the default memory allocation function. Like `malloc()`.

secure_alloc_func: This is the memory allocation function that will be used for sensitive data.

is_secure_func: a function that returns 0 if the memory given is not secure. May be NULL.

realloc_func: A `realloc` function

free_func: The function that frees allocated data. Must accept a NULL pointer.

This is the function where you set the memory allocation functions gnutls is going to use. By default the libc's allocation functions (`malloc()`, `free()`), are used by gnutls, to allocate both sensitive and not sensitive data. This function is provided to set the memory allocation functions to something other than the defaults

This function must be called before `gnutls_global_init()` is called. This function is not thread safe.

gnutls_global_set_mutex

```
void gnutls_global_set_mutex (mutex_init_func init, [Function]
                             mutex_deinit_func deinit, mutex_lock_func lock, mutex_unlock_func
                             unlock)
```

init: mutex initialization function

deinit: mutex deinitialization function

lock: mutex locking function

unlock: mutex unlocking function

With this function you are allowed to override the default mutex locks used in some parts of gnutls and dependent libraries. This function should be used if you have complete control of your program and libraries. Do not call this function from a library. Instead only initialize gnutls and the default OS mutex locks will be used.

This function must be called before `gnutls_global_init()`.

gnutls_global_set_time_function

```
void gnutls_global_set_time_function (gnutls_time_func [Function]
                                     time_func)
```

time_func: it's the system time function

This is the function where you can override the default system time function.

`gnutls_time_func` is of the form, `time_t (*gnutls_time_func)(time*)`;

gnutls_handshake_get_last_in

```
gnutls_handshake_description_t [Function]
    gnutls_handshake_get_last_in (gnutls_session_t session)
```

session: is a `gnutls_session_t` structure.

This function is only useful to check where the last performed handshake failed. If the previous handshake succeed or was not performed at all then no meaningful value will be returned.

Check `gnutls_handshake_description_t` in `gnutls.h` for the available handshake descriptions.

Returns: the last handshake message type received, a `gnutls_handshake_description_t`.

gnutls_handshake_get_last_out

```
gnutls_handshake_description_t [Function]
    gnutls_handshake_get_last_out (gnutls_session_t session)
```

session: is a `gnutls_session_t` structure.

This function is only useful to check where the last performed handshake failed. If the previous handshake succeed or was not performed at all then no meaningful value will be returned.

Check `gnutls_handshake_description_t` in `gnutls.h` for the available handshake descriptions.

Returns: the last handshake message type sent, a `gnutls_handshake_description_t`.

`gnutls_handshake_set_max_packet_length`

`void gnutls_handshake_set_max_packet_length (gnutls_session_t session, size_t max)` [Function]

session: is a `gnutls_session_t` structure.

max: is the maximum number.

This function will set the maximum size of all handshake messages. Handshakes over this size are rejected with `GNUTLS_E_HANDSHAKE_TOO_LARGE` error code. The default value is 48kb which is typically large enough. Set this to 0 if you do not want to set an upper limit.

The reason for restricting the handshake message sizes are to limit Denial of Service attacks.

`gnutls_handshake_set_post_client_hello_function`

`void gnutls_handshake_set_post_client_hello_function (gnutls_session_t session, gnutls_handshake_post_client_hello_func func)` [Function]

session: is a `gnutls_session_t` structure.

func: is the function to be called

This function will set a callback to be called after the client hello has been received (callback valid in server side only). This allows the server to adjust settings based on received extensions.

Those settings could be ciphersuites, requesting certificate, or anything else except for version negotiation (this is done before the hello message is parsed).

This callback must return 0 on success or a gnutls error code to terminate the handshake.

Warning: You should not use this function to terminate the handshake based on client input unless you know what you are doing. Before the handshake is finished there is no way to know if there is a man-in-the-middle attack being performed.

`gnutls_handshake_set_private_extensions`

`void gnutls_handshake_set_private_extensions (gnutls_session_t session, int allow)` [Function]

session: is a `gnutls_session_t` structure.

allow: is an integer (0 or 1)

This function will enable or disable the use of private cipher suites (the ones that start with 0xFF). By default or if `allow` is 0 then these cipher suites will not be advertized nor used.

Currently GnuTLS does not include such cipher-suites or compression algorithms.

Enabling the private ciphersuites when talking to other than gnutls servers and clients may cause interoperability problems.

gnutls_handshake

`int gnutls_handshake (gnutls_session_t session)` [Function]

session: is a `gnutls_session_t` structure.

This function does the handshake of the TLS/SSL protocol, and initializes the TLS connection.

This function will fail if any problem is encountered, and will return a negative error code. In case of a client, if the client has asked to resume a session, but the server couldn't, then a full handshake will be performed.

The non-fatal errors such as `GNUTLS_E_AGAIN` and `GNUTLS_E_INTERRUPTED` interrupt the handshake procedure, which should be later be resumed. Call this function again, until it returns 0; cf. `gnutls_record_get_direction()` and `gnutls_error_is_fatal()`.

If this function is called by a server after a rehandshake request then `GNUTLS_E_GOT_APPLICATION_DATA` or `GNUTLS_E_WARNING_ALERT_RECEIVED` may be returned. Note that these are non fatal errors, only in the specific case of a rehandshake. Their meaning is that the client rejected the rehandshake request or in the case of `GNUTLS_E_GOT_APPLICATION_DATA` it might also mean that some data were pending.

Returns: `GNUTLS_E_SUCCESS` on success, otherwise a negative error code.

gnutls_hash_deinit

`void gnutls_hash_deinit (gnutls_hash_hd_t handle, void * digest)` [Function]

handle: is a `gnutls_hash_hd_t` structure.

digest: is the output value of the hash

This function will deinitialize all resources occupied by the given hash context.

Since: 2.10.0

gnutls_hash_fast

`int gnutls_hash_fast (gnutls_digest_algorithm_t algorithm, const void * text, size_t textlen, void * digest)` [Function]

algorithm: the hash algorithm to use

text: the data to hash

textlen: The length of data to hash

digest: is the output value of the hash

This convenience function will hash the given data and return output on a single call.

Returns: Zero or a negative error code on error.

Since: 2.10.0

gnutls_hash_get_len

`int gnutls_hash_get_len (gnutls_digest_algorithm_t algorithm)` [Function]

algorithm: the hash algorithm to use

This function will return the length of the output data of the given hash algorithm.

Returns: The length or zero on error.

Since: 2.10.0

gnutls_hash_init

`int gnutls_hash_init (gnutls_hash_hd_t * dig, [Function]
gnutls_digest_algorithm_t algorithm)`

dig: is a `gnutls_hash_hd_t` structure.

algorithm: the hash algorithm to use

This function will initialize an context that can be used to produce a Message Digest of data. This will effectively use the current crypto backend in use by gnutls or the cryptographic accelerator in use.

Returns: Zero or a negative error code on error.

Since: 2.10.0

gnutls_hash_output

`void gnutls_hash_output (gnutls_hash_hd_t handle, void * digest) [Function]`

handle: is a `gnutls_hash_hd_t` structure.

digest: is the output value of the hash

This function will output the current hash value.

Since: 2.10.0

gnutls_hash

`int gnutls_hash (gnutls_hash_hd_t handle, const void * text, size_t [Function]
textlen)`

handle: is a `gnutls_cipher_hd_t` structure.

text: the data to hash

textlen: The length of data to hash

This function will hash the given data using the algorithm specified by the context.

Returns: Zero or a negative error code on error.

Since: 2.10.0

gnutls_hex2bin

`int gnutls_hex2bin (const char * hex_data, size_t hex_size, char * [Function]
bin_data, size_t * bin_size)`

hex_data: string with data in hex format

hex_size: size of hex data

bin_data: output array with binary data

bin_size: when calling `*bin_size` should hold size of `bin_data`, on return will hold actual size of `bin_data`.

Convert a buffer with hex data to binary data.

Returns: `GNUTLS_E_SUCCESS` on success, otherwise a negative error code.

Since: 2.4.0

gnutls_hex_decode

```
int gnutls_hex_decode (const gnutls_datum_t * hex_data, char * result, size_t * result_size) [Function]
```

hex_data: contain the encoded data

result: the place where decoded data will be copied

result_size: holds the size of the result

This function will decode the given encoded data, using the hex encoding used by PSK password files.

Note that *hex_data* should be null terminated.

Returns: GNUTLS_E_SHORT_MEMORY_BUFFER if the buffer given is not long enough, or 0 on success.

gnutls_hex_encode

```
int gnutls_hex_encode (const gnutls_datum_t * data, char * result, size_t * result_size) [Function]
```

data: contain the raw data

result: the place where hex data will be copied

result_size: holds the size of the result

This function will convert the given data to printable data, using the hex encoding, as used in the PSK password files.

Returns: GNUTLS_E_SHORT_MEMORY_BUFFER if the buffer given is not long enough, or 0 on success.

gnutls_hmac_deinit

```
void gnutls_hmac_deinit (gnutls_hmac_hd_t handle, void * digest) [Function]
```

handle: is a `gnutls_hmac_hd_t` structure.

digest: is the output value of the MAC

This function will deinitialize all resources occupied by the given hmac context.

Since: 2.10.0

gnutls_hmac_fast

```
int gnutls_hmac_fast (gnutls_mac_algorithm_t algorithm, const void * key, size_t keylen, const void * text, size_t textlen, void * digest) [Function]
```

algorithm: the hash algorithm to use

key: the key to use

keylen: The length of the key

text: the data to hash

textlen: The length of data to hash

digest: is the output value of the hash

This convenience function will hash the given data and return output on a single call.

Returns: Zero or a negative error code on error.

Since: 2.10.0

gnutls_hmac_get_len

`int gnutls_hmac_get_len (gnutls_mac_algorithm_t algorithm)` [Function]
algorithm: the hmac algorithm to use

This function will return the length of the output data of the given hmac algorithm.

Returns: The length or zero on error.

Since: 2.10.0

gnutls_hmac_init

`int gnutls_hmac_init (gnutls_hmac_hd_t * dig,` [Function]
*gnutls_digest_algorithm_t algorithm, const void * key, size_t keylen)*

dig: is a `gnutls_hmac_hd_t` structure.

algorithm: the HMAC algorithm to use

key: The key to be used for encryption

keylen: The length of the key

This function will initialize an context that can be used to produce a Message Authentication Code (MAC) of data. This will effectively use the current crypto backend in use by gnutls or the cryptographic accelerator in use.

Returns: Zero or a negative error code on error.

Since: 2.10.0

gnutls_hmac_output

`void gnutls_hmac_output (gnutls_hmac_hd_t handle, void * digest)` [Function]
handle: is a `gnutls_hmac_hd_t` structure.

digest: is the output value of the MAC

This function will output the current MAC value.

Since: 2.10.0

gnutls_hmac

`int gnutls_hmac (gnutls_hmac_hd_t handle, const void * text, size_t` [Function]
textlen)

handle: is a `gnutls_cipher_hd_t` structure.

text: the data to hash

textlen: The length of data to hash

This function will hash the given data using the algorithm specified by the context.

Returns: Zero or a negative error code on error.

Since: 2.10.0

gnutls_init

`int gnutls_init (gnutls_session_t * session, unsigned int flags)` [Function]

session: is a pointer to a `gnutls_session_t` structure.

flags: indicate if this session is to be used for server or client.

This function initializes the current session to null. Every session must be initialized before use, so internal structures can be allocated. This function allocates structures which can only be free'd by calling `gnutls_deinit()`. Returns `GNUTLS_E_SUCCESS` (0) on success.

flags can be one of `GNUTLS_CLIENT` and `GNUTLS_SERVER`. For a DTLS entity, the flags `GNUTLS_DATAGRAM` and `GNUTLS_NONBLOCK` are also available. The latter flag will enable a non-blocking operation of the DTLS timers.

Returns: `GNUTLS_E_SUCCESS` on success, or an error code.

gnutls_key_generate

`int gnutls_key_generate (gnutls_datum_t * key, unsigned int key_size)` [Function]

key: is a pointer to a `gnutls_datum_t` which will contain a newly created key.

key_size: The number of bytes of the key.

Generates a random key of *key_size* size.

Returns: On success, `GNUTLS_E_SUCCESS` (0) is returned, or an error code.

Since: 3.0.0

gnutls_kx_get_id

`gnutls_kx_algorithm_t gnutls_kx_get_id (const char * name)` [Function]

name: is a KX name

Convert a string to a `gnutls_kx_algorithm_t` value. The names are compared in a case insensitive way.

Returns: an id of the specified KX algorithm, or `GNUTLS_KX_UNKNOWN` on error.

gnutls_kx_get_name

`const char * gnutls_kx_get_name (gnutls_kx_algorithm_t algorithm)` [Function]

algorithm: is a key exchange algorithm

Convert a `gnutls_kx_algorithm_t` value to a string.

Returns: a pointer to a string that contains the name of the specified key exchange algorithm, or `NULL`.

gnutls_kx_get

`gnutls_kx_algorithm_t gnutls_kx_get (gnutls_session_t session)` [Function]

session: is a `gnutls_session_t` structure.

Get currently used key exchange algorithm.

Returns: the key exchange algorithm used in the last handshake, a `gnutls_kx_algorithm_t` value.

`gnutls_kx_list`

`const gnutls_kx_algorithm_t * gnutls_kx_list (void) [Function]`

Get a list of supported key exchange algorithms.

This function is not thread safe.

Returns: a (0)-terminated list of `gnutls_kx_algorithm_t` integers indicating the available key exchange algorithms.

`gnutls_kx_set_priority`

`int gnutls_kx_set_priority (gnutls_session_t session, const int * list) [Function]`

session: is a `gnutls_session_t` structure.

list: is a 0 terminated list of `gnutls_kx_algorithm_t` elements.

Sets the priority on the key exchange algorithms supported by gnutls. Priority is higher for elements specified before others. After specifying the algorithms you want, you must append a 0. Note that the priority is set on the client. The server does not use the algorithm's priority except for disabling algorithms that were not specified.

Returns: `GNUTLS_E_SUCCESS` on success, or an error code.

`gnutls_mac_get_id`

`gnutls_mac_algorithm_t gnutls_mac_get_id (const char * name) [Function]`

name: is a MAC algorithm name

Convert a string to a `gnutls_mac_algorithm_t` value. The names are compared in a case insensitive way.

Returns: a `gnutls_mac_algorithm_t` id of the specified MAC algorithm string, or `GNUTLS_MAC_UNKNOWN` on failures.

`gnutls_mac_get_key_size`

`size_t gnutls_mac_get_key_size (gnutls_mac_algorithm_t algorithm) [Function]`

algorithm: is an encryption algorithm

Get size of MAC key.

Returns: length (in bytes) of the given MAC key size, or 0 if the given MAC algorithm is invalid.

`gnutls_mac_get_name`

`const char * gnutls_mac_get_name (gnutls_mac_algorithm_t algorithm) [Function]`

algorithm: is a MAC algorithm

Convert a `gnutls_mac_algorithm_t` value to a string.

Returns: a string that contains the name of the specified MAC algorithm, or `NULL`.

gnutls_mac_get

`gnutls_mac_algorithm_t gnutls_mac_get (gnutls_session_t session)` [Function]

session: is a `gnutls_session_t` structure.

Get currently used MAC algorithm.

Returns: the currently used mac algorithm, a `gnutls_mac_algorithm_t` value.

gnutls_mac_list

`const gnutls_mac_algorithm_t * gnutls_mac_list (void)` [Function]

Get a list of hash algorithms for use as MACs. Note that not necessarily all MACs are supported in TLS cipher suites. For example, MD2 is not supported as a cipher suite, but is supported for other purposes (e.g., X.509 signature verification or similar).

This function is not thread safe.

Returns: Return a (0)-terminated list of `gnutls_mac_algorithm_t` integers indicating the available MACs.

gnutls_mac_set_priority

`int gnutls_mac_set_priority (gnutls_session_t session, const int * list)` [Function]

session: is a `gnutls_session_t` structure.

list: is a 0 terminated list of `gnutls_mac_algorithm_t` elements.

Sets the priority on the mac algorithms supported by gnutls. Priority is higher for elements specified before others. After specifying the algorithms you want, you must append a 0. Note that the priority is set on the client. The server does not use the algorithm's priority except for disabling algorithms that were not specified.

Returns: GNUTLS_E_SUCCESS on success, or an error code.

gnutls_malloc

`void * gnutls_malloc (size_t s)` [Function]

s: size to allocate in bytes

This function will allocate 's' bytes data, and return a pointer to memory. This function is supposed to be used by callbacks.

The allocation function used is the one set by `gnutls_global_set_mem_functions()`.

gnutls_openpgp_send_cert

`void gnutls_openpgp_send_cert (gnutls_session_t session, gnutls_openpgp_cert_status_t status)` [Function]

session: is a pointer to a `gnutls_session_t` structure.

status: is one of GNUTLS_OPENPGP_CERT, or GNUTLS_OPENPGP_CERT_FINGERPRINT

This function will order gnutls to send the key fingerprint instead of the key in the initial handshake procedure. This should be used with care and only when there is indication or knowledge that the server can obtain the client's key.

gnutls_pcert_deinit

`void gnutls_pcert_deinit (gnutls_pcert_st * pcert)` [Function]

pcert: The structure to be deinitialized

This function will deinitialize a pcert structure.

gnutls_pcert_import_opengpg_raw

`int gnutls_pcert_import_opengpg_raw (gnutls_pcert_st * pcert,` [Function]

`const gnutls_datum_t* cert, gnutls_opengpg_cert_fmt_t format,`
`gnutls_opengpg_keyid_t keyid, unsigned int flags)`

pcert: The pcert structure

cert: The raw certificate to be imported

format: The format of the certificate

keyid: The key ID to use (NULL for the master key)

flags: zero for now

This convenience function will import the given certificate to a `gnutls_pcert_st` structure. The structure must be deinitialized afterwards using `gnutls_pcert_deinit()`;

Returns: On success, `GNUTLS_E_SUCCESS` (0) is returned, otherwise a negative error value.

gnutls_pcert_import_opengpg

`int gnutls_pcert_import_opengpg (gnutls_pcert_st* pcert,` [Function]

`gnutls_opengpg_cert_t crt, unsigned int flags)`

pcert: The pcert structure

crt: The raw certificate to be imported

flags: zero for now

This convenience function will import the given certificate to a `gnutls_pcert_st` structure. The structure must be deinitialized afterwards using `gnutls_pcert_deinit()`;

Returns: On success, `GNUTLS_E_SUCCESS` (0) is returned, otherwise a negative error value.

gnutls_pcert_import_x509_raw

`int gnutls_pcert_import_x509_raw (gnutls_pcert_st * pcert, const` [Function]

`gnutls_datum_t* cert, gnutls_x509_cert_fmt_t format, unsigned int flags)`

pcert: The pcert structure

cert: The raw certificate to be imported

format: The format of the certificate

flags: zero for now

This convenience function will import the given certificate to a `gnutls_pcert_st` structure. The structure must be deinitialized afterwards using `gnutls_pcert_deinit()`;

Returns: On success, GNUTLS_E_SUCCESS (0) is returned, otherwise a negative error value.

gnutls_pcert_import_x509

```
int gnutls_pcert_import_x509 (gnutls_pcert_st* pcert, [Function]
                             gnutls_x509_cert_t crt, unsigned int flags)
```

pcert: The pcert structure

crt: The raw certificate to be imported

flags: zero for now

This convenience function will import the given certificate to a `gnutls_pcert_st` structure. The structure must be deinitialized afterwards using `gnutls_pcert_deinit()`;

Returns: On success, GNUTLS_E_SUCCESS (0) is returned, otherwise a negative error value.

gnutls_pcert_list_import_x509_raw

```
int gnutls_pcert_list_import_x509_raw (gnutls_pcert_st * [Function]
                                       pcerts, unsigned int * pcert_max, const gnutls_datum_t * data,
                                       gnutls_x509_cert_fmt_t format, unsigned int flags)
```

pcerts: The structures to store the parsed certificate. Must not be initialized.

pcert_max: Initially must hold the maximum number of certs. It will be updated with the number of certs available.

data: The certificates.

format: One of DER or PEM.

flags: must be (0) or an OR'd sequence of `gnutls_certificate_import_flags`.

This function will convert the given PEM encoded certificate list to the native `gnutls_x509_cert_t` format. The output will be stored in `certs`. They will be automatically initialized.

If the Certificate is PEM encoded it should have a header of "X509 CERTIFICATE", or "CERTIFICATE".

Returns: the number of certificates read or a negative error value.

gnutls_pem_base64_decode_alloc

```
int gnutls_pem_base64_decode_alloc (const char * header, const [Function]
                                    gnutls_datum_t * b64_data, gnutls_datum_t * result)
```

header: The PEM header (eg. CERTIFICATE)

b64_data: contains the encoded data

result: the place where decoded data lie

This function will decode the given encoded data. The decoded data will be allocated, and stored into `result`. If the header given is non null this function will search for "—BEGIN header" and decode only this part. Otherwise it will decode the first PEM packet found.

You should use `gnutls_free()` to free the returned data.

Returns: On success, `GNUTLS_E_SUCCESS` (0) is returned, otherwise an error code is returned.

`gnutls_pem_base64_decode`

```
int gnutls_pem_base64_decode (const char *header, const [Function]
                             gnutls_datum_t *b64_data, unsigned char *result, size_t *result_size)
```

header: A null terminated string with the PEM header (eg. CERTIFICATE)

b64_data: contain the encoded data

result: the place where decoded data will be copied

result_size: holds the size of the result

This function will decode the given encoded data. If the header given is non null this function will search for "—BEGIN header" and decode only this part. Otherwise it will decode the first PEM packet found.

Returns: On success `GNUTLS_E_SUCCESS` (0) is returned, `GNUTLS_E_SHORT_MEMORY_BUFFER` is returned if the buffer given is not long enough, or 0 on success.

`gnutls_pem_base64_encode_alloc`

```
int gnutls_pem_base64_encode_alloc (const char *msg, const [Function]
                                    gnutls_datum_t *data, gnutls_datum_t *result)
```

msg: is a message to be put in the encoded header

data: contains the raw data

result: will hold the newly allocated encoded data

This function will convert the given data to printable data, using the base64 encoding. This is the encoding used in PEM messages. This function will allocate the required memory to hold the encoded data.

You should use `gnutls_free()` to free the returned data.

Returns: On success, `GNUTLS_E_SUCCESS` (0) is returned, otherwise an error code is returned.

`gnutls_pem_base64_encode`

```
int gnutls_pem_base64_encode (const char *msg, const [Function]
                              gnutls_datum_t *data, char *result, size_t *result_size)
```

msg: is a message to be put in the header

data: contain the raw data

result: the place where base64 data will be copied

result_size: holds the size of the result

This function will convert the given data to printable data, using the base64 encoding. This is the encoding used in PEM messages.

The output string will be null terminated, although the size will not include the terminating null.

Returns: On success `GNUTLS_E_SUCCESS` (0) is returned, `GNUTLS_E_SHORT_MEMORY_BUFFER` is returned if the buffer given is not long enough, or 0 on success.

gnutls_perror

`void gnutls_perror (int error)` [Function]

error: is a GnuTLS error code, a negative error code

This function is like `perror()`. The only difference is that it accepts an error number returned by a `gnutls` function.

gnutls_pk_algorithm_get_name

`const char * gnutls_pk_algorithm_get_name` [Function]

(*gnutls_pk_algorithm_t algorithm*)

algorithm: is a pk algorithm

Convert a `gnutls_pk_algorithm_t` value to a string.

Returns: a string that contains the name of the specified public key algorithm, or `NULL`.

gnutls_pk_bits_to_sec_param

`gnutls_sec_param_t gnutls_pk_bits_to_sec_param` [Function]

(*gnutls_pk_algorithm_t algo, unsigned int bits*)

algo: is a public key algorithm

bits: is the number of bits

This is the inverse of `gnutls_sec_param_to_pk_bits()`. Given an algorithm and the number of bits, it will return the security parameter. This is a rough indication.

Returns: The security parameter.

gnutls_pk_get_id

`gnutls_pk_algorithm_t gnutls_pk_get_id (const char * name)` [Function]

name: is a string containing a public key algorithm name.

Convert a string to a `gnutls_pk_algorithm_t` value. The names are compared in a case insensitive way. For example, `gnutls_pk_get_id("RSA")` will return `GNUTLS_PK_RSA`.

Returns: a `gnutls_pk_algorithm_t` id of the specified public key algorithm string, or `GNUTLS_PK_UNKNOWN` on failures.

Since: 2.6.0

gnutls_pk_get_name

`const char * gnutls_pk_get_name (gnutls_pk_algorithm_t` [Function]

algorithm)

algorithm: is a public key algorithm

Convert a `gnutls_pk_algorithm_t` value to a string.

Returns: a pointer to a string that contains the name of the specified public key algorithm, or `NULL`.

Since: 2.6.0

gnutls_pk_list

`const gnutls_pk_algorithm_t * gnutls_pk_list (void)` [Function]

Get a list of supported public key algorithms.

This function is not thread safe.

Returns: a (0)-terminated list of `gnutls_pk_algorithm_t` integers indicating the available ciphers.

Since: 2.6.0

gnutls_pkcs11_add_provider

`int gnutls_pkcs11_add_provider (const char * name, const char * params)` [Function]

name: The filename of the module

params: should be NULL

This function will load and add a PKCS 11 module to the module list used in gnutls. After this function is called the module will be used for PKCS 11 operations.

Returns: On success, `GNUTLS_E_SUCCESS` (0) is returned, otherwise a negative error value.

gnutls_pkcs11_copy_secret_key

`int gnutls_pkcs11_copy_secret_key (const char * token_url, gnutls_datum_t * key, const char * label, unsigned int key_usage, unsigned int flags)` [Function]

token_url: A PKCS 11 URL specifying a token

key: The raw key

label: A name to be used for the stored data

key_usage: One of `GNUTLS_KEY_*`

flags: One of `GNUTLS_PKCS11_OBJ_FLAG_*`

This function will copy a raw secret (symmetric) key into a PKCS 11 token specified by a URL. The key can be marked as sensitive or not.

Returns: On success, `GNUTLS_E_SUCCESS` (0) is returned, otherwise a negative error value.

gnutls_pkcs11_copy_x509_cert

`int gnutls_pkcs11_copy_x509_cert (const char * token_url, gnutls_x509_cert_t crt, const char * label, unsigned int flags)` [Function]

token_url: A PKCS 11 URL specifying a token

crt: A certificate

label: A name to be used for the stored data

flags: One of `GNUTLS_PKCS11_OBJ_FLAG_*`

This function will copy a certificate into a PKCS 11 token specified by a URL. The certificate can be marked as trusted or not.

Returns: On success, `GNUTLS_E_SUCCESS` (0) is returned, otherwise a negative error value.

`gnutls_pkcs11_copy_x509_privkey`

```
int gnutls_pkcs11_copy_x509_privkey (const char * token_url,      [Function]
                                   gnutls_x509_privkey_t key, const char * label, unsigned int key_usage,
                                   unsigned int flags)
```

token_url: A PKCS 11 URL specifying a token

key: A private key

label: A name to be used for the stored data

key_usage: One of `GNUTLS_KEY_*`

flags: One of `GNUTLS_PKCS11_OBJ_*` flags

This function will copy a private key into a PKCS 11 token specified by a URL. It is highly recommended flags to contain `GNUTLS_PKCS11_OBJ_FLAG_MARK_SENSITIVE` unless there is a strong reason not to.

Returns: On success, `GNUTLS_E_SUCCESS` (0) is returned, otherwise a negative error value.

`gnutls_pkcs11_deinit`

```
void gnutls_pkcs11_deinit ( void)                                [Function]
```

This function will deinitialize the PKCS 11 subsystem in `gnutls`.

`gnutls_pkcs11_delete_url`

```
int gnutls_pkcs11_delete_url (const char * object_url, unsigned [Function]
                              int flags)
```

object_url: The URL of the object to delete.

flags: One of `GNUTLS_PKCS11_OBJ_*` flags

This function will delete objects matching the given URL.

Returns: On success, the number of objects deleted is returned, otherwise a negative error value.

`gnutls_pkcs11_init`

```
int gnutls_pkcs11_init (unsigned int flags, const char *      [Function]
                       configfile)
```

flags: `GNUTLS_PKCS11_FLAG_MANUAL` or `GNUTLS_PKCS11_FLAG_AUTO`

configfile: either `NULL` or the location of a configuration file

This function will initialize the PKCS 11 subsystem in `gnutls`. It will read a configuration file if `GNUTLS_PKCS11_FLAG_AUTO` is used or allow you to independently load PKCS 11 modules using `gnutls_pkcs11_add_provider()` if `GNUTLS_PKCS11_FLAG_MANUAL` is specified.

Normally you don't need to call this function since it is being called by `gnutls_global_init()` using the `GNUTLS_PKCS11_FLAG_AUTO`. If other option is required then it must be called before it.

Returns: On success, `GNUTLS_E_SUCCESS` (0) is returned, otherwise a negative error value.

gnutls_pkcs11_obj_deinit

`void gnutls_pkcs11_obj_deinit (gnutls_pkcs11_obj_t obj)` [Function]
obj: The structure to be initialized
 This function will deinitialize a certificate structure.

gnutls_pkcs11_obj_export_url

`int gnutls_pkcs11_obj_export_url (gnutls_pkcs11_obj_t obj, gnutls_pkcs11_url_type_t detailed, char ** url)` [Function]
obj: Holds the PKCS 11 certificate
detailed: non zero if a detailed URL is required
url: will contain an allocated url
 This function will export a URL identifying the given certificate.
Returns: On success, `GNUTLS_E_SUCCESS` (0) is returned, otherwise a negative error value.

gnutls_pkcs11_obj_export

`int gnutls_pkcs11_obj_export (gnutls_pkcs11_obj_t obj, void * output_data, size_t * output_data_size)` [Function]
obj: Holds the object
output_data: will contain a certificate PEM or DER encoded
output_data_size: holds the size of *output_data* (and will be replaced by the actual size of parameters)
 This function will export the pkcs11 object data. It is normal for PKCS 11 data to be inaccessible and in that case `GNUTLS_E_INVALID_REQUEST` will be returned.
 If the buffer provided is not long enough to hold the output, then **output_data_size* is updated and `GNUTLS_E_SHORT_MEMORY_BUFFER` will be returned.
 If the structure is PEM encoded, it will have a header of "BEGIN CERTIFICATE".
Returns: In case of failure a negative error code will be returned, and `GNUTLS_E_SUCCESS` (0) on success.

gnutls_pkcs11_obj_get_info

`int gnutls_pkcs11_obj_get_info (gnutls_pkcs11_obj_t crt, gnutls_pkcs11_obj_info_t itype, void * output, size_t * output_size)` [Function]
crt: should contain a `gnutls_pkcs11_obj_t` structure
itype: Denotes the type of information requested
output: where output will be stored
output_size: contains the maximum size of the output and will be overwritten with actual

This function will return information about the PKCS 11 certificates such as the label, id as well as token information where the key is stored. When output is text it returns null terminated string although `output_size` contains the size of the actual data only.

Returns: GNUTLS_E_SUCCESS (0) on success or a negative error code on error.

gnutls_pkcs11_obj_get_type

`gnutls_pkcs11_obj_type_t gnutls_pkcs11_obj_get_type` [Function]

(*gnutls_pkcs11_obj_t obj*)

obj: Holds the PKCS 11 object

This function will return the type of the certificate being stored in the structure.

Returns: The type of the certificate.

gnutls_pkcs11_obj_import_url

`int gnutls_pkcs11_obj_import_url` (*gnutls_pkcs11_obj_t cert*, [Function]

*const char * url*, *unsigned int flags*)

cert: The structure to store the parsed certificate

url: a PKCS 11 url identifying the key

flags: One of GNUTLS_PKCS11_OBJ_* flags

This function will "import" a PKCS 11 URL identifying a certificate key to the `gnutls_pkcs11_obj_t` structure. This does not involve any parsing (such as X.509 or OpenPGP) since the `gnutls_pkcs11_obj_t` is format agnostic. Only data are transferred.

Returns: On success, GNUTLS_E_SUCCESS (0) is returned, otherwise a negative error value.

gnutls_pkcs11_obj_init

`int gnutls_pkcs11_obj_init` (*gnutls_pkcs11_obj_t * obj*) [Function]

obj: The structure to be initialized

This function will initialize a pkcs11 certificate structure.

Returns: On success, GNUTLS_E_SUCCESS (0) is returned, otherwise a negative error value.

gnutls_pkcs11_obj_list_import_url

`int gnutls_pkcs11_obj_list_import_url` (*gnutls_pkcs11_obj_t ** [Function]

p_list, *unsigned int * n_list*, *const char * url*, *gnutls_pkcs11_obj_attr_t attrs*, *unsigned int flags*)

p_list: An uninitialized object list (may be NULL)

n_list: initially should hold the maximum size of the list. Will contain the actual size.

url: A PKCS 11 url identifying a set of objects

attrs: Attributes of type `gnutls_pkcs11_obj_attr_t` that can be used to limit output

flags: One of GNUTLS_PKCS11_OBJ_* flags

This function will initialize and set values to an object list by using all objects identified by a PKCS 11 URL.

Returns: On success, GNUTLS_E_SUCCESS (0) is returned, otherwise a negative error value.

gnutls_pkcs11_privkey_deinit

`void gnutls_pkcs11_privkey_deinit (gnutls_pkcs11_privkey_t key)` [Function]
key: The structure to be initialized

This function will deinitialize a private key structure.

gnutls_pkcs11_privkey_export_url

`int gnutls_pkcs11_privkey_export_url (gnutls_pkcs11_privkey_t key, gnutls_pkcs11_url_type_t detailed, char ** url)` [Function]

key: Holds the PKCS 11 key

detailed: non zero if a detailed URL is required

url: will contain an allocated url

This function will export a URL identifying the given key.

Returns: On success, GNUTLS_E_SUCCESS (0) is returned, otherwise a negative error value.

gnutls_pkcs11_privkey_get_info

`int gnutls_pkcs11_privkey_get_info (gnutls_pkcs11_privkey_t pkey, gnutls_pkcs11_obj_info_t itype, void * output, size_t * output_size)` [Function]

pkey: should contain a `gnutls_pkcs11_privkey_t` structure

itype: Denotes the type of information requested

output: where output will be stored

output_size: contains the maximum size of the output and will be overwritten with actual

This function will return information about the PKCS 11 private key such as the label, id as well as token information where the key is stored. When output is text it returns null terminated string although `output_size` contains the size of the actual data only.

Returns: GNUTLS_E_SUCCESS (0) on success or a negative error code on error.

gnutls_pkcs11_privkey_get_pk_algorithm

`int gnutls_pkcs11_privkey_get_pk_algorithm (gnutls_pkcs11_privkey_t key, unsigned int * bits)` [Function]

key: should contain a `gnutls_pkcs11_privkey_t` structure

bits: if bits is non null it will hold the size of the parameters' in bits

This function will return the public key algorithm of a private key.

Returns: a member of the `gnutls_pk_algorithm_t` enumeration on success, or a negative error code on error.

gnutls_pkcs11_privkey_import_url

`int gnutls_pkcs11_privkey_import_url (gnutls_pkcs11_privkey_t pkey, const char * url, unsigned int flags)` [Function]

pkey: The structure to store the parsed key

url: a PKCS 11 url identifying the key

flags: sequence of GNUTLS_PKCS_PRIVKEY_*

This function will "import" a PKCS 11 URL identifying a private key to the `gnutls_pkcs11_privkey_t` structure. In reality since in most cases keys cannot be exported, the private key structure is being associated with the available operations on the token.

Returns: On success, GNUTLS_E_SUCCESS (0) is returned, otherwise a negative error value.

gnutls_pkcs11_privkey_init

`int gnutls_pkcs11_privkey_init (gnutls_pkcs11_privkey_t * key)` [Function]

key: The structure to be initialized

This function will initialize an private key structure.

Returns: On success, GNUTLS_E_SUCCESS (0) is returned, otherwise a negative error value.

gnutls_pkcs11_set_pin_function

`void gnutls_pkcs11_set_pin_function (gnutls_pkcs11_pin_callback_t fn, void * userdata)` [Function]

fn: The PIN callback

userdata: data to be supplied to callback

This function will set a callback function to be used when a PIN is required for PKCS 11 operations.

Callback for PKCS11 PIN entry. The callback provides the PIN code to unlock the token with label 'token_label', specified by the URL 'token_url'.

The PIN code, as a NUL-terminated ASCII string, should be copied into the 'pin' buffer (of maximum size `pin_max`), and return 0 to indicate success. Alternatively, the callback may return a negative gnutls error code to indicate failure and cancel PIN entry (in which case, the contents of the 'pin' parameter are ignored).

When a PIN is required, the callback will be invoked repeatedly (and indefinitely) until either the returned PIN code is correct, the callback returns failure, or the token refuses login (e.g. when the token is locked due to too many incorrect PINs!). For the first such invocation, the 'attempt' counter will have value zero; it will increase by one for each subsequent attempt.

Returns: On success, GNUTLS_E_SUCCESS (0) is returned, otherwise a negative error value.

gnutls_pkcs11_set_token_function

`void gnutls_pkcs11_set_token_function` [Function]

(*gnutls_pkcs11_token_callback_t fn*, *void * userdata*)

fn: The token callback

userdata: data to be supplied to callback

This function will set a callback function to be used when a token needs to be inserted to continue PKCS 11 operations.

Returns: On success, GNUTLS_E_SUCCESS (0) is returned, otherwise a negative error value.

gnutls_pkcs11_token_get_flags

`int gnutls_pkcs11_token_get_flags` (*const char * url*, *unsigned int * flags*) [Function]

url: should contain a PKCS 11 URL

flags: The output flags (GNUTLS_PKCS11_TOKEN_*)

This function will return information about the PKCS 11 token flags.

Returns: GNUTLS_E_SUCCESS (0) on success or a negative error code on error.

gnutls_pkcs11_token_get_info

`int gnutls_pkcs11_token_get_info` (*const char * url*, *gnutls_pkcs11_token_info_t ttype*, *void * output*, *size_t * output_size*) [Function]

url: should contain a PKCS 11 URL

ttype: Denotes the type of information requested

output: where output will be stored

output_size: contains the maximum size of the output and will be overwritten with actual

This function will return information about the PKCS 11 token such as the label, id as well as token information where the key is stored.

Returns: GNUTLS_E_SUCCESS (0) on success or a negative error code on error.

gnutls_pkcs11_token_get_mechanism

`int gnutls_pkcs11_token_get_mechanism` (*const char * url*, *int idx*, *unsigned long * mechanism*) [Function]

url: should contain a PKCS 11 URL

idx: The index of the mechanism

mechanism: The PKCS 11 mechanism ID

This function will return the names of the supported mechanisms by the token. It should be called with an increasing index until it return GNUTLS_E_REQUESTED_DATA_NOT_AVAILABLE.

Returns: GNUTLS_E_SUCCESS (0) on success or a negative error code on error.

gnutls_pkcs11_token_get_url

int gnutls_pkcs11_token_get_url (*unsigned int seq*, [Function]
gnutls_pkcs11_url_type_t detailed, *char ** url*)

seq: sequence number starting from 0

detailed: non zero if a detailed URL is required

url: will contain an allocated url

This function will return the URL for each token available in system. The url has to be released using `gnutls_free()`

Returns: On success, `GNUTLS_E_SUCCESS (0)` is returned, `GNUTLS_E_REQUESTED_DATA_NOT_AVAILABLE` if the sequence number exceeds the available tokens, otherwise a negative error value.

gnutls_pkcs11_token_init

int gnutls_pkcs11_token_init (*const char * token_url*, *const char* [Function]
** so_pin*, *const char * label*)

token_url: A PKCS 11 URL specifying a token

so_pin: Security Officer's PIN

label: A name to be used for the token

This function will initialize (format) a token. If the token is at a factory defaults state the security officer's PIN given will be set to be the default. Otherwise it should match the officer's PIN.

Returns: On success, `GNUTLS_E_SUCCESS (0)` is returned, otherwise a negative error value.

gnutls_pkcs11_token_set_pin

int gnutls_pkcs11_token_set_pin (*const char * token_url*, *const* [Function]
*char * oldpin*, *const char * newpin*, *unsigned int flags*)

token_url: A PKCS 11 URL specifying a token

oldpin: old user's PIN

newpin: new user's PIN

flags: one of `gnutls_pkcs11_pin_flag_t`

This function will modify or set a user's PIN for the given token. If it is called to set a user pin for first time the oldpin must be NULL.

Returns: On success, `GNUTLS_E_SUCCESS (0)` is returned, otherwise a negative error value.

gnutls_prf_raw

int gnutls_prf_raw (*gnutls_session_t session*, *size_t label_size*, [Function]
*const char * label*, *size_t seed_size*, *const char * seed*, *size_t outsize*,
*char * out*)

session: is a `gnutls_session_t` structure.

label_size: length of the `label` variable.

label: label used in PRF computation, typically a short string.

seed_size: length of the `seed` variable.

seed: optional extra data to seed the PRF with.

outside: size of pre-allocated output buffer to hold the output.

out: pre-allocate buffer to hold the generated data.

Apply the TLS Pseudo-Random-Function (PRF) using the master secret on some data.

The `label` variable usually contain a string denoting the purpose for the generated data. The `seed` usually contain data such as the client and server random, perhaps together with some additional data that is added to guarantee uniqueness of the output for a particular purpose.

Because the output is not guaranteed to be unique for a particular session unless `seed` include the client random and server random fields (the PRF would output the same data on another connection resumed from the first one), it is not recommended to use this function directly. The `gnutls_prf()` function seed the PRF with the client and server random fields directly, and is recommended if you want to generate pseudo random data unique for each session.

Returns: `GNUTLS_E_SUCCESS` on success, or an error code.

gnutls_prf

```
int gnutls_prf (gnutls_session_t session, size_t label_size, const [Function]
                char * label, int server_random_first, size_t extra_size, const char *
                extra, size_t outside, char * out)
```

session: is a `gnutls_session_t` structure.

label_size: length of the `label` variable.

label: label used in PRF computation, typically a short string.

server_random_first: non-0 if server random field should be first in seed

extra_size: length of the `extra` variable.

extra: optional extra data to seed the PRF with.

outside: size of pre-allocated output buffer to hold the output.

out: pre-allocate buffer to hold the generated data.

Apply the TLS Pseudo-Random-Function (PRF) using the master secret on some data, seeded with the client and server random fields.

The `label` variable usually contain a string denoting the purpose for the generated data. The `server_random_first` indicate whether the client random field or the server random field should be first in the seed. Non-0 indicate that the server random field is first, 0 that the client random field is first.

The `extra` variable can be used to add more data to the seed, after the random variables. It can be used to tie make sure the generated output is strongly connected to some additional data (e.g., a string used in user authentication).

The output is placed in `*OUT`, which must be pre-allocated.

Returns: `GNUTLS_E_SUCCESS` on success, or an error code.

gnutls_priority_deinit

void gnutls_priority_deinit (*gnutls_priority_t* *priority_cache*) [Function]

priority_cache: is a *gnutls_priority_t* structure.

Deinitializes the priority cache.

gnutls_priority_init

int gnutls_priority_init (*gnutls_priority_t* **priority_cache*, [Function]
const char **priorities*, *const char* ***err_pos*)

priority_cache: is a *gnutls_priority_t* structure.

priorities: is a string describing priorities

err_pos: In case of an error this will have the position in the string the error occurred

Sets priorities for the ciphers, key exchange methods, macs and compression methods.

The *priorities* option allows you to specify a colon separated list of the cipher priorities to enable. Some keywords are defined to provide quick access to common preferences.

"PERFORMANCE" means all the "secure" ciphersuites are enabled, limited to 128 bit ciphers and sorted by terms of speed performance.

"NORMAL" means all "secure" ciphersuites. The 256-bit ciphers are included as a fallback only. The ciphers are sorted by security margin.

"SECURE128" means all "secure" ciphersuites of security level 128-bit or more.

"SECURE192" means all "secure" ciphersuites of security level 192-bit or more.

"SUITEB128" means all the NSA SuiteB ciphersuites with security level of 128.

"SUITEB192" means all the NSA SuiteB ciphersuites with security level of 192.

"EXPORT" means all ciphersuites are enabled, including the low-security 40 bit ciphers.

"NONE" means nothing is enabled. This disables even protocols and compression methods.

Special keywords are "!", "-", and "+". "!" or "-" appended with an algorithm will remove this algorithm. "+" appended with an algorithm will add this algorithm.

Check the GnuTLS manual section "Priority strings" for detailed information.

Examples: "NONE:+VERS-TLS-ALL:+MAC-ALL:+RSA:+AES-128-CBC:+SIGN-ALL:+COMP-NULL"

"NORMAL:-ARCFOUR-128" means normal ciphers except for ARCFOUR-128.

"SECURE:-VERS-SSL3.0:+COMP-DEFLATE" means that only secure ciphers are enabled, SSL3.0 is disabled, and libz compression enabled.

"NONE:+VERS-TLS-ALL:+AES-128-CBC:+RSA:+SHA1:+COMP-NULL:+SIGN-RSA-SHA1",

"NONE:+VERS-TLS-ALL:+AES-128-CBC:+ECDHE-RSA:+SHA1:+COMP-NULL:+SIGN-RSA-SHA1:+CURVE-SECP256R1",

"NORMAL:COMPAT" is the most compatible mode.

Returns: On syntax error `GNUTLS_E_INVALID_REQUEST` is returned, `GNUTLS_E_SUCCESS` on success, or an error code.

gnutls_priority_set_direct

```
int gnutls_priority_set_direct (gnutls_session_t session, const char * priorities, const char ** err_pos) [Function]
```

session: is a `gnutls_session_t` structure.

priorities: is a string describing priorities

err_pos: In case of an error this will have the position in the string the error occurred

Sets the priorities to use on the ciphers, key exchange methods, macs and compression methods. This function avoids keeping a priority cache and is used to directly set string priorities to a TLS session. For documentation check the `gnutls_priority_init()`.

Returns: On syntax error `GNUTLS_E_INVALID_REQUEST` is returned, `GNUTLS_E_SUCCESS` on success, or an error code.

gnutls_priority_set

```
int gnutls_priority_set (gnutls_session_t session, gnutls_priority_t priority) [Function]
```

session: is a `gnutls_session_t` structure.

priority: is a `gnutls_priority_t` structure.

Sets the priorities to use on the ciphers, key exchange methods, macs and compression methods.

Returns: `GNUTLS_E_SUCCESS` on success, or an error code.

gnutls_privkey_decrypt_data

```
int gnutls_privkey_decrypt_data (gnutls_privkey_t key, unsigned int flags, const gnutls_datum_t * ciphertext, gnutls_datum_t * plaintext) [Function]
```

key: Holds the key

flags: zero for now

ciphertext: holds the data to be decrypted

plaintext: will contain the decrypted data, allocated with `gnutls_malloc()`

This function will decrypt the given data using the algorithm supported by the private key.

Returns: On success, `GNUTLS_E_SUCCESS` (0) is returned, otherwise a negative error value.

gnutls_privkey_deinit

```
void gnutls_privkey_deinit (gnutls_privkey_t key) [Function]
```

key: The structure to be deinitialized

This function will deinitialize a private key structure.

gnutls_privkey_get_pk_algorithm

`int gnutls_privkey_get_pk_algorithm (gnutls_privkey_t key, [Function]
 unsigned int *bits)`

key: should contain a `gnutls_privkey_t` structure

bits: If set will return the number of bits of the parameters (may be NULL)

This function will return the public key algorithm of a private key and if possible will return a number of bits that indicates the security parameter of the key.

Returns: a member of the `gnutls_pk_algorithm_t` enumeration on success, or a negative error code on error.

gnutls_privkey_get_type

`gnutls_privkey_type_t gnutls_privkey_get_type [Function]
 (gnutls_privkey_t key)`

key: should contain a `gnutls_privkey_t` structure

This function will return the type of the private key. This is actually the type of the subsystem used to set this private key.

Returns: a member of the `gnutls_privkey_type_t` enumeration on success, or a negative error code on error.

gnutls_privkey_import_openpgp

`int gnutls_privkey_import_openpgp (gnutls_privkey_t pkey, [Function]
 gnutls_openpgp_privkey_t key, unsigned int flags)`

pkey: The private key

key: The private key to be imported

flags: should be zero or `GNUTLS_PRIVKEY_IMPORT_AUTO_RELEASE`

This function will import the given private key to the abstract `gnutls_privkey_t` structure.

The `gnutls_openpgp_privkey_t` object must not be deallocated during the lifetime of this structure. The subkey set as preferred will be used, or the master key otherwise.

Returns: On success, `GNUTLS_E_SUCCESS` (0) is returned, otherwise a negative error value.

gnutls_privkey_import_pkcs11

`int gnutls_privkey_import_pkcs11 (gnutls_privkey_t pkey, [Function]
 gnutls_pkcs11_privkey_t key, unsigned int flags)`

pkey: The private key

key: The private key to be imported

flags: should be zero or `GNUTLS_PRIVKEY_IMPORT_AUTO_RELEASE`

This function will import the given private key to the abstract `gnutls_privkey_t` structure.

The `gnutls_pkcs11_privkey_t` object must not be deallocated during the lifetime of this structure.

Returns: On success, `GNUTLS_E_SUCCESS` (0) is returned, otherwise a negative error value.

`gnutls_privkey_import_x509`

`int gnutls_privkey_import_x509 (gnutls_privkey_t pkey, [Function]
gnutls_x509_privkey_t key, unsigned int flags)`

pkey: The private key

key: The private key to be imported

flags: should be zero or `GNUTLS_PRIVKEY_IMPORT_AUTO_RELEASE`

This function will import the given private key to the abstract `gnutls_privkey_t` structure.

The `gnutls_x509_privkey_t` object must not be deallocated during the lifetime of this structure.

Returns: On success, `GNUTLS_E_SUCCESS` (0) is returned, otherwise a negative error value.

`gnutls_privkey_init`

`int gnutls_privkey_init (gnutls_privkey_t * key) [Function]`

key: The structure to be initialized

This function will initialize an private key structure.

Returns: On success, `GNUTLS_E_SUCCESS` (0) is returned, otherwise a negative error value.

`gnutls_privkey_sign_data`

`int gnutls_privkey_sign_data (gnutls_privkey_t signer, [Function]
gnutls_digest_algorithm_t hash, unsigned int flags, const gnutls_datum_t *
data, gnutls_datum_t * signature)`

signer: Holds the key

hash: should be a digest algorithm

flags: should be 0 for now

data: holds the data to be signed

signature: will contain the signature allocate with `gnutls_malloc()`

This function will sign the given data using a signature algorithm supported by the private key. Signature algorithms are always used together with a hash functions. Different hash functions may be used for the RSA algorithm, but only the SHA family for the DSA keys.

Use `gnutls_pubkey_get_preferred_hash_algorithm()` to determine the hash algorithm.

Returns: On success, `GNUTLS_E_SUCCESS` (0) is returned, otherwise a negative error value.

Since: 2.12.0

gnutls_privkey_sign_hash

```
int gnutls_privkey_sign_hash (gnutls_privkey_t signer,           [Function]
                             gnutls_digest_algorithm_t hash_algo, unsigned int flags, const
                             gnutls_datum_t * hash_data, gnutls_datum_t * signature)
```

signer: Holds the signer's key

hash_algo: The hash algorithm used

flags: zero for now

hash_data: holds the data to be signed

signature: will contain newly allocated signature

This function will sign the given hashed data using a signature algorithm supported by the private key. Signature algorithms are always used together with a hash functions. Different hash functions may be used for the RSA algorithm, but only SHA-XXX for the DSA keys.

Use `gnutls_pubkey_get_preferred_hash_algorithm()` to determine the hash algorithm.

Returns: On success, GNUTLS_E_SUCCESS (0) is returned, otherwise a negative error value.

Since: 2.12.0

gnutls_protocol_get_id

```
gnutls_protocol_t gnutls_protocol_get_id (const char * name)    [Function]
name: is a protocol name
```

The names are compared in a case insensitive way.

Returns: an id of the specified protocol, or GNUTLS_VERSION_UNKNOWN on error.

gnutls_protocol_get_name

```
const char * gnutls_protocol_get_name (gnutls_protocol_t        [Function]
                                       version)
```

version: is a (gnutls) version number

Convert a `gnutls_protocol_t` value to a string.

Returns: a string that contains the name of the specified TLS version (e.g., "TLS1.0"), or NULL.

gnutls_protocol_get_version

```
gnutls_protocol_t gnutls_protocol_get_version (gnutls_session_t [Function]
                                               session)
```

session: is a `gnutls_session_t` structure.

Get TLS version, a `gnutls_protocol_t` value.

Returns: the version of the currently used protocol.

gnutls_protocol_list

`const gnutls_protocol_t * gnutls_protocol_list (void)` [Function]

Get a list of supported protocols, e.g. SSL 3.0, TLS 1.0 etc.

This function is not thread safe.

Returns: a (0)-terminated list of `gnutls_protocol_t` integers indicating the available protocols.

gnutls_protocol_set_priority

`int gnutls_protocol_set_priority (gnutls_session_t session, const int * list)` [Function]

session: is a `gnutls_session_t` structure.

list: is a 0 terminated list of `gnutls_protocol_t` elements.

Sets the priority on the protocol versions supported by gnutls. This function actually enables or disables protocols. Newer protocol versions always have highest priority.

Returns: `GNUTLS_E_SUCCESS` on success, or an error code.

gnutls_psk_allocate_client_credentials

`int gnutls_psk_allocate_client_credentials (gnutls_psk_client_credentials_t * sc)` [Function]

sc: is a pointer to a `gnutls_psk_server_credentials_t` structure.

This structure is complex enough to manipulate directly thus this helper function is provided in order to allocate it.

Returns: `GNUTLS_E_SUCCESS` on success, or an error code.

gnutls_psk_allocate_server_credentials

`int gnutls_psk_allocate_server_credentials (gnutls_psk_server_credentials_t * sc)` [Function]

sc: is a pointer to a `gnutls_psk_server_credentials_t` structure.

This structure is complex enough to manipulate directly thus this helper function is provided in order to allocate it.

Returns: `GNUTLS_E_SUCCESS` on success, or an error code.

gnutls_psk_client_get_hint

`const char * gnutls_psk_client_get_hint (gnutls_session_t session)` [Function]

session: is a gnutls session

The PSK identity hint may give the client help in deciding which username to use. This should only be called in case of PSK authentication and in case of a client.

Returns: the identity hint of the peer, or NULL in case of an error.

Since: 2.4.0

gnutls_psk_free_client_credentials

void gnutls_psk_free_client_credentials [Function]

(*gnutls_psk_client_credentials_t sc*)

sc: is a *gnutls_psk_client_credentials_t* structure.

This structure is complex enough to manipulate directly thus this helper function is provided in order to free (deallocate) it.

gnutls_psk_free_server_credentials

void gnutls_psk_free_server_credentials [Function]

(*gnutls_psk_server_credentials_t sc*)

sc: is a *gnutls_psk_server_credentials_t* structure.

This structure is complex enough to manipulate directly thus this helper function is provided in order to free (deallocate) it.

gnutls_psk_server_get_username

const char * gnutls_psk_server_get_username (*gnutls_session_t session*) [Function]

session: is a gnutls session

This should only be called in case of PSK authentication and in case of a server.

Returns: the username of the peer, or NULL in case of an error.

gnutls_psk_set_client_credentials_function

void gnutls_psk_set_client_credentials_function [Function]

(*gnutls_psk_client_credentials_t cred*, *gnutls_psk_client_credentials_function * func*)

cred: is a *gnutls_psk_server_credentials_t* structure.

func: is the callback function

This function can be used to set a callback to retrieve the username and password for client PSK authentication. The callback's function form is: int (*callback)(*gnutls_session_t*, char** *username*, *gnutls_datum_t* key*);

The *username* and *key->data* must be allocated using *gnutls_malloc()*. *username* should be ASCII strings or UTF-8 strings prepared using the "SASLprep" profile of "stringprep".

The callback function will be called once per handshake.

The callback function should return 0 on success. -1 indicates an error.

gnutls_psk_set_client_credentials

int gnutls_psk_set_client_credentials [Function]

(*gnutls_psk_client_credentials_t res*, *const char * username*, *const gnutls_datum_t * key*, *gnutls_psk_key_flags flags*)

res: is a *gnutls_psk_client_credentials_t* structure.

username: is the user's zero-terminated userid

key: is the user's key

flags: indicate the format of the key, either `GNUTLS_PSK_KEY_RAW` or `GNUTLS_PSK_KEY_HEX`.

This function sets the username and password, in a `gnutls_psk_client_credentials_t` structure. Those will be used in PSK authentication. `username` should be an ASCII string or UTF-8 strings prepared using the "SASLprep" profile of "stringprep". The key can be either in raw byte format or in Hex format (without the 0x prefix).

Returns: `GNUTLS_E_SUCCESS` on success, or an error code.

gnutls_psk_set_params_function

```
void gnutls_psk_set_params_function [Function]
    (gnutls_psk_server_credentials_t res, gnutls_params_function * func)
```

res: is a `gnutls_psk_server_credentials_t` structure

func: is the function to be called

This function will set a callback in order for the server to get the Diffie-Hellman or RSA parameters for PSK authentication. The callback should return `GNUTLS_E_SUCCESS` (0) on success.

gnutls_psk_set_server_credentials_file

```
int gnutls_psk_set_server_credentials_file [Function]
    (gnutls_psk_server_credentials_t res, const char * password_file)
```

res: is a `gnutls_psk_server_credentials_t` structure.

password_file: is the PSK password file (passwd.psk)

This function sets the password file, in a `gnutls_psk_server_credentials_t` structure. This password file holds usernames and keys and will be used for PSK authentication.

Returns: `GNUTLS_E_SUCCESS` on success, or an error code.

gnutls_psk_set_server_credentials_function

```
void gnutls_psk_set_server_credentials_function [Function]
    (gnutls_psk_server_credentials_t cred, gnutls_psk_server_credentials_function *
    func)
```

cred: is a `gnutls_psk_server_credentials_t` structure.

func: is the callback function

This function can be used to set a callback to retrieve the user's PSK credentials. The callback's function form is: `int (*callback)(gnutls_session_t, const char* username, gnutls_datum_t* key);`

`username` contains the actual username. The `key` must be filled in using the `gnutls_malloc()`.

In case the callback returned a negative number then gnutls will assume that the username does not exist.

The callback function will only be called once per handshake. The callback function should return 0 on success, while -1 indicates an error.

gnutls_psk_set_server_credentials_hint

`int gnutls_psk_set_server_credentials_hint` [Function]

(*gnutls_psk_server_credentials_t res*, *const char * hint*)

res: is a `gnutls_psk_server_credentials_t` structure.

hint: is the PSK identity hint string

This function sets the identity hint, in a `gnutls_psk_server_credentials_t` structure. This hint is sent to the client to help it chose a good PSK credential (i.e., username and password).

Returns: `GNUTLS_E_SUCCESS` on success, or an error code.

Since: 2.4.0

gnutls_psk_set_server_dh_params

`void gnutls_psk_set_server_dh_params` [Function]

(*gnutls_psk_server_credentials_t res*, *gnutls_dh_params_t dh_params*)

res: is a `gnutls_psk_server_credentials_t` structure

dh_params: is a structure that holds Diffie-Hellman parameters.

This function will set the Diffie-Hellman parameters for an anonymous server to use. These parameters will be used in Diffie-Hellman exchange with PSK cipher suites.

gnutls_psk_set_server_params_function

`void gnutls_psk_set_server_params_function` [Function]

(*gnutls_psk_server_credentials_t res*, *gnutls_params_function * func*)

res: is a `gnutls_certificate_credentials_t` structure

func: is the function to be called

This function will set a callback in order for the server to get the Diffie-Hellman parameters for PSK authentication. The callback should return `GNUTLS_E_SUCCESS` (0) on success.

gnutls_pubkey_deinit

`void gnutls_pubkey_deinit` (*gnutls_pubkey_t key*) [Function]

key: The structure to be deinitialized

This function will deinitialize a public key structure.

gnutls_pubkey_export

`int gnutls_pubkey_export` (*gnutls_pubkey_t key*, [Function]

gnutls_x509_cert_fmt_t format, *void * output_data*, *size_t * output_data_size*)

key: Holds the certificate

format: the format of output params. One of PEM or DER.

output_data: will contain a certificate PEM or DER encoded

output_data_size: holds the size of *output_data* (and will be replaced by the actual size of parameters)

This function will export the certificate to DER or PEM format.

If the buffer provided is not long enough to hold the output, then **output_data_size* is updated and `GNUTLS_E_SHORT_MEMORY_BUFFER` will be returned.

If the structure is PEM encoded, it will have a header of "BEGIN CERTIFICATE".

Returns: In case of failure a negative error code will be returned, and 0 on success.

gnutls_pubkey_get_key_id

```
int gnutls_pubkey_get_key_id (gnutls_pubkey_t key, unsigned int flags, unsigned char * output_data, size_t * output_data_size) [Function]
```

key: Holds the public key

flags: should be 0 for now

output_data: will contain the key ID

output_data_size: holds the size of *output_data* (and will be replaced by the actual size of parameters)

This function will return a unique ID the depends on the public key parameters. This ID can be used in checking whether a certificate corresponds to the given public key.

If the buffer provided is not long enough to hold the output, then **output_data_size* is updated and `GNUTLS_E_SHORT_MEMORY_BUFFER` will be returned. The output will normally be a SHA-1 hash output, which is 20 bytes.

Returns: In case of failure a negative error code will be returned, and 0 on success.

gnutls_pubkey_get_key_usage

```
int gnutls_pubkey_get_key_usage (gnutls_pubkey_t key, unsigned int * usage) [Function]
```

key: should contain a `gnutls_pubkey_t` structure

usage: If set will return the number of bits of the parameters (may be NULL)

This function will return the key usage of the public key.

Returns: On success, `GNUTLS_E_SUCCESS` (0) is returned, otherwise a negative error value.

gnutls_pubkey_get_openpgp_key_id

```
int gnutls_pubkey_get_openpgp_key_id (gnutls_pubkey_t key, unsigned int flags, unsigned char * output_data, size_t * output_data_size, unsigned int * subkey) [Function]
```

key: Holds the public key

flags: should be 0 for now

output_data: will contain the key ID

output_data_size: holds the size of *output_data* (and will be replaced by the actual size of parameters)

subkey: Will be non zero if the key ID corresponds to a subkey

This function will return a unique ID that depends on the public key parameters. This ID can be used in checking whether a certificate corresponds to the given public key. If the buffer provided is not long enough to hold the output, then **output_data_size* is updated and `GNUTLS_E_SHORT_MEMORY_BUFFER` will be returned. The output will normally be a SHA-1 hash output, which is 20 bytes.

Returns: In case of failure a negative error code will be returned, and 0 on success.

gnutls_pubkey_get_pk_algorithm

```
int gnutls_pubkey_get_pk_algorithm (gnutls_pubkey_t key,          [Function]
                                   unsigned int * bits)
```

key: should contain a `gnutls_pubkey_t` structure

bits: If set will return the number of bits of the parameters (may be NULL)

This function will return the public key algorithm of a public key and if possible will return a number of bits that indicates the security parameter of the key.

Returns: a member of the `gnutls_pk_algorithm_t` enumeration on success, or a negative error code on error.

gnutls_pubkey_get_pk_dsa_raw

```
int gnutls_pubkey_get_pk_dsa_raw (gnutls_pubkey_t key,          [Function]
                                   gnutls_datum_t * p, gnutls_datum_t * q, gnutls_datum_t * g, gnutls_datum_t
                                   * y)
```

key: Holds the public key

p: will hold the p

q: will hold the q

g: will hold the g

y: will hold the y

This function will export the DSA public key's parameters found in the given certificate. The new parameters will be allocated using `gnutls_malloc()` and will be stored in the appropriate datum.

Returns: `GNUTLS_E_SUCCESS` on success, otherwise a negative error code.

gnutls_pubkey_get_pk_ecc_raw

```
int gnutls_pubkey_get_pk_ecc_raw (gnutls_pubkey_t key,          [Function]
                                   gnutls_ecc_curve_t * curve, gnutls_datum_t * x, gnutls_datum_t * y)
```

key: Holds the public key

curve: will hold the curve

x: will hold x

y: will hold y

This function will export the ECC public key's parameters found in the given certificate. The new parameters will be allocated using `gnutls_malloc()` and will be stored in the appropriate datum.

Returns: `GNUTLS_E_SUCCESS` on success, otherwise a negative error code.

gnutls_pubkey_get_pk_rsa_raw

`int gnutls_pubkey_get_pk_rsa_raw (gnutls_pubkey_t key, [Function]
 gnutls_datum_t * m, gnutls_datum_t * e)`

key: Holds the certificate

m: will hold the modulus

e: will hold the public exponent

This function will export the RSA public key's parameters found in the given structure. The new parameters will be allocated using `gnutls_malloc()` and will be stored in the appropriate datum.

Returns: GNUTLS_E_SUCCESS on success, otherwise a negative error code.

gnutls_pubkey_get_preferred_hash_algorithm

`int gnutls_pubkey_get_preferred_hash_algorithm [Function]
 (gnutls_pubkey_t key, gnutls_digest_algorithm_t * hash, unsigned int * mand)`

key: Holds the certificate

hash: The result of the call with the hash algorithm used for signature

mand: If non zero it means that the algorithm MUST use this hash. May be NULL.

This function will read the certificate and return the appropriate digest algorithm to use for signing with this certificate. Some certificates (i.e. DSA might not be able to sign without the preferred algorithm).

Returns: the 0 if the hash algorithm is found. A negative error code is returned on error.

Since: 2.11.0

gnutls_pubkey_get_verify_algorithm

`int gnutls_pubkey_get_verify_algorithm (gnutls_pubkey_t key, [Function]
 const gnutls_datum_t * signature, gnutls_digest_algorithm_t * hash)`

key: Holds the certificate

signature: contains the signature

hash: The result of the call with the hash algorithm used for signature

This function will read the certificate and the signed data to determine the hash algorithm used to generate the signature.

Returns: the 0 if the hash algorithm is found. A negative error code is returned on error.

gnutls_pubkey_import_dsa_raw

`int gnutls_pubkey_import_dsa_raw (gnutls_pubkey_t key, const [Function]
 gnutls_datum_t * p, const gnutls_datum_t * q, const gnutls_datum_t * g, const
 gnutls_datum_t * y)`

key: The structure to store the parsed key

p: holds the p

q: holds the q
g: holds the g
y: holds the y

This function will convert the given DSA raw parameters to the native `gnutls_pubkey_t` format. The output will be stored in `key`.

Returns: On success, `GNUTLS_E_SUCCESS` (0) is returned, otherwise a negative error value.

`gnutls_pubkey_import_opengpg`

```
int gnutls_pubkey_import_opengpg (gnutls_pubkey_t key,           [Function]
                                  gnutls_opengpg_cert_t crt, unsigned int flags)
```

key: The public key
crt: The certificate to be imported
flags: should be zero

This function will import the given public key to the abstract `gnutls_pubkey_t` structure. The subkey set as preferred will be imported or the master key otherwise.

Returns: On success, `GNUTLS_E_SUCCESS` (0) is returned, otherwise a negative error value.

`gnutls_pubkey_import_pkcs11_url`

```
int gnutls_pubkey_import_pkcs11_url (gnutls_pubkey_t key, const [Function]
                                      char * url, unsigned int flags)
```

key: A key of type `gnutls_pubkey_t`
url: A PKCS 11 url
flags: One of `GNUTLS_PKCS11_OBJ_*` flags

This function will import a PKCS 11 certificate to a `gnutls_pubkey_t` structure.

Returns: On success, `GNUTLS_E_SUCCESS` (0) is returned, otherwise a negative error value.

`gnutls_pubkey_import_pkcs11`

```
int gnutls_pubkey_import_pkcs11 (gnutls_pubkey_t key,           [Function]
                                  gnutls_pkcs11_obj_t obj, unsigned int flags)
```

key: The public key
obj: The parameters to be imported
flags: should be zero

This function will import the given public key to the abstract `gnutls_pubkey_t` structure.

Returns: On success, `GNUTLS_E_SUCCESS` (0) is returned, otherwise a negative error value.

gnutls_pubkey_import_privkey

`int gnutls_pubkey_import_privkey (gnutls_pubkey_t key, [Function]
 gnutls_privkey_t pkey, unsigned int usage, unsigned int flags)`

key: The public key

pkey: The private key

usage: GNUTLS_KEY_* key usage flags.

flags: should be zero

This function will import the given public key to the abstract `gnutls_pubkey_t` structure.

Returns: On success, GNUTLS_E_SUCCESS (0) is returned, otherwise a negative error value.

Since: 2.12.0

gnutls_pubkey_import_rsa_raw

`int gnutls_pubkey_import_rsa_raw (gnutls_pubkey_t key, const [Function]
 gnutls_datum_t * m, const gnutls_datum_t * e)`

key: Is a structure will hold the parameters

m: holds the modulus

e: holds the public exponent

This function will replace the parameters in the given structure. The new parameters should be stored in the appropriate `gnutls_datum`.

Returns: GNUTLS_E_SUCCESS on success, or an negative error code.

gnutls_pubkey_import_x509

`int gnutls_pubkey_import_x509 (gnutls_pubkey_t key, [Function]
 gnutls_x509_cert_t crt, unsigned int flags)`

key: The public key

crt: The certificate to be imported

flags: should be zero

This function will import the given public key to the abstract `gnutls_pubkey_t` structure.

Returns: On success, GNUTLS_E_SUCCESS (0) is returned, otherwise a negative error value.

gnutls_pubkey_import

`int gnutls_pubkey_import (gnutls_pubkey_t key, const [Function]
 gnutls_datum_t * data, gnutls_x509_cert_fmt_t format)`

key: The structure to store the parsed public key.

data: The DER or PEM encoded certificate.

format: One of DER or PEM

This function will convert the given DER or PEM encoded Public key to the native `gnutls_pubkey_t` format. The output will be stored * in `key`. If the Certificate is PEM encoded it should have a header of "PUBLIC KEY".

Returns: On success, `GNUTLS_E_SUCCESS` (0) is returned, otherwise a negative error value.

gnutls_pubkey_init

```
int gnutls_pubkey_init (gnutls_pubkey_t * key) [Function]
    key: The structure to be initialized
```

This function will initialize an public key structure.

Returns: On success, `GNUTLS_E_SUCCESS` (0) is returned, otherwise a negative error value.

gnutls_pubkey_set_key_usage

```
int gnutls_pubkey_set_key_usage (gnutls_pubkey_t key, unsigned int usage) [Function]
```

`key`: a certificate of type `gnutls_x509_cert_t`

`usage`: an ORed sequence of the `GNUTLS_KEY_*` elements.

This function will set the key usage flags of the public key. This is only useful if the key is to be exported to a certificate or certificate request.

Returns: On success, `GNUTLS_E_SUCCESS` (0) is returned, otherwise a negative error value.

gnutls_pubkey_verify_data2

```
int gnutls_pubkey_verify_data2 (gnutls_pubkey_t pubkey, gnutls_sign_algorithm_t algo, unsigned int flags, const gnutls_datum_t * data, const gnutls_datum_t * signature) [Function]
```

`pubkey`: Holds the public key

`algo`: The signature algorithm used

`flags`: should be 0 for now

`data`: holds the signed data

`signature`: contains the signature

This function will verify the given signed data, using the parameters from the certificate.

Returns: In case of a verification failure `GNUTLS_E_PK_SIG_VERIFY_FAILED` is returned, and a positive code on success.

Since: 2.12.0

gnutls_pubkey_verify_data

```
int gnutls_pubkey_verify_data (gnutls_pubkey_t pubkey, unsigned int flags, const gnutls_datum_t * data, const gnutls_datum_t * signature) [Function]
```

`pubkey`: Holds the public key

flags: should be 0 for now
data: holds the signed data
signature: contains the signature

This function will verify the given signed data, using the parameters from the certificate.

Returns: In case of a verification failure `GNUTLS_E_PK_SIG_VERIFY_FAILED` is returned, and a positive code on success.

Since: 2.12.0

gnutls_pubkey_verify_hash

```
int gnutls_pubkey_verify_hash (gnutls_pubkey_t key, unsigned int [Function]
                             flags, const gnutls_datum_t * hash, const gnutls_datum_t * signature)
```

key: Holds the certificate
flags: should be 0 for now
hash: holds the hash digest to be verified
signature: contains the signature

This function will verify the given signed digest, using the parameters from the certificate.

Returns: In case of a verification failure `GNUTLS_E_PK_SIG_VERIFY_FAILED` is returned, and a positive code on success.

gnutls_record_check_pending

```
size_t gnutls_record_check_pending (gnutls_session_t session) [Function]
session: is a gnutls_session_t structure.
```

This function checks if there are any data to receive in the gnutls buffers.

Returns: the size of that data or 0.

gnutls_record_disable_padding

```
void gnutls_record_disable_padding (gnutls_session_t session) [Function]
session: is a gnutls_session_t structure.
```

Used to disabled padding in TLS 1.0 and above. Normally you do not need to use this function, but there are buggy clients that complain if a server pads the encrypted data. This of course will disable protection against statistical attacks on the data.

Normally only servers that require maximum compatibility with everything out there, need to call this function.

gnutls_record_get_direction

```
int gnutls_record_get_direction (gnutls_session_t session) [Function]
session: is a gnutls_session_t structure.
```

This function provides information about the internals of the record protocol and is only useful if a prior gnutls function call (e.g. `gnutls_handshake()`) was interrupted

for some reason, that is, if a function returned `GNUTLS_E_INTERRUPTED` or `GNUTLS_E_AGAIN`. In such a case, you might want to call `select()` or `poll()` before calling the interrupted gnutls function again. To tell you whether a file descriptor should be selected for either reading or writing, `gnutls_record_get_direction()` returns 0 if the interrupted function was trying to read data, and 1 if it was trying to write data.

Returns: 0 if trying to read data, 1 if trying to write data.

`gnutls_record_get_max_size`

`size_t gnutls_record_get_max_size (gnutls_session_t session)` [Function]

session: is a `gnutls_session_t` structure.

Get the record size. The maximum record size is negotiated by the client after the first handshake message.

Returns: The maximum record packet size in this connection.

`gnutls_record_recv_seq`

`ssize_t gnutls_record_recv_seq (gnutls_session_t session, void * data, size_t data_size, unsigned char * seq)` [Function]

session: is a `gnutls_session_t` structure.

data: the buffer that the data will be read into

data_size: the number of requested bytes

seq: is the packet's 64-bit sequence number. Should have space for 8 bytes.

This function is the same as `gnutls_record_recv()`, except that it returns in addition to data, the sequence number of the data. This is useful in DTLS where record packets might be received out-of-order. In DTLS the least significant 48-bits are a unique sequence number, per handshake. If your application is using TLS re-handshakes then the full 64-bits should be used as a unique sequence.

Returns: the number of bytes received and zero on EOF. A negative error code is returned in case of an error. The number of bytes received might be less than `data_size`.

`gnutls_record_recv`

`ssize_t gnutls_record_recv (gnutls_session_t session, void * data, size_t data_size)` [Function]

session: is a `gnutls_session_t` structure.

data: the buffer that the data will be read into

data_size: the number of requested bytes

This function has the similar semantics with `recv()`. The only difference is that it accepts a GnuTLS session, and uses different error codes. In the special case that a server requests a renegotiation, the client may receive an error code of `GNUTLS_E_REHANDSHAKE`. This message may be simply ignored, replied with an alert `GNUTLS_A_NO_RENEGOTIATION`, or replied with a new handshake, depending on the client's will. If `EINTR` is returned by the internal push function (the default is `recv()`) then `GNUTLS_E_INTERRUPTED` will be returned. If `GNUTLS_E_INTERRUPTED` or `GNUTLS_E_AGAIN` is

returned, you must call this function again to get the data. See also `gnutls_record_get_direction()`. A server may also receive `GNUTLS_E_REHANDSHAKE` when a client has initiated a handshake. In that case the server can only initiate a handshake or terminate the connection.

Returns: the number of bytes received and zero on EOF (for stream connections). A negative error code is returned in case of an error. The number of bytes received might be less than the requested `data_size`.

`gnutls_record_send`

`ssize_t gnutls_record_send (gnutls_session_t session, const void * data, size_t data_size)` [Function]

session: is a `gnutls_session_t` structure.

data: contains the data to send

data_size: is the length of the data

This function has the similar semantics with `send()`. The only difference is that it accepts a GnuTLS session, and uses different error codes. Note that if the send buffer is full, `send()` will block this function. See the `send()` documentation for full information. You can replace the default push function by using `gnutls_transport_set_ptr2()` with a call to `send()` with a `MSG_DONTWAIT` flag if blocking is a problem. If the `EINTR` is returned by the internal push function (the default is `send()`) then `GNUTLS_E_INTERRUPTED` will be returned. If `GNUTLS_E_INTERRUPTED` or `GNUTLS_E_AGAIN` is returned, you must call this function again, with the same parameters; alternatively you could provide a `NULL` pointer for data, and 0 for size. cf. `gnutls_record_get_direction()`.

Returns: the number of bytes sent, or a negative error code. The number of bytes sent might be less than `data_size`. The maximum number of bytes this function can send in a single call depends on the negotiated maximum record size.

`gnutls_record_set_max_size`

`ssize_t gnutls_record_set_max_size (gnutls_session_t session, size_t size)` [Function]

session: is a `gnutls_session_t` structure.

size: is the new size

This function sets the maximum record packet size in this connection. This property can only be set to clients. The server may choose not to accept the requested size.

Acceptable values are 512(=2⁹), 1024(=2¹⁰), 2048(=2¹¹) and 4096(=2¹²). The requested record size does get in effect immediately only while sending data. The receive part will take effect after a successful handshake.

This function uses a TLS extension called 'max record size'. Not all TLS implementations use or even understand this extension.

Returns: On success, `GNUTLS_E_SUCCESS` (0) is returned, otherwise a negative error code is returned.

gnutls_rehandshake

`int gnutls_rehandshake (gnutls_session_t session)` [Function]

session: is a `gnutls_session_t` structure.

This function will renegotiate security parameters with the client. This should only be called in case of a server.

This message informs the peer that we want to renegotiate parameters (perform a handshake).

If this function succeeds (returns 0), you must call the `gnutls_handshake()` function in order to negotiate the new parameters.

Since TLS is full duplex some application data might have been sent during peer's processing of this message. In that case one should call `gnutls_record_recv()` until `GNUTLS_E_REHANDSHAKE` is returned to clear any pending data. Care must be taken if rehandshake is mandatory to terminate if it does not start after some threshold.

If the client does not wish to renegotiate parameters he will should with an alert message, thus the return code will be `GNUTLS_E_WARNING_ALERT_RECEIVED` and the alert will be `GNUTLS_A_NO_RENEGOTIATION`. A client may also choose to ignore this message.

Returns: `GNUTLS_E_SUCCESS` on success, otherwise a negative error code.

gnutls_rnd

`int gnutls_rnd (gnutls_rnd_level_t level, void * data, size_t len)` [Function]

level: a security level

data: place to store random bytes

len: The requested size

This function will generate random data and store it to output buffer.

Returns: Zero or a negative error code on error.

gnutls_rsa_export_get_modulus_bits

`int gnutls_rsa_export_get_modulus_bits (gnutls_session_t session)` [Function]

session: is a gnutls session

Get the export RSA parameter's modulus size.

Returns: the bits used in the last RSA-EXPORT key exchange with the peer, or a negative error code in case of error.

gnutls_rsa_export_get_pubkey

`int gnutls_rsa_export_get_pubkey (gnutls_session_t session, gnutls_datum_t * exponent, gnutls_datum_t * modulus)` [Function]

session: is a gnutls session

exponent: will hold the exponent.

modulus: will hold the modulus.

This function will return the peer's public key exponent and modulus used in the last RSA-EXPORT authentication. The output parameters must be freed with `gnutls_free()`.

Returns: On success, `GNUTLS_E_SUCCESS` (0) is returned, otherwise an error code is returned.

gnutls_rsa_params_cpy

```
int gnutls_rsa_params_cpy (gnutls_rsa_params_t dst,          [Function]
                          gnutls_rsa_params_t src)
```

dst: Is the destination structure, which should be initialized.

src: Is the source structure

This function will copy the RSA parameters structure from source to destination.

Returns: `GNUTLS_E_SUCCESS` on success, or an negative error code.

gnutls_rsa_params_deinit

```
void gnutls_rsa_params_deinit (gnutls_rsa_params_t rsa_params) [Function]
```

rsa_params: Is a structure that holds the parameters

This function will deinitialize the RSA parameters structure.

gnutls_rsa_params_export_pkcs1

```
int gnutls_rsa_params_export_pkcs1 (gnutls_rsa_params_t params, [Function]
                                     gnutls_x509_cert_fmt_t format, unsigned char * params_data, size_t *
                                     params_data_size)
```

params: Holds the RSA parameters

format: the format of output params. One of PEM or DER.

params_data: will contain a PKCS1 RSAPublicKey structure PEM or DER encoded

params_data_size: holds the size of *params_data* (and will be replaced by the actual size of parameters)

This function will export the given RSA parameters to a PKCS1 RSAPublicKey structure. If the buffer provided is not long enough to hold the output, then `GNUTLS_E_SHORT_MEMORY_BUFFER` will be returned.

If the structure is PEM encoded, it will have a header of "BEGIN RSA PRIVATE KEY".

Returns: `GNUTLS_E_SUCCESS` on success, or an negative error code.

gnutls_rsa_params_export_raw

```
int gnutls_rsa_params_export_raw (gnutls_rsa_params_t rsa,          [Function]
                                  gnutls_datum_t * m, gnutls_datum_t * e, gnutls_datum_t * d, gnutls_datum_t
                                  * p, gnutls_datum_t * q, gnutls_datum_t * u, unsigned int * bits)
```

rsa: a structure that holds the rsa parameters

m: will hold the modulus

e: will hold the public exponent
d: will hold the private exponent
p: will hold the first prime (p)
q: will hold the second prime (q)
u: will hold the coefficient

bits: if non null will hold the prime's number of bits

This function will export the RSA parameters found in the given structure. The new parameters will be allocated using `gnutls_malloc()` and will be stored in the appropriate datum.

Returns: GNUTLS_E_SUCCESS on success, or an negative error code.

gnutls_rsa_params_generate2

```
int gnutls_rsa_params_generate2 (gnutls_rsa_params_t params,      [Function]
                               unsigned int bits)
```

params: The structure where the parameters will be stored

bits: is the prime's number of bits

This function will generate new temporary RSA parameters for use in RSA-EXPORT ciphersuites. This function is normally slow.

Note that if the parameters are to be used in export cipher suites the bits value should be 512 or less. Also note that the generation of new RSA parameters is only useful to servers. Clients use the parameters sent by the server, thus it's no use calling this in client side.

Returns: GNUTLS_E_SUCCESS on success, or an negative error code.

gnutls_rsa_params_import_pkcs1

```
int gnutls_rsa_params_import_pkcs1 (gnutls_rsa_params_t params,  [Function]
                                     const gnutls_datum_t * pkcs1_params,
                                     gnutls_x509_crt_fmt_t format)
```

params: A structure where the parameters will be copied to

pkcs1_params: should contain a PKCS1 RSAPublicKey structure PEM or DER encoded

format: the format of params. PEM or DER.

This function will extract the RSAPublicKey found in a PKCS1 formatted structure. If the structure is PEM encoded, it should have a header of "BEGIN RSA PRIVATE KEY".

Returns: GNUTLS_E_SUCCESS on success, or an negative error code.

gnutls_rsa_params_import_raw

```
int gnutls_rsa_params_import_raw (gnutls_rsa_params_t rsa_params,  [Function]
                                  const gnutls_datum_t * m,
                                  const gnutls_datum_t * e,
                                  const gnutls_datum_t * d,
                                  const gnutls_datum_t * p,
                                  const gnutls_datum_t * q,
                                  const gnutls_datum_t * u)
```

rsa_params: Is a structure will hold the parameters

m: holds the modulus
e: holds the public exponent
d: holds the private exponent
p: holds the first prime (p)
q: holds the second prime (q)
u: holds the coefficient

This function will replace the parameters in the given structure. The new parameters should be stored in the appropriate `gnutls_datum`.

Returns: GNUTLS_E_SUCCESS on success, or an negative error code.

gnutls_rsa_params_init

`int gnutls_rsa_params_init (gnutls_rsa_params_t *rsa_params)` [Function]
rsa_params: Is a structure that will hold the parameters

This function will initialize the temporary RSA parameters structure.

Returns: GNUTLS_E_SUCCESS on success, or an negative error code.

gnutls_safe_renegotiation_status

`int gnutls_safe_renegotiation_status (gnutls_session_t session)` [Function]
session: is a `gnutls_session_t` structure.

Can be used to check whether safe renegotiation is being used in the current session.

Returns: 0 when safe renegotiation is not used and non (0) when safe renegotiation is used.

Since: 2.10.0

gnutls_sec_param_get_name

`const char * gnutls_sec_param_get_name (gnutls_sec_param_t param)` [Function]

param: is a security parameter

Convert a `gnutls_sec_param_t` value to a string.

Returns: a pointer to a string that contains the name of the specified public key algorithm, or NULL.

gnutls_sec_param_to_pk_bits

`unsigned int gnutls_sec_param_to_pk_bits (gnutls_pk_algorithm_t algo, gnutls_sec_param_t param)` [Function]

algo: is a public key algorithm

param: is a security parameter

When generating private and public key pairs a difficult question is which size of "bits" the modulus will be in RSA and the group size in DSA. The easy answer is 1024, which is also wrong. This function will convert a human understandable security parameter to an appropriate size for the specific algorithm.

Returns: The number of bits, or (0).

gnutls_server_name_get

```
int gnutls_server_name_get (gnutls_session_t session, void * data, [Function]
                          size_t * data_length, unsigned int * type, unsigned int indx)
```

session: is a `gnutls_session_t` structure.

data: will hold the data

data_length: will hold the data length. Must hold the maximum size of data.

type: will hold the server name indicator type

indx: is the index of the server name

This function will allow you to get the name indication (if any), a client has sent. The name indication may be any of the enumeration `gnutls_server_name_type_t`.

If *type* is `GNUTLS_NAME_DNS`, then this function is to be used by servers that support virtual hosting, and the data will be a null terminated UTF-8 string.

If *data* has not enough size to hold the server name `GNUTLS_E_SHORT_MEMORY_BUFFER` is returned, and *data_length* will hold the required size.

index is used to retrieve more than one server names (if sent by the client). The first server name has an index of 0, the second 1 and so on. If no name with the given index exists `GNUTLS_E_REQUESTED_DATA_NOT_AVAILABLE` is returned.

Returns: On success, `GNUTLS_E_SUCCESS` (0) is returned, otherwise a negative error code is returned.

gnutls_server_name_set

```
int gnutls_server_name_set (gnutls_session_t session, [Function]
                          gnutls_server_name_type_t type, const void * name, size_t name_length)
```

session: is a `gnutls_session_t` structure.

type: specifies the indicator type

name: is a string that contains the server name.

name_length: holds the length of name

This function is to be used by clients that want to inform (via a TLS extension mechanism) the server of the name they connected to. This should be used by clients that connect to servers that do virtual hosting.

The value of *name* depends on the *type* type. In case of `GNUTLS_NAME_DNS`, an ASCII (0)-terminated domain name string, without the trailing dot, is expected. IPv4 or IPv6 addresses are not permitted.

Returns: On success, `GNUTLS_E_SUCCESS` (0) is returned, otherwise a negative error code is returned.

gnutls_session_channel_binding

```
int gnutls_session_channel_binding (gnutls_session_t session, [Function]
                                   gnutls_channel_binding_t cbtype, gnutls_datum_t * cb)
```

session: is a `gnutls_session_t` structure.

cbtype: an `gnutls_channel_binding_t` enumeration type

cb: output buffer array with data

Extract given channel binding data of the *cbtype* (e.g., `GNUTLS_CB_TLS_UNIQUE`) type.

Returns: `GNUTLS_E_SUCCESS` on success, `GNUTLS_E_UNIMPLEMENTED_FEATURE` if the *cbtype* is unsupported, `GNUTLS_E_CHANNEL_BINDING_NOT_AVAILABLE` if the data is not currently available, or an error code.

Since: 2.12.0

`gnutls_session_enable_compatibility_mode`

`void gnutls_session_enable_compatibility_mode` [Function]
 (*gnutls_session_t* *session*)

session: is a `gnutls_session_t` structure.

This function can be used to disable certain (security) features in TLS in order to maintain maximum compatibility with buggy clients. It is equivalent to calling: `gnutls_record_disable_padding()`

Normally only servers that require maximum compatibility with everything out there, need to call this function.

`gnutls_session_get_data2`

`int gnutls_session_get_data2` (*gnutls_session_t* *session*, [Function]
 gnutls_datum_t * *data*)

session: is a `gnutls_session_t` structure.

data: is a pointer to a datum that will hold the session.

Returns all session parameters, in order to support resuming. The client should call this, and keep the returned session, if he wants to resume that current version later by calling `gnutls_session_set_data()`. This function must be called after a successful handshake. The returned datum must be freed with `gnutls_free()`.

Resuming sessions is really useful and speedups connections after a successful one.

Returns: On success, `GNUTLS_E_SUCCESS` (0) is returned, otherwise an error code is returned.

`gnutls_session_get_data`

`int gnutls_session_get_data` (*gnutls_session_t* *session*, void * [Function]
 session_data, *size_t* * *session_data_size*)

session: is a `gnutls_session_t` structure.

session_data: is a pointer to space to hold the session.

session_data_size: is the *session_data*'s size, or it will be set by the function.

Returns all session parameters, in order to support resuming. The client should call this, and keep the returned session, if he wants to resume that current version later by calling `gnutls_session_set_data()` This function must be called after a successful handshake.

Resuming sessions is really useful and speedups connections after a successful one.

Returns: On success, `GNUTLS_E_SUCCESS` (0) is returned, otherwise an error code is returned.

`gnutls_session_get_id`

```
int gnutls_session_get_id (gnutls_session_t session, void *      [Function]
                          session_id, size_t * session_id_size)
```

session: is a `gnutls_session_t` structure.

session_id: is a pointer to space to hold the session id.

session_id_size: is the session id's size, or it will be set by the function.

Returns the current session id. This can be used if you want to check if the next session you tried to resume was actually resumed. This is because resumed sessions have the same sessionID with the original session.

Session id is some data set by the server, that identify the current session. In TLS 1.0 and SSL 3.0 session id is always less than 32 bytes.

Returns: On success, `GNUTLS_E_SUCCESS` (0) is returned, otherwise an error code is returned.

`gnutls_session_get_ptr`

```
void * gnutls_session_get_ptr (gnutls_session_t session)      [Function]
```

session: is a `gnutls_session_t` structure.

Get user pointer for session. Useful in callbacks. This is the pointer set with `gnutls_session_set_ptr()`.

Returns: the user given pointer from the session structure, or `NULL` if it was never set.

`gnutls_session_is_resumed`

```
int gnutls_session_is_resumed (gnutls_session_t session)      [Function]
```

session: is a `gnutls_session_t` structure.

Check whether session is resumed or not.

Returns: non zero if this session is resumed, or a zero if this is a new session.

`gnutls_session_set_data`

```
int gnutls_session_set_data (gnutls_session_t session, const void  [Function]
                             * session_data, size_t session_data_size)
```

session: is a `gnutls_session_t` structure.

session_data: is a pointer to space to hold the session.

session_data_size: is the session's size

Sets all session parameters, in order to resume a previously established session. The session data given must be the one returned by `gnutls_session_get_data()`. This function should be called before `gnutls_handshake()`.

Keep in mind that session resuming is advisory. The server may choose not to resume the session, thus a full handshake will be performed.

Returns: On success, GNUTLS_E_SUCCESS (0) is returned, otherwise an error code is returned.

gnutls_session_set_ptr

void gnutls_session_set_ptr (*gnutls_session_t session*, void * *ptr*) [Function]
session: is a gnutls_session_t structure.

ptr: is the user pointer

This function will set (associate) the user given pointer *ptr* to the session structure. This pointer can be accessed with gnutls_session_get_ptr().

gnutls_session_ticket_enable_client

int gnutls_session_ticket_enable_client (*gnutls_session_t session*) [Function]

session: is a gnutls_session_t structure.

Request that the client should attempt session resumption using SessionTicket.

Returns: On success, GNUTLS_E_SUCCESS (0) is returned, or an error code.

Since: 2.10.0

gnutls_session_ticket_enable_server

int gnutls_session_ticket_enable_server (*gnutls_session_t session*, const *gnutls_datum_t * key*) [Function]

session: is a gnutls_session_t structure.

key: key to encrypt session parameters.

Request that the server should attempt session resumption using SessionTicket. *key* must be initialized with gnutls_session_ticket_key_generate().

Returns: On success, GNUTLS_E_SUCCESS (0) is returned, or an error code.

Since: 2.10.0

gnutls_session_ticket_key_generate

int gnutls_session_ticket_key_generate (*gnutls_datum_t * key*) [Function]

key: is a pointer to a gnutls_datum_t which will contain a newly created key.

Generate a random key to encrypt security parameters within SessionTicket.

Returns: On success, GNUTLS_E_SUCCESS (0) is returned, or an error code.

Since: 2.10.0

gnutls_set_default_export_priority

int gnutls_set_default_export_priority (*gnutls_session_t session*) [Function]

session: is a gnutls_session_t structure.

Sets some default priority on the ciphers, key exchange methods, macs and compression methods. This function also includes weak algorithms.

This is the same as calling: `gnutls_priority_set_direct (session, "EXPORT", NULL);`

This function is kept around for backwards compatibility, but because of its wide use it is still fully supported. If you wish to allow users to provide a string that specify which ciphers to use (which is recommended), you should use `gnutls_priority_set_direct()` or `gnutls_priority_set()` instead.

Returns: `GNUTLS_E_SUCCESS` on success, or an error code.

`gnutls_set_default_priority`

`int gnutls_set_default_priority (gnutls_session_t session) [Function]`

session: is a `gnutls_session_t` structure.

Sets some default priority on the ciphers, key exchange methods, macs and compression methods.

This is the same as calling: `gnutls_priority_set_direct (session, "NORMAL", NULL);`

This function is kept around for backwards compatibility, but because of its wide use it is still fully supported. If you wish to allow users to provide a string that specify which ciphers to use (which is recommended), you should use `gnutls_priority_set_direct()` or `gnutls_priority_set()` instead.

Returns: `GNUTLS_E_SUCCESS` on success, or an error code.

`gnutls_sign_algorithm_get_requested`

`int gnutls_sign_algorithm_get_requested (gnutls_session_t session, size_t indx, gnutls_sign_algorithm_t * algo) [Function]`

session: is a `gnutls_session_t` structure.

indx: is an index of the signature algorithm to return

algo: the returned certificate type will be stored there

Returns the signature algorithm specified by index that was requested by the peer. If the specified index has no data available this function returns `GNUTLS_E_REQUESTED_DATA_NOT_AVAILABLE`. If the negotiated TLS version does not support signature algorithms then `GNUTLS_E_REQUESTED_DATA_NOT_AVAILABLE` will be returned even for the first index. The first index is 0.

This function is useful in the certificate callback functions to assist in selecting the correct certificate.

Returns: On success, `GNUTLS_E_SUCCESS` (0) is returned, otherwise an error code is returned.

Since: 2.10.0

`gnutls_sign_callback_get`

`gnutls_sign_func gnutls_sign_callback_get (gnutls_session_t session, void ** userdata) [Function]`

session: is a gnutls session

userdata: if non-NULL, will be set to abstract callback pointer.

Retrieve the callback function, and its userdata pointer.

Returns: The function pointer set by `gnutls_sign_callback_set()`, or if not set, `NULL`.

Deprecated: Use the PKCS 11 interfaces instead.

gnutls_sign_callback_set

```
void gnutls_sign_callback_set (gnutls_session_t session,          [Function]
                             gnutls_sign_func sign_func, void * userdata)
```

session: is a gnutls session

sign_func: function pointer to application's sign callback.

userdata: void pointer that will be passed to sign callback.

Set the callback function. The function must have this prototype:

```
typedef int (*gnutls_sign_func) (gnutls_session_t session, void *userdata,
                                gnutls_certificate_type_t cert_type, const gnutls_datum_t * cert, const
                                gnutls_datum_t * hash, gnutls_datum_t * signature);
```

The `userdata` parameter is passed to the `sign_func` verbatim, and can be used to store application-specific data needed in the callback function. See also `gnutls_sign_callback_get()`.

Deprecated: Use the PKCS 11 interfaces instead.

gnutls_sign_get_id

```
gnutls_sign_algorithm_t gnutls_sign_get_id (const char * name) [Function]
name: is a MAC algorithm name
```

The names are compared in a case insensitive way.

Returns: return a `gnutls_sign_algorithm_t` value corresponding to the specified cipher, or `GNUTLS_SIGN_UNKNOWN` on error.

gnutls_sign_get_name

```
const char * gnutls_sign_get_name (gnutls_sign_algorithm_t sign) [Function]
sign: is a sign algorithm
```

Convert a `gnutls_sign_algorithm_t` value to a string.

Returns: a string that contains the name of the specified sign algorithm, or `NULL`.

gnutls_sign_list

```
const gnutls_sign_algorithm_t * gnutls_sign_list (void) [Function]
Get a list of supported public key signature algorithms.
```

Returns: a (0)-terminated list of `gnutls_sign_algorithm_t` integers indicating the available ciphers.

gnutls_srp_allocate_client_credentials

`int gnutls_srp_allocate_client_credentials` [Function]
 (`gnutls_srp_client_credentials_t * sc`)

`sc`: is a pointer to a `gnutls_srp_server_credentials_t` structure.

This structure is complex enough to manipulate directly thus this helper function is provided in order to allocate it.

Returns: On success, `GNUTLS_E_SUCCESS` (0) is returned, or an error code.

gnutls_srp_allocate_server_credentials

`int gnutls_srp_allocate_server_credentials` [Function]
 (`gnutls_srp_server_credentials_t * sc`)

`sc`: is a pointer to a `gnutls_srp_server_credentials_t` structure.

This structure is complex enough to manipulate directly thus this helper function is provided in order to allocate it.

Returns: On success, `GNUTLS_E_SUCCESS` (0) is returned, or an error code.

gnutls_srp_base64_decode_alloc

`int gnutls_srp_base64_decode_alloc` (`const gnutls_datum_t * b64_data`, `gnutls_datum_t * result`) [Function]

`b64_data`: contains the encoded data

`result`: the place where decoded data lie

This function will decode the given encoded data. The decoded data will be allocated, and stored into `result`. It will decode using the base64 algorithm as used in `libsrp`.

You should use `gnutls_free()` to free the returned data.

Warning! This base64 encoding is not the "standard" encoding, so do not use it for non-SRP purposes.

Returns: 0 on success, or an error code.

gnutls_srp_base64_decode

`int gnutls_srp_base64_decode` (`const gnutls_datum_t * b64_data`, `char * result`, `size_t * result_size`) [Function]

`b64_data`: contain the encoded data

`result`: the place where decoded data will be copied

`result_size`: holds the size of the result

This function will decode the given encoded data, using the base64 encoding found in `libsrp`.

Note that `b64_data` should be null terminated.

Warning! This base64 encoding is not the "standard" encoding, so do not use it for non-SRP purposes.

Returns: `GNUTLS_E_SHORT_MEMORY_BUFFER` if the buffer given is not long enough, or 0 on success.

gnutls_srp_base64_encode_alloc

```
int gnutls_srp_base64_encode_alloc (const gnutls_datum_t *      [Function]
    data, gnutls_datum_t * result)
```

data: contains the raw data

result: will hold the newly allocated encoded data

This function will convert the given data to printable data, using the base64 encoding. This is the encoding used in SRP password files. This function will allocate the required memory to hold the encoded data.

You should use `gnutls_free()` to free the returned data.

Warning! This base64 encoding is not the "standard" encoding, so do not use it for non-SRP purposes.

Returns: 0 on success, or an error code.

gnutls_srp_base64_encode

```
int gnutls_srp_base64_encode (const gnutls_datum_t * data, char *  [Function]
    result, size_t * result_size)
```

data: contain the raw data

result: the place where base64 data will be copied

result_size: holds the size of the result

This function will convert the given data to printable data, using the base64 encoding, as used in the libsrp. This is the encoding used in SRP password files. If the provided buffer is not long enough GNUTLS_E_SHORT_MEMORY_BUFFER is returned.

Warning! This base64 encoding is not the "standard" encoding, so do not use it for non-SRP purposes.

Returns: GNUTLS_E_SHORT_MEMORY_BUFFER if the buffer given is not long enough, or 0 on success.

gnutls_srp_free_client_credentials

```
void gnutls_srp_free_client_credentials (gnutls_srp_client_credentials_t sc)  [Function]
```

sc: is a `gnutls_srp_client_credentials_t` structure.

This structure is complex enough to manipulate directly thus this helper function is provided in order to free (deallocate) it.

gnutls_srp_free_server_credentials

```
void gnutls_srp_free_server_credentials (gnutls_srp_server_credentials_t sc)  [Function]
```

sc: is a `gnutls_srp_server_credentials_t` structure.

This structure is complex enough to manipulate directly thus this helper function is provided in order to free (deallocate) it.

gnutls_srp_server_get_username

```
const char * gnutls_srp_server_get_username (gnutls_session_t session) [Function]
```

session: is a gnutls session

This function will return the username of the peer. This should only be called in case of SRP authentication and in case of a server. Returns NULL in case of an error.

Returns: SRP username of the peer, or NULL in case of error.

gnutls_srp_set_client_credentials_function

```
void gnutls_srp_set_client_credentials_function (gnutls_srp_client_credentials_t cred, gnutls_srp_client_credentials_function * func) [Function]
```

cred: is a gnutls_srp_server_credentials_t structure.

func: is the callback function

This function can be used to set a callback to retrieve the username and password for client SRP authentication. The callback's function form is:

```
int (*callback)(gnutls_session_t, char** username, char**password);
```

The **username** and **password** must be allocated using `gnutls_malloc()`. **username** and **password** should be ASCII strings or UTF-8 strings prepared using the "SASLprep" profile of "stringprep".

The callback function will be called once per handshake before the initial hello message is sent.

The callback should not return a negative error code the second time called, since the handshake procedure will be aborted.

The callback function should return 0 on success. -1 indicates an error.

gnutls_srp_set_client_credentials

```
int gnutls_srp_set_client_credentials (gnutls_srp_client_credentials_t res, const char * username, const char * password) [Function]
```

res: is a gnutls_srp_client_credentials_t structure.

username: is the user's userid

password: is the user's password

This function sets the username and password, in a `gnutls_srp_client_credentials_t` structure. Those will be used in SRP authentication. **username** and **password** should be ASCII strings or UTF-8 strings prepared using the "SASLprep" profile of "stringprep".

Returns: On success, GNUTLS_E_SUCCESS (0) is returned, or an error code.

gnutls_srp_set_prime_bits

`void gnutls_srp_set_prime_bits (gnutls_session_t session, [Function]
 unsigned int bits)`

session: is a `gnutls_session_t` structure.

bits: is the number of bits

This function sets the minimum accepted number of bits, for use in an SRP key exchange. If zero, the default 2048 bits will be used.

In the client side it sets the minimum accepted number of bits. If a server sends a prime with less bits than that `GNUTLS_E_RECEIVED_ILLEGAL_PARAMETER` will be returned by the handshake.

This function has no effect in server side.

Since: 2.6.0

gnutls_srp_set_server_credentials_file

`int gnutls_srp_set_server_credentials_file [Function]
 (gnutls_srp_server_credentials_t res, const char * password_file, const char
 * password_conf_file)`

res: is a `gnutls_srp_server_credentials_t` structure.

password_file: is the SRP password file (`tpasswd`)

password_conf_file: is the SRP password conf file (`tpasswd.conf`)

This function sets the password files, in a `gnutls_srp_server_credentials_t` structure. Those password files hold usernames and verifiers and will be used for SRP authentication.

Returns: On success, `GNUTLS_E_SUCCESS` (0) is returned, or an error code.

gnutls_srp_set_server_credentials_function

`void gnutls_srp_set_server_credentials_function [Function]
 (gnutls_srp_server_credentials_t cred, gnutls_srp_server_credentials_function *
 func)`

cred: is a `gnutls_srp_server_credentials_t` structure.

func: is the callback function

This function can be used to set a callback to retrieve the user's SRP credentials. The callback's function form is:

```
int (*callback)(gnutls_session_t, const char* username, gnutls_datum_t* salt,
gnutls_datum_t *verifier, gnutls_datum_t* g, gnutls_datum_t* n);
```

username contains the actual username. The *salt*, *verifier*, *generator* and *prime* must be filled in using the `gnutls_malloc()`. For convenience *prime* and *generator* may also be one of the static parameters defined in `extra.h`.

In case the callback returned a negative number then `gnutls` will assume that the username does not exist.

In order to prevent attackers from guessing valid usernames, if a user does not exist, `g` and `n` values should be filled in using a random user's parameters. In that case the callback must return the special value (1).

The callback function will only be called once per handshake. The callback function should return 0 on success, while -1 indicates an error.

gnutls_srp_verifier

```
int gnutls_srp_verifier (const char * username, const char * password, const gnutls_datum_t * salt, const gnutls_datum_t * generator,
                        const gnutls_datum_t * prime, gnutls_datum_t * res)
```

[Function]

username: is the user's name

password: is the user's password

salt: should be some randomly generated bytes

generator: is the generator of the group

prime: is the group's prime

res: where the verifier will be stored.

This function will create an SRP verifier, as specified in RFC2945. The `prime` and `generator` should be one of the static parameters defined in `gnutls/extra.h` or may be generated.

The verifier will be allocated with `gnutls_malloc()` and will be stored in `res` using binary format.

Returns: On success, `GNUTLS_E_SUCCESS` (0) is returned, or an error code.

gnutls_strerror_name

```
const char * gnutls_strerror_name (int error)
```

[Function]

error: is an error returned by a gnutls function.

Return the GnuTLS error code define as a string. For example, `gnutls_strerror_name(GNUTLS_E_DH_PRIME_UNACCEPTABLE)` will return the string "GNUTLS_E_DH_PRIME_UNACCEPTABLE".

Returns: A string corresponding to the symbol name of the error code.

Since: 2.6.0

gnutls_strerror

```
const char * gnutls_strerror (int error)
```

[Function]

error: is a GnuTLS error code, a negative error code

This function is similar to `strerror`. The difference is that it accepts an error number returned by a gnutls function; In case of an unknown error a descriptive string is sent instead of `NULL`.

Error codes are always a negative error code.

Returns: A string explaining the GnuTLS error message.

gnutls_supplemental_get_name

`const char * gnutls_supplemental_get_name` [Function]

(*gnutls_supplemental_data_format_type_t type*)

type: is a supplemental data format type

Convert a `gnutls_supplemental_data_format_type_t` value to a string.

Returns: a string that contains the name of the specified supplemental data format type, or NULL for unknown types.

gnutls_transport_get_ptr2

`void gnutls_transport_get_ptr2` (*gnutls_session_t session*, [Function]

*gnutls_transport_ptr_t * recv_ptr, gnutls_transport_ptr_t * send_ptr*)

session: is a `gnutls_session_t` structure.

recv_ptr: will hold the value for the pull function

send_ptr: will hold the value for the push function

Used to get the arguments of the transport functions (like PUSH and PULL). These should have been set using `gnutls_transport_set_ptr2()`.

gnutls_transport_get_ptr

`gnutls_transport_ptr_t gnutls_transport_get_ptr` [Function]

(*gnutls_session_t session*)

session: is a `gnutls_session_t` structure.

Used to get the first argument of the transport function (like PUSH and PULL). This must have been set using `gnutls_transport_set_ptr()`.

Returns: first argument of the transport function.

gnutls_transport_set_errno_function

`void gnutls_transport_set_errno_function` (*gnutls_session_t* [Function]

session, gnutls_errno_func errno_func)

session: is a `gnutls_session_t` structure.

errno_func: a callback function similar to `write()`

This is the function where you set a function to retrieve errno after a failed push or pull operation.

errno_func is of the form, `int (*gnutls_errno_func)(gnutls_transport_ptr_t)`; and should return the errno.

gnutls_transport_set_errno

`void gnutls_transport_set_errno` (*gnutls_session_t session, int* [Function]

err)

session: is a `gnutls_session_t` structure.

err: error value to store in session-specific errno variable.

Store `err` in the session-specific `errno` variable. Useful values for `err` is `EAGAIN` and `EINTR`, other values are treated will be treated as real errors in the push/pull function.

This function is useful in replacement push/pull functions set by `gnutls_transport_set_push_function` and `gnutls_transport_set_pullpush_function` under Windows, where the replacement push/pull may not have access to the same `errno` variable that is used by GnuTLS (e.g., the application is linked to `msvcrt.dll` and `gnutls` is linked to `msvcrt.dll`).

gnutls_transport_set_ptr2

```
void gnutls_transport_set_ptr2 (gnutls_session_t session, [Function]
                               gnutls_transport_ptr_t recv_ptr, gnutls_transport_ptr_t send_ptr)
```

session: is a `gnutls_session_t` structure.

recv_ptr: is the value for the pull function

send_ptr: is the value for the push function

Used to set the first argument of the transport function (like `PUSH` and `PULL`). In berkeley style sockets this function will set the connection handle. With this function you can use two different pointers for receiving and sending.

gnutls_transport_set_ptr

```
void gnutls_transport_set_ptr (gnutls_session_t session, [Function]
                               gnutls_transport_ptr_t ptr)
```

session: is a `gnutls_session_t` structure.

ptr: is the value.

Used to set the first argument of the transport function (like `PUSH` and `PULL`). In berkeley style sockets this function will set the connection handle.

gnutls_transport_set_pull_function

```
void gnutls_transport_set_pull_function (gnutls_session_t [Function]
                                         session, gnutls_pull_func pull_func)
```

session: is a `gnutls_session_t` structure.

pull_func: a callback function similar to `read()`

This is the function where you set a function for `gnutls` to receive data. Normally, if you use berkeley style sockets, do not need to use this function since the default (`recv(2)`) will probably be ok. The callback should return 0 on connection termination, a positive number indicating the number of bytes received, and -1 on error.

`gnutls_pull_func` is of the form, `ssize_t (*gnutls_pull_func)(gnutls_transport_ptr_t, void*, size_t)`;

gnutls_transport_set_pull_timeout_function

```
void gnutls_transport_set_pull_timeout_function [Function]
        (gnutls_session_t session, gnutls_pull_timeout_func func)
```

session: is a `gnutls_session_t` structure.

func: a callback function

This is the function where you set a function for gnutls to know whether data are ready to be received within a time limit in milliseconds. The callback should return 0 on timeout, a positive number if data can be received, and -1 on error. If the `data_size` is non-zero that function should copy that amount of data received in peek mode (i.e., if any other function is called to receive data, it should return them again).

The callback function is used in DTLS only.

`gnutls_pull_timeout_func` is of the form, `ssize_t (*gnutls_pull_timeout_func)(gnutls_transport_ptr_t, void*data, size_t size, unsigned int ms)`;

gnutls_transport_set_push_function

```
void gnutls_transport_set_push_function (gnutls_session_t      [Function]
    session, gnutls_push_func push_func)
```

session: is a `gnutls_session_t` structure.

push_func: a callback function similar to `write()`

This is the function where you set a push function for gnutls to use in order to send data. If you are going to use berkeley style sockets, you do not need to use this function since the default (`send(2)`) will probably be ok. Otherwise you should specify this function for gnutls to be able to send data. The callback should return a positive number indicating the bytes sent, and -1 on error.

`push_func` is of the form, `ssize_t (*gnutls_push_func)(gnutls_transport_ptr_t, const void*, size_t)`;

gnutls_transport_set_vec_push_function

```
void gnutls_transport_set_vec_push_function (gnutls_session_t  [Function]
    session, gnutls_vec_push_func vec_func)
```

session: is a `gnutls_session_t` structure.

vec_func: a callback function similar to `writenv()`

This is the function where you set a push function for gnutls to use in order to send data. If you are going to use berkeley style sockets, you do not need to use this function since the default (`send(2)`) will probably be ok. Otherwise you should specify this function for gnutls to be able to send data.

`vec_func` is of the form, `ssize_t (*gnutls_vec_push_func) (gnutls_transport_ptr_t, const giovec_t * iov, int iovcnt)`;

gnutls_x509_crq_set_pubkey

```
int gnutls_x509_crq_set_pubkey (gnutls_x509_crq_t crq,      [Function]
    gnutls_pubkey_t key)
```

crq: should contain a `gnutls_x509_crq_t` structure

key: holds a public key

This function will set the public parameters from the given public key to the request.

Returns: On success, `GNUTLS_E_SUCCESS (0)` is returned, otherwise a negative error value.

gnutls_x509_cert_import_pkcs11_url

`int gnutls_x509_cert_import_pkcs11_url (gnutls_x509_cert_t crt, [Function]
 const char * url, unsigned int flags)`

crt: A certificate of type `gnutls_x509_cert_t`

url: A PKCS 11 url

flags: One of `GNUTLS_PKCS11_OBJ_*` flags

This function will import a PKCS 11 certificate directly from a token without involving the `gnutls_pkcs11_obj_t` structure. This function will fail if the certificate stored is not of X.509 type.

Returns: On success, `GNUTLS_E_SUCCESS` (0) is returned, otherwise a negative error value.

gnutls_x509_cert_import_pkcs11

`int gnutls_x509_cert_import_pkcs11 (gnutls_x509_cert_t crt, [Function]
 gnutls_pkcs11_obj_t pkcs11_cert)`

crt: A certificate of type `gnutls_x509_cert_t`

pkcs11_cert: A PKCS 11 object that contains a certificate

This function will import a PKCS 11 certificate to a `gnutls_x509_cert_t` structure.

Returns: On success, `GNUTLS_E_SUCCESS` (0) is returned, otherwise a negative error value.

gnutls_x509_cert_list_import_pkcs11

`int gnutls_x509_cert_list_import_pkcs11 (gnutls_x509_cert_t * [Function]
 certs, unsigned int cert_max, gnutls_pkcs11_obj_t * const objs, unsigned
 int flags)`

certs: A list of certificates of type `gnutls_x509_cert_t`

cert_max: The maximum size of the list

objs: A list of PKCS 11 objects

flags: 0 for now

This function will import a PKCS 11 certificate list to a list of `gnutls_x509_cert_t` structure. These must not be initialized.

Returns: On success, `GNUTLS_E_SUCCESS` (0) is returned, otherwise a negative error value.

gnutls_x509_cert_set_pubkey

`int gnutls_x509_cert_set_pubkey (gnutls_x509_cert_t crt, [Function]
 gnutls_pubkey_t key)`

crt: should contain a `gnutls_x509_cert_t` structure

key: holds a public key

This function will set the public parameters from the given public key to the request.

Returns: On success, `GNUTLS_E_SUCCESS` (0) is returned, otherwise a negative error value.

C.2 X.509 Certificate Functions

The following functions are to be used for X.509 certificate handling. Their prototypes lie in 'gnutls/x509.h'.

gnutls_pkcs12_bag_decrypt

`int gnutls_pkcs12_bag_decrypt (gnutls_pkcs12_bag_t bag, const char * pass)` [Function]

bag: The bag

pass: The password used for encryption, must be ASCII.

This function will decrypt the given encrypted bag and return 0 on success.

Returns: On success, GNUTLS_E_SUCCESS (0) is returned, otherwise a negative error code is returned.

gnutls_pkcs12_bag_deinit

`void gnutls_pkcs12_bag_deinit (gnutls_pkcs12_bag_t bag)` [Function]

bag: The structure to be initialized

This function will deinitialize a PKCS12 Bag structure.

gnutls_pkcs12_bag_encrypt

`int gnutls_pkcs12_bag_encrypt (gnutls_pkcs12_bag_t bag, const char * pass, unsigned int flags)` [Function]

bag: The bag

pass: The password used for encryption, must be ASCII

flags: should be one of `gnutls_pkcs_encrypt_flags_t` elements bitwise or'd

This function will encrypt the given bag.

Returns: On success, GNUTLS_E_SUCCESS (0) is returned, otherwise a negative error code is returned.

gnutls_pkcs12_bag_get_count

`int gnutls_pkcs12_bag_get_count (gnutls_pkcs12_bag_t bag)` [Function]

bag: The bag

This function will return the number of the elements withing the bag.

Returns: Number of elements in bag, or an negative error code on error.

gnutls_pkcs12_bag_get_data

`int gnutls_pkcs12_bag_get_data (gnutls_pkcs12_bag_t bag, int indx, gnutls_datum_t * data)` [Function]

bag: The bag

indx: The element of the bag to get the data from

data: where the bag's data will be. Should be treated as constant.

This function will return the bag's data. The data is a constant that is stored into the bag. Should not be accessed after the bag is deleted.

Returns: On success, GNUTLS_E_SUCCESS (0) is returned, otherwise a negative error value.

gnutls_pkcs12_bag_get_friendly_name

```
int gnutls_pkcs12_bag_get_friendly_name (gnutls_pkcs12_bag_t bag, int indx, char ** name) [Function]
```

bag: The bag

indx: The bag's element to add the id

name: will hold a pointer to the name (to be treated as const)

This function will return the friendly name, of the specified bag element. The key ID is usually used to distinguish the local private key and the certificate pair.

Returns: On success, GNUTLS_E_SUCCESS (0) is returned, otherwise a negative error value. or a negative error code on error.

gnutls_pkcs12_bag_get_key_id

```
int gnutls_pkcs12_bag_get_key_id (gnutls_pkcs12_bag_t bag, int indx, gnutls_datum_t * id) [Function]
```

bag: The bag

indx: The bag's element to add the id

id: where the ID will be copied (to be treated as const)

This function will return the key ID, of the specified bag element. The key ID is usually used to distinguish the local private key and the certificate pair.

Returns: On success, GNUTLS_E_SUCCESS (0) is returned, otherwise a negative error value. or a negative error code on error.

gnutls_pkcs12_bag_get_type

```
gnutls_pkcs12_bag_type_t gnutls_pkcs12_bag_get_type (gnutls_pkcs12_bag_t bag, int indx) [Function]
```

bag: The bag

indx: The element of the bag to get the type

This function will return the bag's type.

Returns: One of the gnutls_pkcs12_bag_type_t enumerations.

gnutls_pkcs12_bag_init

```
int gnutls_pkcs12_bag_init (gnutls_pkcs12_bag_t * bag) [Function]
```

bag: The structure to be initialized

This function will initialize a PKCS12 bag structure. PKCS12 Bags usually contain private keys, lists of X.509 Certificates and X.509 Certificate revocation lists.

Returns: On success, GNUTLS_E_SUCCESS (0) is returned, otherwise a negative error value.

gnutls_pkcs12_bag_set_crl

int gnutls_pkcs12_bag_set_crl (*gnutls_pkcs12_bag_t bag*, [Function]
gnutls_x509_crl_t crl)

bag: The bag

crl: the CRL to be copied.

This function will insert the given CRL into the bag. This is just a wrapper over `gnutls_pkcs12_bag_set_data()`.

Returns: the index of the added bag on success, or a negative error code on failure.

gnutls_pkcs12_bag_set_crt

int gnutls_pkcs12_bag_set_crt (*gnutls_pkcs12_bag_t bag*, [Function]
gnutls_x509_crt_t crt)

bag: The bag

crt: the certificate to be copied.

This function will insert the given certificate into the bag. This is just a wrapper over `gnutls_pkcs12_bag_set_data()`.

Returns: the index of the added bag on success, or a negative value on failure.

gnutls_pkcs12_bag_set_data

int gnutls_pkcs12_bag_set_data (*gnutls_pkcs12_bag_t bag*, [Function]
gnutls_pkcs12_bag_type_t type, *const gnutls_datum_t * data*)

bag: The bag

type: The data's type

data: the data to be copied.

This function will insert the given data of the given type into the bag.

Returns: the index of the added bag on success, or a negative value on error.

gnutls_pkcs12_bag_set_friendly_name

int gnutls_pkcs12_bag_set_friendly_name (*gnutls_pkcs12_bag_t* [Function]
bag, *int indx*, *const char * name*)

bag: The bag

indx: The bag's element to add the id

name: the name

This function will add the given key friendly name, to the specified, by the index, bag element. The name will be encoded as a 'Friendly name' bag attribute, which is usually used to set a user name to the local private key and the certificate pair.

Returns: On success, `GNUTLS_E_SUCCESS` (0) is returned, otherwise a negative error value. or a negative error code on error.

gnutls_pkcs12_bag_set_key_id

```
int gnutls_pkcs12_bag_set_key_id (gnutls_pkcs12_bag_t bag, int      [Function]
                                indx, const gnutls_datum_t * id)
```

bag: The bag

indx: The bag's element to add the id

id: the ID

This function will add the given key ID, to the specified, by the index, bag element. The key ID will be encoded as a 'Local key identifier' bag attribute, which is usually used to distinguish the local private key and the certificate pair.

Returns: On success, GNUTLS_E_SUCCESS (0) is returned, otherwise a negative error value. or a negative error code on error.

gnutls_pkcs12_deinit

```
void gnutls_pkcs12_deinit (gnutls_pkcs12_t pkcs12)                [Function]
pkcs12: The structure to be initialized
```

This function will deinitialize a PKCS12 structure.

gnutls_pkcs12_export

```
int gnutls_pkcs12_export (gnutls_pkcs12_t pkcs12,                [Function]
                          gnutls_x509_crt_fmt_t format, void * output_data, size_t *
                          output_data_size)
```

pkcs12: Holds the pkcs12 structure

format: the format of output params. One of PEM or DER.

output_data: will contain a structure PEM or DER encoded

output_data_size: holds the size of output_data (and will be replaced by the actual size of parameters)

This function will export the pkcs12 structure to DER or PEM format.

If the buffer provided is not long enough to hold the output, then *output_data_size will be updated and GNUTLS_E_SHORT_MEMORY_BUFFER will be returned.

If the structure is PEM encoded, it will have a header of "BEGIN PKCS12".

Return value: In case of failure a negative error code will be returned, and 0 on success.

gnutls_pkcs12_generate_mac

```
int gnutls_pkcs12_generate_mac (gnutls_pkcs12_t pkcs12, const    [Function]
                                char * pass)
```

pkcs12: should contain a gnutls_pkcs12_t structure

pass: The password for the MAC

This function will generate a MAC for the PKCS12 structure.

Returns: On success, GNUTLS_E_SUCCESS (0) is returned, otherwise a negative error value.

gnutls_pkcs12_get_bag

`int gnutls_pkcs12_get_bag (gnutls_pkcs12_t pkcs12, int indx, gnutls_pkcs12_bag_t bag)` [Function]

pkcs12: should contain a gnutls_pkcs12_t structure

indx: contains the index of the bag to extract

bag: An initialized bag, where the contents of the bag will be copied

This function will return a Bag from the PKCS12 structure.

After the last Bag has been read GNUTLS_E_REQUESTED_DATA_NOT_AVAILABLE will be returned.

Returns: On success, GNUTLS_E_SUCCESS (0) is returned, otherwise a negative error value.

gnutls_pkcs12_import

`int gnutls_pkcs12_import (gnutls_pkcs12_t pkcs12, const gnutls_datum_t * data, gnutls_x509_crt_fmt_t format, unsigned int flags)` [Function]

pkcs12: The structure to store the parsed PKCS12.

data: The DER or PEM encoded PKCS12.

format: One of DER or PEM

flags: an ORed sequence of gnutls_privkey_pkcs8_flags

This function will convert the given DER or PEM encoded PKCS12 to the native gnutls_pkcs12_t format. The output will be stored in 'pkcs12'.

If the PKCS12 is PEM encoded it should have a header of "PKCS12".

Returns: On success, GNUTLS_E_SUCCESS (0) is returned, otherwise a negative error value.

gnutls_pkcs12_init

`int gnutls_pkcs12_init (gnutls_pkcs12_t * pkcs12)` [Function]

pkcs12: The structure to be initialized

This function will initialize a PKCS12 structure. PKCS12 structures usually contain lists of X.509 Certificates and X.509 Certificate revocation lists.

Returns: On success, GNUTLS_E_SUCCESS (0) is returned, otherwise a negative error value.

gnutls_pkcs12_set_bag

`int gnutls_pkcs12_set_bag (gnutls_pkcs12_t pkcs12, gnutls_pkcs12_bag_t bag)` [Function]

pkcs12: should contain a gnutls_pkcs12_t structure

bag: An initialized bag

This function will insert a Bag into the PKCS12 structure.

Returns: On success, GNUTLS_E_SUCCESS (0) is returned, otherwise a negative error value.

gnutls_pkcs12_verify_mac

`int gnutls_pkcs12_verify_mac (gnutls_pkcs12_t pkcs12, const char * pass)` [Function]

pkcs12: should contain a `gnutls_pkcs12_t` structure

pass: The password for the MAC

This function will verify the MAC for the PKCS12 structure.

Returns: On success, `GNUTLS_E_SUCCESS` (0) is returned, otherwise a negative error value.

gnutls_pkcs7_deinit

`void gnutls_pkcs7_deinit (gnutls_pkcs7_t pkcs7)` [Function]

pkcs7: The structure to be initialized

This function will deinitialize a PKCS7 structure.

gnutls_pkcs7_delete_crl

`int gnutls_pkcs7_delete_crl (gnutls_pkcs7_t pkcs7, int indx)` [Function]

pkcs7: should contain a `gnutls_pkcs7_t` structure

indx: the index of the crl to delete

This function will delete a crl from a PKCS7 or RFC2630 crl set. Index starts from 0. Returns 0 on success.

Returns: On success, `GNUTLS_E_SUCCESS` (0) is returned, otherwise a negative error value.

gnutls_pkcs7_delete_cert

`int gnutls_pkcs7_delete_cert (gnutls_pkcs7_t pkcs7, int indx)` [Function]

pkcs7: should contain a `gnutls_pkcs7_t` structure

indx: the index of the certificate to delete

This function will delete a certificate from a PKCS7 or RFC2630 certificate set. Index starts from 0. Returns 0 on success.

Returns: On success, `GNUTLS_E_SUCCESS` (0) is returned, otherwise a negative error value.

gnutls_pkcs7_export

`int gnutls_pkcs7_export (gnutls_pkcs7_t pkcs7, gnutls_x509_cert_fmt_t format, void * output_data, size_t * output_data_size)` [Function]

pkcs7: Holds the `pkcs7` structure

format: the format of output params. One of PEM or DER.

output_data: will contain a structure PEM or DER encoded

output_data_size: holds the size of `output_data` (and will be replaced by the actual size of parameters)

This function will export the `pkcs7` structure to DER or PEM format.

If the buffer provided is not long enough to hold the output, then `*output_data_size` is updated and `GNUTLS_E_SHORT_MEMORY_BUFFER` will be returned.

If the structure is PEM encoded, it will have a header of "BEGIN PKCS7".

Returns: On success, `GNUTLS_E_SUCCESS` (0) is returned, otherwise a negative error value.

`gnutls_pkcs7_get_crl_count`

```
int gnutls_pkcs7_get_crl_count (gnutls_pkcs7_t pkcs7)           [Function]
    pkcs7: should contain a gnutls_pkcs7_t structure
```

This function will return the number of certificates in the PKCS7 or RFC2630 crl set.

Returns: On success, `GNUTLS_E_SUCCESS` (0) is returned, otherwise a negative error value.

`gnutls_pkcs7_get_crl_raw`

```
int gnutls_pkcs7_get_crl_raw (gnutls_pkcs7_t pkcs7, int indx,   [Function]
    void *crl, size_t *crl_size)
    pkcs7: should contain a gnutls_pkcs7_t structure
```

`indx`: contains the index of the crl to extract

`crl`: the contents of the crl will be copied there (may be null)

`crl_size`: should hold the size of the crl

This function will return a crl of the PKCS7 or RFC2630 crl set.

Returns: On success, `GNUTLS_E_SUCCESS` (0) is returned, otherwise a negative error value. If the provided buffer is not long enough, then `crl_size` is updated and `GNUTLS_E_SHORT_MEMORY_BUFFER` is returned. After the last crl has been read `GNUTLS_E_REQUESTED_DATA_NOT_AVAILABLE` will be returned.

`gnutls_pkcs7_get_cert_count`

```
int gnutls_pkcs7_get_cert_count (gnutls_pkcs7_t pkcs7)         [Function]
    pkcs7: should contain a gnutls_pkcs7_t structure
```

This function will return the number of certificates in the PKCS7 or RFC2630 certificate set.

Returns: On success, `GNUTLS_E_SUCCESS` (0) is returned, otherwise a negative error value.

`gnutls_pkcs7_get_cert_raw`

```
int gnutls_pkcs7_get_cert_raw (gnutls_pkcs7_t pkcs7, int indx, [Function]
    void *certificate, size_t *certificate_size)
```

`pkcs7`: should contain a `gnutls_pkcs7_t` structure

`indx`: contains the index of the certificate to extract

`certificate`: the contents of the certificate will be copied there (may be null)

certificate_size: should hold the size of the certificate

This function will return a certificate of the PKCS7 or RFC2630 certificate set.

After the last certificate has been read GNUTLS_E_REQUESTED_DATA_NOT_AVAILABLE will be returned.

Returns: On success, GNUTLS_E_SUCCESS (0) is returned, otherwise a negative error value. If the provided buffer is not long enough, then *certificate_size* is updated and GNUTLS_E_SHORT_MEMORY_BUFFER is returned.

gnutls_pkcs7_import

```
int gnutls_pkcs7_import (gnutls_pkcs7_t pkcs7, const          [Function]
                        gnutls_datum_t * data, gnutls_x509_crt_fmt_t format)
```

pkcs7: The structure to store the parsed PKCS7.

data: The DER or PEM encoded PKCS7.

format: One of DER or PEM

This function will convert the given DER or PEM encoded PKCS7 to the native `gnutls_pkcs7_t` format. The output will be stored in `pkcs7`.

If the PKCS7 is PEM encoded it should have a header of "PKCS7".

Returns: On success, GNUTLS_E_SUCCESS (0) is returned, otherwise a negative error value.

gnutls_pkcs7_init

```
int gnutls_pkcs7_init (gnutls_pkcs7_t * pkcs7)              [Function]
```

pkcs7: The structure to be initialized

This function will initialize a PKCS7 structure. PKCS7 structures usually contain lists of X.509 Certificates and X.509 Certificate revocation lists.

Returns: On success, GNUTLS_E_SUCCESS (0) is returned, otherwise a negative error value.

gnutls_pkcs7_set_crl_raw

```
int gnutls_pkcs7_set_crl_raw (gnutls_pkcs7_t pkcs7, const  [Function]
                              gnutls_datum_t * crl)
```

pkcs7: should contain a `gnutls_pkcs7_t` structure

crl: the DER encoded crl to be added

This function will add a crl to the PKCS7 or RFC2630 crl set.

Returns: On success, GNUTLS_E_SUCCESS (0) is returned, otherwise a negative error value.

gnutls_pkcs7_set_crl

```
int gnutls_pkcs7_set_crl (gnutls_pkcs7_t pkcs7, gnutls_x509_crl_t  [Function]
                          crl)
```

pkcs7: should contain a `gnutls_pkcs7_t` structure

crl: the DER encoded *crl* to be added

This function will add a parsed CRL to the PKCS7 or RFC2630 *crl* set.

Returns: On success, GNUTLS_E_SUCCESS (0) is returned, otherwise a negative error value.

gnutls_pkcs7_set_cert_raw

```
int gnutls_pkcs7_set_cert_raw (gnutls_pkcs7_t pkcs7, const      [Function]
                               gnutls_datum_t * crt)
```

pkcs7: should contain a *gnutls_pkcs7_t* structure

crt: the DER encoded certificate to be added

This function will add a certificate to the PKCS7 or RFC2630 certificate set.

Returns: On success, GNUTLS_E_SUCCESS (0) is returned, otherwise a negative error value.

gnutls_pkcs7_set_cert

```
int gnutls_pkcs7_set_cert (gnutls_pkcs7_t pkcs7, gnutls_x509_cert_t  [Function]
                           crt)
```

pkcs7: should contain a *gnutls_pkcs7_t* structure

crt: the certificate to be copied.

This function will add a parsed certificate to the PKCS7 or RFC2630 certificate set. This is a wrapper function over *gnutls_pkcs7_set_cert_raw()* .

Returns: On success, GNUTLS_E_SUCCESS (0) is returned, otherwise a negative error value.

gnutls_x509_crl_check_issuer

```
int gnutls_x509_crl_check_issuer (gnutls_x509_crl_t crl,          [Function]
                                   gnutls_x509_cert_t issuer)
```

crl: is the CRL to be checked

issuer: is the certificate of a possible issuer

This function will check if the given CRL was issued by the given issuer certificate. It will return true (1) if the given CRL was issued by the given issuer, and false (0) if not.

Returns: On success, GNUTLS_E_SUCCESS (0) is returned, otherwise a negative error value.

gnutls_x509_crl_deinit

```
void gnutls_x509_crl_deinit (gnutls_x509_crl_t crl)             [Function]
```

crl: The structure to be initialized

This function will deinitialize a CRL structure.

gnutls_x509_crl_export

`int gnutls_x509_crl_export (gnutls_x509_crl_t crl, [Function]
 gnutls_x509_crt_fmt_t format, void * output_data, size_t *
 output_data_size)`

crl: Holds the revocation list

format: the format of output params. One of PEM or DER.

output_data: will contain a private key PEM or DER encoded

output_data_size: holds the size of output_data (and will be replaced by the actual size of parameters)

This function will export the revocation list to DER or PEM format.

If the buffer provided is not long enough to hold the output, then `GNUTLS_E_SHORT_MEMORY_BUFFER` will be returned.

If the structure is PEM encoded, it will have a header of "BEGIN X509 CRL".

Returns: On success, `GNUTLS_E_SUCCESS` (0) is returned, otherwise a negative error value. and a negative error code on failure.

gnutls_x509_crl_get_authority_key_id

`int gnutls_x509_crl_get_authority_key_id (gnutls_x509_crl_t [Function]
 crl, void * ret, size_t * ret_size, unsigned int * critical)`

crl: should contain a `gnutls_x509_crl_t` structure

ret: The place where the identifier will be copied

ret_size: Holds the size of the result field.

critical: will be non (0) if the extension is marked as critical (may be null)

This function will return the CRL authority's key identifier. This is obtained by the X.509 Authority Key identifier extension field (2.5.29.35). Note that this function only returns the keyIdentifier field of the extension.

Returns: On success, `GNUTLS_E_SUCCESS` (0) is returned, otherwise a negative error code in case of an error.

Since: 2.8.0

gnutls_x509_crl_get_crt_count

`int gnutls_x509_crl_get_crt_count (gnutls_x509_crl_t crl) [Function]`
crl: should contain a `gnutls_x509_crl_t` structure

This function will return the number of revoked certificates in the given CRL.

Returns: number of certificates, a negative error code on failure.

gnutls_x509_crl_get_crt_serial

`int gnutls_x509_crl_get_crt_serial (gnutls_x509_crl_t crl, int [Function]
 indx, unsigned char * serial, size_t * serial_size, time_t * t)`

crl: should contain a `gnutls_x509_crl_t` structure

indx: the index of the certificate to extract (starting from 0)

serial: where the serial number will be copied

serial_size: initially holds the size of *serial*

t: if non null, will hold the time this certificate was revoked

This function will retrieve the serial number of the specified, by the index, revoked certificate.

Returns: On success, GNUTLS_E_SUCCESS (0) is returned, otherwise a negative error value. and a negative error code on error.

gnutls_x509_crl_get_dn_oid

```
int gnutls_x509_crl_get_dn_oid (gnutls_x509_crl_t crl, int indx,      [Function]
                               void * oid, size_t * sizeof_oid)
```

crl: should contain a `gnutls_x509_crl_t` structure

indx: Specifies which DN OID to send. Use (0) to get the first one.

oid: a pointer to a structure to hold the name (may be null)

sizeof_oid: initially holds the size of 'oid'

This function will extract the requested OID of the name of the CRL issuer, specified by the given index.

If *oid* is null then only the size will be filled.

Returns: GNUTLS_E_SHORT_MEMORY_BUFFER if the provided buffer is not long enough, and in that case the *sizeof_oid* will be updated with the required size. On success 0 is returned.

gnutls_x509_crl_get_extension_data

```
int gnutls_x509_crl_get_extension_data (gnutls_x509_crl_t crl,      [Function]
                                         int indx, void * data, size_t * sizeof_data)
```

crl: should contain a `gnutls_x509_crl_t` structure

indx: Specifies which extension OID to send. Use (0) to get the first one.

data: a pointer to a structure to hold the data (may be null)

sizeof_data: initially holds the size of *oid*

This function will return the requested extension data in the CRL. The extension data will be stored as a string in the provided buffer.

Use `gnutls_x509_crl_get_extension_info()` to extract the OID and critical flag. Use `gnutls_x509_crl_get_extension_info()` instead, if you want to get data indexed by the extension OID rather than sequence.

Returns: On success, GNUTLS_E_SUCCESS (0) is returned, otherwise a negative error code in case of an error. If you have reached the last extension available GNUTLS_E_REQUESTED_DATA_NOT_AVAILABLE will be returned.

Since: 2.8.0

gnutls_x509_crl_get_extension_info

```
int gnutls_x509_crl_get_extension_info (gnutls_x509_crl_t crl,      [Function]
                                       int indx, void * oid, size_t * sizeof_oid, int * critical)
```

crl: should contain a `gnutls_x509_crl_t` structure

indx: Specifies which extension OID to send, use (0) to get the first one.

oid: a pointer to a structure to hold the OID

sizeof_oid: initially holds the maximum size of *oid*, on return holds actual size of *oid*.

critical: output variable with critical flag, may be NULL.

This function will return the requested extension OID in the CRL, and the critical flag for it. The extension OID will be stored as a string in the provided buffer. Use `gnutls_x509_crl_get_extension_data()` to extract the data.

If the buffer provided is not long enough to hold the output, then **sizeof_oid* is updated and `GNUTLS_E_SHORT_MEMORY_BUFFER` will be returned.

Returns: On success, `GNUTLS_E_SUCCESS` (0) is returned, otherwise a negative error code in case of an error. If your have reached the last extension available `GNUTLS_E_REQUESTED_DATA_NOT_AVAILABLE` will be returned.

Since: 2.8.0

gnutls_x509_crl_get_extension_oid

```
int gnutls_x509_crl_get_extension_oid (gnutls_x509_crl_t crl,      [Function]
                                       int indx, void * oid, size_t * sizeof_oid)
```

crl: should contain a `gnutls_x509_crl_t` structure

indx: Specifies which extension OID to send, use (0) to get the first one.

oid: a pointer to a structure to hold the OID (may be null)

sizeof_oid: initially holds the size of *oid*

This function will return the requested extension OID in the CRL. The extension OID will be stored as a string in the provided buffer.

Returns: On success, `GNUTLS_E_SUCCESS` (0) is returned, otherwise a negative error code in case of an error. If your have reached the last extension available `GNUTLS_E_REQUESTED_DATA_NOT_AVAILABLE` will be returned.

Since: 2.8.0

gnutls_x509_crl_get_issuer_dn_by_oid

```
int gnutls_x509_crl_get_issuer_dn_by_oid (gnutls_x509_crl_t      [Function]
                                           crl, const char * oid, int indx, unsigned int raw_flag, void * buf, size_t *
                                           sizeof_buf)
```

crl: should contain a `gnutls_x509_crl_t` structure

oid: holds an Object Identified in null terminated string

indx: In case multiple same OIDs exist in the RDN, this specifies which to send. Use (0) to get the first one.

raw_flag: If non (0) returns the raw DER data of the DN part.

buf: a pointer to a structure to hold the peer's name (may be null)

sizeof_buf: initially holds the size of *buf*

This function will extract the part of the name of the CRL issuer specified by the given OID. The output will be encoded as described in RFC2253. The output string will be ASCII or UTF-8 encoded, depending on the certificate data.

Some helper macros with popular OIDs can be found in `gnutls/x509.h`. If `raw` flag is (0), this function will only return known OIDs as text. Other OIDs will be DER encoded, as described in RFC2253 – in hex format with a `'\#'` prefix. You can check about known OIDs using `gnutls_x509_dn_oid_known()`.

If *buf* is null then only the size will be filled.

Returns: `GNUTLS_E_SHORT_MEMORY_BUFFER` if the provided buffer is not long enough, and in that case the *sizeof_buf* will be updated with the required size, and 0 on success.

`gnutls_x509_crl_get_issuer_dn`

```
int gnutls_x509_crl_get_issuer_dn (const gnutls_x509_crl_t crl,      [Function]
    char * buf, size_t * sizeof_buf)
```

crl: should contain a `gnutls_x509_crl_t` structure

buf: a pointer to a structure to hold the peer's name (may be null)

sizeof_buf: initially holds the size of *buf*

This function will copy the name of the CRL issuer in the provided buffer. The name will be in the form "C=xxxx,O=yyyy,CN=zzzz" as described in RFC2253. The output string will be ASCII or UTF-8 encoded, depending on the certificate data.

If *buf* is NULL then only the size will be filled.

Returns: `GNUTLS_E_SHORT_MEMORY_BUFFER` if the provided buffer is not long enough, and in that case the *sizeof_buf* will be updated with the required size, and 0 on success.

`gnutls_x509_crl_get_next_update`

```
time_t gnutls_x509_crl_get_next_update (gnutls_x509_crl_t crl)    [Function]
```

crl: should contain a `gnutls_x509_crl_t` structure

This function will return the time the next CRL will be issued. This field is optional in a CRL so it might be normal to get an error instead.

Returns: when the next CRL will be issued, or `(time_t)-1` on error.

`gnutls_x509_crl_get_number`

```
int gnutls_x509_crl_get_number (gnutls_x509_crl_t crl, void * ret, [Function]
    size_t * ret_size, unsigned int * critical)
```

crl: should contain a `gnutls_x509_crl_t` structure

ret: The place where the number will be copied

ret_size: Holds the size of the result field.

critical: will be non (0) if the extension is marked as critical (may be null)

This function will return the CRL number extension. This is obtained by the CRL Number extension field (2.5.29.20).

Returns: On success, GNUTLS_E_SUCCESS (0) is returned, otherwise a negative error code in case of an error.

Since: 2.8.0

gnutls_x509_crl_get_raw_issuer_dn

int gnutls_x509_crl_get_raw_issuer_dn (gnutls_x509_crl_t crl, [Function]
gnutls_datum_t * dn)

cr1: should contain a gnutls_x509_crl_t structure

dn: will hold the starting point of the DN

This function will return a pointer to the DER encoded DN structure and the length.

Returns: a negative error code on error, and (0) on success.

Since: 2.12.0

gnutls_x509_crl_get_signature_algorithm

int gnutls_x509_crl_get_signature_algorithm (gnutls_x509_crl_t [Function]
cr1)

cr1: should contain a gnutls_x509_crl_t structure

This function will return a value of the gnutls_sign_algorithm_t enumeration that is the signature algorithm.

Returns: On success, GNUTLS_E_SUCCESS (0) is returned, otherwise a negative error value.

gnutls_x509_crl_get_signature

int gnutls_x509_crl_get_signature (gnutls_x509_crl_t cr1, char * [Function]
sig, size_t * sizeof_sig)

cr1: should contain a gnutls_x509_crl_t structure

sig: a pointer where the signature part will be copied (may be null).

sizeof_sig: initially holds the size of *sig*

This function will extract the signature field of a CRL.

Returns: On success, GNUTLS_E_SUCCESS (0) is returned, otherwise a negative error value. and a negative error code on error.

gnutls_x509_crl_get_this_update

time_t gnutls_x509_crl_get_this_update (gnutls_x509_crl_t cr1) [Function]

cr1: should contain a gnutls_x509_crl_t structure

This function will return the time this CRL was issued.

Returns: when the CRL was issued, or (time_t)-1 on error.

gnutls_x509_crl_get_version

int gnutls_x509_crl_get_version (gnutls_x509_crl_t cr1) [Function]

cr1: should contain a gnutls_x509_crl_t structure

This function will return the version of the specified CRL.

Returns: The version number, or a negative error code on error.

gnutls_x509_crl_import

```
int gnutls_x509_crl_import (gnutls_x509_crl_t crl, const [Function]
                          gnutls_datum_t * data, gnutls_x509_crt_fmt_t format)
```

crl: The structure to store the parsed CRL.

data: The DER or PEM encoded CRL.

format: One of DER or PEM

This function will convert the given DER or PEM encoded CRL to the native `gnutls_x509_crl_t` format. The output will be stored in '*crl*'.

If the CRL is PEM encoded it should have a header of "X509 CRL".

Returns: On success, `GNUTLS_E_SUCCESS` (0) is returned, otherwise a negative error value.

gnutls_x509_crl_init

```
int gnutls_x509_crl_init (gnutls_x509_crl_t * crl) [Function]
```

crl: The structure to be initialized

This function will initialize a CRL structure. CRL stands for Certificate Revocation List. A revocation list usually contains lists of certificate serial numbers that have been revoked by an Authority. The revocation lists are always signed with the authority's private key.

Returns: On success, `GNUTLS_E_SUCCESS` (0) is returned, otherwise a negative error value.

gnutls_x509_crl_list_import2

```
int gnutls_x509_crl_list_import2 (gnutls_x509_crl_t ** crls, [Function]
                                  unsigned int * size, const gnutls_datum_t * data, gnutls_x509_crt_fmt_t
                                  format, unsigned int flags)
```

crls: The structures to store the parsed crl list. Must not be initialized.

size: It will contain the size of the list.

data: The PEM encoded CRL.

format: One of DER or PEM.

flags: must be (0) or an OR'd sequence of `gnutls_certificate_import_flags`.

This function will convert the given PEM encoded CRL list to the native `gnutls_x509_crl_t` format. The output will be stored in *crls*. They will be automatically initialized.

If the Certificate is PEM encoded it should have a header of "X509 CRL".

Returns: the number of certificates read or a negative error value.

gnutls_x509_crl_list_import

```
int gnutls_x509_crl_list_import (gnutls_x509_crl_t * crls, [Function]
                                  unsigned int * crl_max, const gnutls_datum_t * data, gnutls_x509_crt_fmt_t
                                  format, unsigned int flags)
```

crls: The structures to store the parsed CRLs. Must not be initialized.

crl_max: Initially must hold the maximum number of crls. It will be updated with the number of crls available.

data: The PEM encoded CRLs

format: One of DER or PEM.

flags: must be (0) or an OR'd sequence of `gnutls_certificate_import_flags`.

This function will convert the given PEM encoded CRL list to the native `gnutls_x509_crl_t` format. The output will be stored in `crls`. They will be automatically initialized.

If the Certificate is PEM encoded it should have a header of "X509 CRL".

Returns: the number of certificates read or a negative error value.

gnutls_x509_crl_print

```
int gnutls_x509_crl_print (gnutls_x509_crl_t crl, [Function]
                          gnutls_certificate_print_formats_t format, gnutls_datum_t * out)
```

crl: The structure to be printed

format: Indicate the format to use

out: Newly allocated datum with (0) terminated string.

This function will pretty print a X.509 certificate revocation list, suitable for display to a human.

The output `out` needs to be deallocate using `gnutls_free()`.

Returns: On success, `GNUTLS_E_SUCCESS` (0) is returned, otherwise a negative error value.

gnutls_x509_crl_privkey_sign

```
int gnutls_x509_crl_privkey_sign (gnutls_x509_crl_t crl, [Function]
                                  gnutls_x509_cert_t issuer, gnutls_privkey_t issuer_key,
                                  gnutls_digest_algorithm_t dig, unsigned int flags)
```

crl: should contain a `gnutls_x509_crl_t` structure

issuer: is the certificate of the certificate issuer

issuer_key: holds the issuer's private key

dig: The message digest to use. `GNUTLS_DIG_SHA1` is the safe choice unless you know what you're doing.

flags: must be 0

This function will sign the CRL with the issuer's private key, and will copy the issuer's information into the CRL.

This must be the last step in a certificate CRL since all the previously set parameters are now signed.

Returns: On success, `GNUTLS_E_SUCCESS` (0) is returned, otherwise a negative error value.

gnutls_x509_crl_set_authority_key_id

`int gnutls_x509_crl_set_authority_key_id (gnutls_x509_crl_t crl, const void * id, size_t id_size)` [Function]

crl: a CRL of type `gnutls_x509_crl_t`

id: The key ID

id_size: Holds the size of the serial field.

This function will set the CRL's authority key ID extension. Only the `keyIdentifier` field can be set with this function.

Returns: On success, `GNUTLS_E_SUCCESS` (0) is returned, otherwise a negative error value.

Since: 2.8.0

gnutls_x509_crl_set_cert_serial

`int gnutls_x509_crl_set_cert_serial (gnutls_x509_crl_t crl, const void * serial, size_t serial_size, time_t revocation_time)` [Function]

crl: should contain a `gnutls_x509_crl_t` structure

serial: The revoked certificate's serial number

serial_size: Holds the size of the serial field.

revocation_time: The time this certificate was revoked

This function will set a revoked certificate's serial number to the CRL.

Returns: On success, `GNUTLS_E_SUCCESS` (0) is returned, otherwise a negative error value.

gnutls_x509_crl_set_cert

`int gnutls_x509_crl_set_cert (gnutls_x509_crl_t crl, gnutls_x509_cert_t cert, time_t revocation_time)` [Function]

crl: should contain a `gnutls_x509_crl_t` structure

cert: a certificate of type `gnutls_x509_cert_t` with the revoked certificate

revocation_time: The time this certificate was revoked

This function will set a revoked certificate's serial number to the CRL.

Returns: On success, `GNUTLS_E_SUCCESS` (0) is returned, otherwise a negative error value.

gnutls_x509_crl_set_next_update

`int gnutls_x509_crl_set_next_update (gnutls_x509_crl_t crl, time_t exp_time)` [Function]

crl: should contain a `gnutls_x509_crl_t` structure

exp_time: The actual time

This function will set the time this CRL will be updated.

Returns: On success, `GNUTLS_E_SUCCESS` (0) is returned, otherwise a negative error value.

gnutls_x509_crl_set_number

`int gnutls_x509_crl_set_number (gnutls_x509_crl_t crl, const void *nr, size_t nr_size)` [Function]

crl: a CRL of type `gnutls_x509_crl_t`

nr: The CRL number

nr_size: Holds the size of the *nr* field.

This function will set the CRL's number extension.

Returns: On success, `GNUTLS_E_SUCCESS` (0) is returned, otherwise a negative error value.

Since: 2.8.0

gnutls_x509_crl_set_this_update

`int gnutls_x509_crl_set_this_update (gnutls_x509_crl_t crl, time_t act_time)` [Function]

crl: should contain a `gnutls_x509_crl_t` structure

act_time: The actual time

This function will set the time this CRL was issued.

Returns: On success, `GNUTLS_E_SUCCESS` (0) is returned, otherwise a negative error value.

gnutls_x509_crl_set_version

`int gnutls_x509_crl_set_version (gnutls_x509_crl_t crl, unsigned int version)` [Function]

crl: should contain a `gnutls_x509_crl_t` structure

version: holds the version number. For CRLv1 crls must be 1.

This function will set the version of the CRL. This must be one for CRL version 1, and so on. The CRLs generated by gnutls should have a version number of 2.

Returns: On success, `GNUTLS_E_SUCCESS` (0) is returned, otherwise a negative error value.

gnutls_x509_crl_sign2

`int gnutls_x509_crl_sign2 (gnutls_x509_crl_t crl, gnutls_x509_cert_t issuer, gnutls_x509_privkey_t issuer_key, gnutls_digest_algorithm_t dig, unsigned int flags)` [Function]

crl: should contain a `gnutls_x509_crl_t` structure

issuer: is the certificate of the certificate issuer

issuer_key: holds the issuer's private key

dig: The message digest to use. `GNUTLS_DIG_SHA1` is the safe choice unless you know what you're doing.

flags: must be 0

This function will sign the CRL with the issuer's private key, and will copy the issuer's information into the CRL.

This must be the last step in a certificate CRL since all the previously set parameters are now signed.

Returns: On success, `GNUTLS_E_SUCCESS` (0) is returned, otherwise a negative error value.

Deprecated: Use `gnutls_x509_crl_privkey_sign()` instead.

gnutls_x509_crl_sign

```
int gnutls_x509_crl_sign (gnutls_x509_crl_t crl, gnutls_x509_cert_t issuer, gnutls_x509_privkey_t issuer_key) [Function]
```

crl: should contain a `gnutls_x509_crl_t` structure

issuer: is the certificate of the certificate issuer

issuer_key: holds the issuer's private key

This function is the same as `gnutls_x509_crl_sign2()` with no flags, and SHA1 as the hash algorithm.

Returns: On success, `GNUTLS_E_SUCCESS` (0) is returned, otherwise a negative error value.

Deprecated: Use `gnutls_x509_crl_privkey_sign()`.

gnutls_x509_crl_verify

```
int gnutls_x509_crl_verify (gnutls_x509_crl_t crl, const gnutls_x509_cert_t * CA_list, int CA_list_length, unsigned int flags, unsigned int * verify) [Function]
```

crl: is the crl to be verified

CA_list: is a certificate list that is considered to be trusted one

CA_list_length: holds the number of CA certificates in *CA_list*

flags: Flags that may be used to change the verification algorithm. Use OR of the `gnutls_certificate_verify_flags` enumerations.

verify: will hold the crl verification output.

This function will try to verify the given crl and return its status. See `gnutls_x509_crl_list_verify()` for a detailed description of return values.

Returns: On success, `GNUTLS_E_SUCCESS` (0) is returned, otherwise a negative error value.

gnutls_x509_crq_deinit

```
void gnutls_x509_crq_deinit (gnutls_x509_crq_t crq) [Function]
```

crq: The structure to be initialized

This function will deinitialize a PKCS10 certificate request structure.

gnutls_x509_crq_export

```
int gnutls_x509_crq_export (gnutls_x509_crq_t crq,           [Function]
                           gnutls_x509_crq_fmt_t format, void * output_data, size_t *
                           output_data_size)
```

crq: should contain a `gnutls_x509_crq_t` structure

format: the format of output params. One of PEM or DER.

output_data: will contain a certificate request PEM or DER encoded

output_data_size: holds the size of *output_data* (and will be replaced by the actual size of parameters)

This function will export the certificate request to a PEM or DER encoded PKCS10 structure.

If the buffer provided is not long enough to hold the output, then `GNUTLS_E_SHORT_MEMORY_BUFFER` will be returned and *output_data_size* will be updated.

If the structure is PEM encoded, it will have a header of "BEGIN NEW CERTIFICATE REQUEST".

Return value: In case of failure a negative error code will be returned, and 0 on success.

gnutls_x509_crq_get_attribute_by_oid

```
int gnutls_x509_crq_get_attribute_by_oid (gnutls_x509_crq_t      [Function]
                                           crq, const char * oid, int indx, void * buf, size_t * sizeof_buf)
```

crq: should contain a `gnutls_x509_crq_t` structure

oid: holds an Object Identified in (0)-terminated string

indx: In case multiple same OIDs exist in the attribute list, this specifies which to send, use (0) to get the first one

buf: a pointer to a structure to hold the attribute data (may be NULL)

sizeof_buf: initially holds the size of *buf*

This function will return the attribute in the certificate request specified by the given Object ID. The attribute will be DER encoded.

Returns: On success, `GNUTLS_E_SUCCESS` (0) is returned, otherwise a negative error value.

gnutls_x509_crq_get_attribute_data

```
int gnutls_x509_crq_get_attribute_data (gnutls_x509_crq_t crq,   [Function]
                                         int indx, void * data, size_t * sizeof_data)
```

crq: should contain a `gnutls_x509_crq_t` structure

indx: Specifies which attribute OID to send. Use (0) to get the first one.

data: a pointer to a structure to hold the data (may be null)

sizeof_data: initially holds the size of *oid*

This function will return the requested attribute data in the certificate request. The attribute data will be stored as a string in the provided buffer.

Use `gnutls_x509_crq_get_attribute_info()` to extract the OID. Use `gnutls_x509_crq_get_attribute_by_oid()` instead, if you want to get data indexed by the attribute OID rather than sequence.

Returns: On success, `GNUTLS_E_SUCCESS` (0) is returned, otherwise a negative error code in case of an error. If you have reached the last extension available `GNUTLS_E_REQUESTED_DATA_NOT_AVAILABLE` will be returned.

Since: 2.8.0

`gnutls_x509_crq_get_attribute_info`

`int gnutls_x509_crq_get_attribute_info (gnutls_x509_crq_t crq, [Function]
int indx, void * oid, size_t * sizeof_oid)`

crq: should contain a `gnutls_x509_crq_t` structure

indx: Specifies which attribute OID to send. Use (0) to get the first one.

oid: a pointer to a structure to hold the OID

sizeof_oid: initially holds the maximum size of *oid*, on return holds actual size of *oid*.

This function will return the requested attribute OID in the certificate, and the critical flag for it. The attribute OID will be stored as a string in the provided buffer. Use `gnutls_x509_crq_get_attribute_data()` to extract the data.

If the buffer provided is not long enough to hold the output, then `*sizeof_oid` is updated and `GNUTLS_E_SHORT_MEMORY_BUFFER` will be returned.

Returns: On success, `GNUTLS_E_SUCCESS` (0) is returned, otherwise a negative error code in case of an error. If you have reached the last extension available `GNUTLS_E_REQUESTED_DATA_NOT_AVAILABLE` will be returned.

Since: 2.8.0

`gnutls_x509_crq_get_basic_constraints`

`int gnutls_x509_crq_get_basic_constraints (gnutls_x509_crq_t [Function]
crq, unsigned int * critical, int * ca, int * pathlen)`

crq: should contain a `gnutls_x509_crq_t` structure

critical: will be non (0) if the extension is marked as critical

ca: pointer to output integer indicating CA status, may be NULL, value is 1 if the certificate CA flag is set, 0 otherwise.

pathlen: pointer to output integer indicating path length (may be NULL), non-negative error codes indicate a present `pathLenConstraint` field and the actual value, -1 indicate that the field is absent.

This function will read the certificate's basic constraints, and return the certificates CA status. It reads the `basicConstraints X.509` extension (2.5.29.19).

Return value: If the certificate is a CA a positive value will be returned, or (0) if the certificate does not have CA flag set. A negative error code may be returned in case of errors. If the certificate does not contain the `basicConstraints` extension `GNUTLS_E_REQUESTED_DATA_NOT_AVAILABLE` will be returned.

Since: 2.8.0

gnutls_x509_crq_get_challenge_password

```
int gnutls_x509_crq_get_challenge_password (gnutls_x509_crq_t crq, char * pass, size_t * sizeof_pass) [Function]
```

crq: should contain a *gnutls_x509_crq_t* structure

pass: will hold a (0)-terminated password string

sizeof_pass: Initially holds the size of *pass*.

This function will return the challenge password in the request. The challenge password is intended to be used for requesting a revocation of the certificate.

Returns: On success, GNUTLS_E_SUCCESS (0) is returned, otherwise a negative error value.

gnutls_x509_crq_get_dn_by_oid

```
int gnutls_x509_crq_get_dn_by_oid (gnutls_x509_crq_t crq, const char * oid, int indx, unsigned int raw_flag, void * buf, size_t * sizeof_buf) [Function]
```

crq: should contain a *gnutls_x509_crq_t* structure

oid: holds an Object Identified in null terminated string

indx: In case multiple same OIDs exist in the RDN, this specifies which to send. Use (0) to get the first one.

raw_flag: If non (0) returns the raw DER data of the DN part.

buf: a pointer to a structure to hold the name (may be NULL)

sizeof_buf: initially holds the size of *buf*

This function will extract the part of the name of the Certificate request subject, specified by the given OID. The output will be encoded as described in RFC2253. The output string will be ASCII or UTF-8 encoded, depending on the certificate data.

Some helper macros with popular OIDs can be found in *gnutls/x509.h* If raw flag is (0), this function will only return known OIDs as text. Other OIDs will be DER encoded, as described in RFC2253 – in hex format with a '\#' prefix. You can check about known OIDs using *gnutls_x509_dn_oid_known()*.

Returns: GNUTLS_E_SHORT_MEMORY_BUFFER if the provided buffer is not long enough, and in that case the **sizeof_buf* will be updated with the required size. On success 0 is returned.

gnutls_x509_crq_get_dn_oid

```
int gnutls_x509_crq_get_dn_oid (gnutls_x509_crq_t crq, int indx, void * oid, size_t * sizeof_oid) [Function]
```

crq: should contain a *gnutls_x509_crq_t* structure

indx: Specifies which DN OID to send. Use (0) to get the first one.

oid: a pointer to a structure to hold the name (may be NULL)

sizeof_oid: initially holds the size of *oid*

This function will extract the requested OID of the name of the certificate request subject, specified by the given index.

Returns: GNUTLS_E_SHORT_MEMORY_BUFFER if the provided buffer is not long enough, and in that case the `*sizeof_oid` will be updated with the required size. On success 0 is returned.

gnutls_x509_crq_get_dn

```
int gnutls_x509_crq_get_dn (gnutls_x509_crq_t crq, char * buf,      [Function]
                          size_t * sizeof_buf)
```

crq: should contain a `gnutls_x509_crq_t` structure

buf: a pointer to a structure to hold the name (may be NULL)

sizeof_buf: initially holds the size of *buf*

This function will copy the name of the Certificate request subject to the provided buffer. The name will be in the form "C=xxxx,O=yyyy,CN=zzzz" as described in RFC 2253. The output string *buf* will be ASCII or UTF-8 encoded, depending on the certificate data.

Returns: GNUTLS_E_SHORT_MEMORY_BUFFER if the provided buffer is not long enough, and in that case the `*sizeof_buf` will be updated with the required size. On success 0 is returned.

gnutls_x509_crq_get_extension_by_oid

```
int gnutls_x509_crq_get_extension_by_oid (gnutls_x509_crq_t      [Function]
                                           crq, const char * oid, int indx, void * buf, size_t * sizeof_buf, unsigned
                                           int * critical)
```

crq: should contain a `gnutls_x509_crq_t` structure

oid: holds an Object Identified in null terminated string

indx: In case multiple same OIDs exist in the extensions, this specifies which to send. Use (0) to get the first one.

buf: a pointer to a structure to hold the name (may be null)

sizeof_buf: initially holds the size of *buf*

critical: will be non (0) if the extension is marked as critical

This function will return the extension specified by the OID in the certificate. The extensions will be returned as binary data DER encoded, in the provided buffer.

Returns: On success, GNUTLS_E_SUCCESS (0) is returned, otherwise a negative error code in case of an error. If the certificate does not contain the specified extension GNUTLS_E_REQUESTED_DATA_NOT_AVAILABLE will be returned.

Since: 2.8.0

gnutls_x509_crq_get_extension_data

```
int gnutls_x509_crq_get_extension_data (gnutls_x509_crq_t crq,      [Function]
                                         int indx, void * data, size_t * sizeof_data)
```

crq: should contain a `gnutls_x509_crq_t` structure

indx: Specifies which extension OID to send. Use (0) to get the first one.

data: a pointer to a structure to hold the data (may be null)

sizeof_data: initially holds the size of *oid*

This function will return the requested extension data in the certificate. The extension data will be stored as a string in the provided buffer.

Use `gnutls_x509_crq_get_extension_info()` to extract the OID and critical flag. Use `gnutls_x509_crq_get_extension_by_oid()` instead, if you want to get data indexed by the extension OID rather than sequence.

Returns: On success, `GNUTLS_E_SUCCESS` (0) is returned, otherwise a negative error code in case of an error. If you have reached the last extension available `GNUTLS_E_REQUESTED_DATA_NOT_AVAILABLE` will be returned.

Since: 2.8.0

`gnutls_x509_crq_get_extension_info`

```
int gnutls_x509_crq_get_extension_info (gnutls_x509_crq_t crq,      [Function]
                                       int indx, void * oid, size_t * sizeof_oid, int * critical)
```

crq: should contain a `gnutls_x509_crq_t` structure

indx: Specifies which extension OID to send. Use (0) to get the first one.

oid: a pointer to a structure to hold the OID

sizeof_oid: initially holds the maximum size of *oid*, on return holds actual size of *oid*.

critical: output variable with critical flag, may be NULL.

This function will return the requested extension OID in the certificate, and the critical flag for it. The extension OID will be stored as a string in the provided buffer. Use `gnutls_x509_crq_get_extension_data()` to extract the data.

If the buffer provided is not long enough to hold the output, then `*sizeof_oid` is updated and `GNUTLS_E_SHORT_MEMORY_BUFFER` will be returned.

Returns: On success, `GNUTLS_E_SUCCESS` (0) is returned, otherwise a negative error code in case of an error. If you have reached the last extension available `GNUTLS_E_REQUESTED_DATA_NOT_AVAILABLE` will be returned.

Since: 2.8.0

`gnutls_x509_crq_get_key_id`

```
int gnutls_x509_crq_get_key_id (gnutls_x509_crq_t crq, unsigned   [Function]
                                int flags, unsigned char * output_data, size_t * output_data_size)
```

crq: a certificate of type `gnutls_x509_crq_t`

flags: should be 0 for now

output_data: will contain the key ID

output_data_size: holds the size of *output_data* (and will be replaced by the actual size of parameters)

This function will return a unique ID that depends on the public key parameters. This ID can be used in checking whether a certificate corresponds to the given private key.

If the buffer provided is not long enough to hold the output, then `*output_data_size` is updated and `GNUTLS_E_SHORT_MEMORY_BUFFER` will be returned.

The output will normally be a SHA-1 hash output, which is 20 bytes.

Return value: In case of failure a negative error code will be returned, and 0 on success.

Since: 2.8.0

gnutls_x509_crq_get_key_purpose_oid

```
int gnutls_x509_crq_get_key_purpose_oid (gnutls_x509_crq_t crq, [Function]
    int indx, void * oid, size_t * sizeof_oid, unsigned int * critical)
```

crq: should contain a `gnutls_x509_crq_t` structure

indx: This specifies which OID to return, use (0) to get the first one

oid: a pointer to a buffer to hold the OID (may be NULL)

sizeof_oid: initially holds the size of *oid*

critical: output variable with critical flag, may be NULL.

This function will extract the key purpose OIDs of the Certificate specified by the given index. These are stored in the Extended Key Usage extension (2.5.29.37). See the `GNUTLS_KP_*` definitions for human readable names.

Returns: `GNUTLS_E_SHORT_MEMORY_BUFFER` if the provided buffer is not long enough, and in that case the `*sizeof_oid` will be updated with the required size. On success 0 is returned.

Since: 2.8.0

gnutls_x509_crq_get_key_rsa_raw

```
int gnutls_x509_crq_get_key_rsa_raw (gnutls_x509_crq_t crq, [Function]
    gnutls_datum_t * m, gnutls_datum_t * e)
```

crq: Holds the certificate

m: will hold the modulus

e: will hold the public exponent

This function will export the RSA public key's parameters found in the given structure. The new parameters will be allocated using `gnutls_malloc()` and will be stored in the appropriate datum.

Returns: On success, `GNUTLS_E_SUCCESS` (0) is returned, otherwise a negative error value.

Since: 2.8.0

gnutls_x509_crq_get_key_usage

```
int gnutls_x509_crq_get_key_usage (gnutls_x509_crq_t crq, [Function]
    unsigned int * key_usage, unsigned int * critical)
```

crq: should contain a `gnutls_x509_crq_t` structure

key_usage: where the key usage bits will be stored

critical: will be non (0) if the extension is marked as critical

This function will return certificate's key usage, by reading the keyUsage X.509 extension (2.5.29.15). The key usage value will

ORed values of the: GNUTLS_KEY_DIGITAL_SIGNATURE, GNUTLS_KEY_NON_REPUDIATION, GNUTLS_KEY_KEY_ENCIPHERMENT, GNUTLS_KEY_DATA_ENCIPHERMENT, GNUTLS_KEY_KEY_AGREEMENT, GNUTLS_KEY_KEY_CERT_SIGN, GNUTLS_KEY_CRL_SIGN, GNUTLS_KEY_ENCIPHER_ONLY, GNUTLS_KEY_DECIPHER_ONLY.

Returns: the certificate key usage, or a negative error code in case of parsing error. If the certificate does not contain the keyUsage extension GNUTLS_E_REQUESTED_DATA_NOT_AVAILABLE will be returned.

Since: 2.8.0

gnutls_x509_crq_get_pk_algorithm

```
int gnutls_x509_crq_get_pk_algorithm (gnutls_x509_crq_t crq,      [Function]
                                     unsigned int * bits)
```

crq: should contain a `gnutls_x509_crq_t` structure

bits: if bits is non-NULL it will hold the size of the parameters' in bits

This function will return the public key algorithm of a PKCS10 certificate request.

If bits is non-NULL, it should have enough size to hold the parameters size in bits. For RSA the bits returned is the modulus. For DSA the bits returned are of the public exponent.

Returns: a member of the `gnutls_pk_algorithm_t` enumeration on success, or a negative error code on error.

gnutls_x509_crq_get_subject_alt_name

```
int gnutls_x509_crq_get_subject_alt_name (gnutls_x509_crq_t      [Function]
                                           crq, unsigned int seq, void * ret, size_t * ret_size, unsigned int *
                                           ret_type, unsigned int * critical)
```

crq: should contain a `gnutls_x509_crq_t` structure

seq: specifies the sequence number of the alt name, 0 for the first one, 1 for the second etc.

ret: is the place where the alternative name will be copied to

ret_size: holds the size of *ret*.

ret_type: holds the `gnutls_x509_subject_alt_name_t` name type

critical: will be non (0) if the extension is marked as critical (may be null)

This function will return the alternative names, contained in the given certificate. It is the same as `gnutls_x509_crq_get_subject_alt_name()` except for the fact that it will return the type of the alternative name in `ret_type` even if the function fails for some reason (i.e. the buffer provided is not enough).

Returns: the alternative subject name type on success, one of the enumerated `gnutls_x509_subject_alt_name_t`. It will return `GNUTLS_E_SHORT_MEMORY_BUFFER` if *ret_size* is not large enough to hold the value. In that case *ret_size* will be updated with the required size. If the certificate request does not have an Alternative name with the specified sequence number then `GNUTLS_E_REQUESTED_DATA_NOT_AVAILABLE` is returned.

Since: 2.8.0

gnutls_x509_crq_get_subject_alt_othername_oid

`int gnutls_x509_crq_get_subject_alt_othername_oid` [Function]
 (`gnutls_x509_crq_t crq`, `unsigned int seq`, `void * ret`, `size_t * ret_size`)

`crq`: should contain a `gnutls_x509_crq_t` structure

`seq`: specifies the sequence number of the alt name (0 for the first one, 1 for the second etc.)

`ret`: is the place where the otherName OID will be copied to

`ret_size`: holds the size of `ret`.

This function will extract the type OID of an otherName Subject Alternative Name, contained in the given certificate, and return the type as an enumerated element.

This function is only useful if `gnutls_x509_crq_get_subject_alt_name()` returned `GNUTLS_SAN_OTHERNAME`.

Returns: the alternative subject name type on success, one of the enumerated `gnutls_x509_subject_alt_name_t`. For supported OIDs, it will return one of the virtual (`GNUTLS_SAN_OTHERNAME_*`) types, e.g. `GNUTLS_SAN_OTHERNAME_XMPP`, and `GNUTLS_SAN_OTHERNAME` for unknown OIDs. It will return `GNUTLS_E_SHORT_MEMORY_BUFFER` if `ret_size` is not large enough to hold the value. In that case `ret_size` will be updated with the required size. If the certificate does not have an Alternative name with the specified sequence number and with the otherName type then `GNUTLS_E_REQUESTED_DATA_NOT_AVAILABLE` is returned.

Since: 2.8.0

gnutls_x509_crq_get_version

`int gnutls_x509_crq_get_version` (`gnutls_x509_crq_t crq`) [Function]

`crq`: should contain a `gnutls_x509_crq_t` structure

This function will return the version of the specified Certificate request.

Returns: version of certificate request, or a negative error code on error.

gnutls_x509_crq_import

`int gnutls_x509_crq_import` (`gnutls_x509_crq_t crq`, `const gnutls_datum_t * data`, `gnutls_x509 crt_fmt_t format`) [Function]

`crq`: The structure to store the parsed certificate request.

`data`: The DER or PEM encoded certificate.

`format`: One of DER or PEM

This function will convert the given DER or PEM encoded certificate request to a `gnutls_x509_crq_t` structure. The output will be stored in `crq`.

If the Certificate is PEM encoded it should have a header of "NEW CERTIFICATE REQUEST".

Returns: On success, `GNUTLS_E_SUCCESS` (0) is returned, otherwise a negative error value.

gnutls_x509_crq_init

`int gnutls_x509_crq_init (gnutls_x509_crq_t * crq)` [Function]

crq: The structure to be initialized

This function will initialize a PKCS10 certificate request structure.

Returns: On success, GNUTLS_E_SUCCESS (0) is returned, otherwise a negative error value.

gnutls_x509_crq_print

`int gnutls_x509_crq_print (gnutls_x509_crq_t crq, gnutls_certificate_print_formats_t format, gnutls_datum_t * out)` [Function]

crq: The structure to be printed

format: Indicate the format to use

out: Newly allocated datum with (0) terminated string.

This function will pretty print a certificate request, suitable for display to a human.

The output *out* needs to be deallocate using `gnutls_free()`.

Returns: On success, GNUTLS_E_SUCCESS (0) is returned, otherwise a negative error value.

Since: 2.8.0

gnutls_x509_crq_privkey_sign

`int gnutls_x509_crq_privkey_sign (gnutls_x509_crq_t crq, gnutls_privkey_t key, gnutls_digest_algorithm_t dig, unsigned int flags)` [Function]

crq: should contain a `gnutls_x509_crq_t` structure

key: holds a private key

dig: The message digest to use, i.e., GNUTLS_DIG_SHA1

flags: must be 0

This function will sign the certificate request with a private key. This must be the same key as the one used in `gnutls_x509 crt_set_key()` since a certificate request is self signed.

This must be the last step in a certificate request generation since all the previously set parameters are now signed.

Returns: GNUTLS_E_SUCCESS on success, otherwise a negative error code. GNUTLS_E_ASN1_VALUE_NOT_FOUND is returned if you didn't set all information in the certificate request (e.g., the version using `gnutls_x509_crq_set_version()`).

gnutls_x509_crq_set_attribute_by_oid

`int gnutls_x509_crq_set_attribute_by_oid (gnutls_x509_crq_t crq, const char * oid, void * buf, size_t sizeof_buf)` [Function]

crq: should contain a `gnutls_x509_crq_t` structure

oid: holds an Object Identified in (0)-terminated string

buf: a pointer to a structure that holds the attribute data

sizeof_buf: holds the size of *buf*

This function will set the attribute in the certificate request specified by the given Object ID. The attribute must be DER encoded.

Returns: On success, GNUTLS_E_SUCCESS (0) is returned, otherwise a negative error value.

gnutls_x509_crq_set_basic_constraints

```
int gnutls_x509_crq_set_basic_constraints (gnutls_x509_crq_t      [Function]
      crq, unsigned int ca, int pathLenConstraint)
```

crq: a certificate request of type `gnutls_x509_crq_t`

ca: true(1) or false(0) depending on the Certificate authority status.

pathLenConstraint: non-negative error codes indicate maximum length of path, and negative error codes indicate that the `pathLenConstraints` field should not be present.

This function will set the `basicConstraints` certificate extension.

Returns: On success, GNUTLS_E_SUCCESS (0) is returned, otherwise a negative error value.

Since: 2.8.0

gnutls_x509_crq_set_challenge_password

```
int gnutls_x509_crq_set_challenge_password (gnutls_x509_crq_t  [Function]
      crq, const char * pass)
```

crq: should contain a `gnutls_x509_crq_t` structure

pass: holds a (0)-terminated password

This function will set a challenge password to be used when revoking the request.

Returns: On success, GNUTLS_E_SUCCESS (0) is returned, otherwise a negative error value.

gnutls_x509_crq_set_dn_by_oid

```
int gnutls_x509_crq_set_dn_by_oid (gnutls_x509_crq_t crq, const [Function]
      char * oid, unsigned int raw_flag, const void * data, unsigned int
      sizeof_data)
```

crq: should contain a `gnutls_x509_crq_t` structure

oid: holds an Object Identifier in a (0)-terminated string

raw_flag: must be 0, or 1 if the data are DER encoded

data: a pointer to the input data

sizeof_data: holds the size of `data`

This function will set the part of the name of the Certificate request subject, specified by the given OID. The input string should be ASCII or UTF-8 encoded.

Some helper macros with popular OIDs can be found in `gnutls/x509.h`. With this function you can only set the known OIDs. You can test for known OIDs using `gnutls_x509_dn_oid_known()`. For OIDs that are not known (by `gnutls`) you should properly DER encode your data, and call this function with `raw_flag` set.

Returns: On success, GNUTLS_E_SUCCESS (0) is returned, otherwise a negative error value.

gnutls_x509_crq_set_key_purpose_oid

```
int gnutls_x509_crq_set_key_purpose_oid (gnutls_x509_crq_t crq, [Function]
    const void * oid, unsigned int critical)
```

crq: a certificate of type `gnutls_x509_crq_t`

oid: a pointer to a (0)-terminated string that holds the OID

critical: Whether this extension will be critical or not

This function will set the key purpose OIDs of the Certificate. These are stored in the Extended Key Usage extension (2.5.29.37) See the GNUTLS_KP_* definitions for human readable names.

Subsequent calls to this function will append OIDs to the OID list.

Returns: On success, GNUTLS_E_SUCCESS (0) is returned, otherwise a negative error value.

Since: 2.8.0

gnutls_x509_crq_set_key_rsa_raw

```
int gnutls_x509_crq_set_key_rsa_raw (gnutls_x509_crq_t crq, [Function]
    const gnutls_datum_t * m, const gnutls_datum_t * e)
```

crq: should contain a `gnutls_x509_crq_t` structure

m: holds the modulus

e: holds the public exponent

This function will set the public parameters from the given private key to the request. Only RSA keys are currently supported.

Returns: On success, GNUTLS_E_SUCCESS (0) is returned, otherwise a negative error value.

Since: 2.6.0

gnutls_x509_crq_set_key_usage

```
int gnutls_x509_crq_set_key_usage (gnutls_x509_crq_t crq, [Function]
    unsigned int usage)
```

crq: a certificate request of type `gnutls_x509_crq_t`

usage: an ORed sequence of the GNUTLS_KEY_* elements.

This function will set the keyUsage certificate extension.

Returns: On success, GNUTLS_E_SUCCESS (0) is returned, otherwise a negative error value.

Since: 2.8.0

gnutls_x509_crq_set_key

`int gnutls_x509_crq_set_key (gnutls_x509_crq_t crq, [Function]
gnutls_x509_privkey_t key)`

crq: should contain a `gnutls_x509_crq_t` structure

key: holds a private key

This function will set the public parameters from the given private key to the request. Only RSA keys are currently supported.

Returns: On success, `GNUTLS_E_SUCCESS` (0) is returned, otherwise a negative error value.

gnutls_x509_crq_set_subject_alt_name

`int gnutls_x509_crq_set_subject_alt_name (gnutls_x509_crq_t [Function]
crq, gnutls_x509_subject_alt_name_t nt, const void * data, unsigned int
data_size, unsigned int flags)`

crq: a certificate request of type `gnutls_x509_crq_t`

nt: is one of the `gnutls_x509_subject_alt_name_t` enumerations

data: The data to be set

data_size: The size of data to be set

flags: `GNUTLS_FSAN_SET` to clear previous data or `GNUTLS_FSAN_APPEND` to append.

This function will set the subject alternative name certificate extension. It can set the following types:

Returns: On success, `GNUTLS_E_SUCCESS` (0) is returned, otherwise a negative error value.

Since: 2.8.0

gnutls_x509_crq_set_version

`int gnutls_x509_crq_set_version (gnutls_x509_crq_t crq, unsigned [Function]
int version)`

crq: should contain a `gnutls_x509_crq_t` structure

version: holds the version number, for v1 Requests must be 1

This function will set the version of the certificate request. For version 1 requests this must be one.

Returns: On success, `GNUTLS_E_SUCCESS` (0) is returned, otherwise a negative error value.

gnutls_x509_crq_sign2

`int gnutls_x509_crq_sign2 (gnutls_x509_crq_t crq, [Function]
gnutls_x509_privkey_t key, gnutls_digest_algorithm_t dig, unsigned int
flags)`

crq: should contain a `gnutls_x509_crq_t` structure

key: holds a private key

dig: The message digest to use, i.e., GNUTLS_DIG_SHA1

flags: must be 0

This function will sign the certificate request with a private key. This must be the same key as the one used in `gnutls_x509_cert_set_key()` since a certificate request is self signed.

This must be the last step in a certificate request generation since all the previously set parameters are now signed.

Returns: GNUTLS_E_SUCCESS on success, otherwise a negative error code. GNUTLS_E_ASN1_VALUE_NOT_FOUND is returned if you didn't set all information in the certificate request (e.g., the version using `gnutls_x509_crq_set_version()`).

Deprecated: Use `gnutls_x509_crq_privkey_sign()` instead.

gnutls_x509_crq_sign

```
int gnutls_x509_crq_sign (gnutls_x509_crq_t crq, [Function]
                        gnutls_x509_privkey_t key)
```

crq: should contain a `gnutls_x509_crq_t` structure

key: holds a private key

This function is the same as `gnutls_x509_crq_sign2()` with no flags, and SHA1 as the hash algorithm.

Returns: On success, GNUTLS_E_SUCCESS (0) is returned, otherwise a negative error value.

Deprecated: Use `gnutls_x509_crq_privkey_sign()` instead.

gnutls_x509_crq_verify

```
int gnutls_x509_crq_verify (gnutls_x509_crq_t crq, unsigned int [Function]
                           flags)
```

crq: is the crq to be verified

flags: Flags that may be used to change the verification algorithm. Use OR of the `gnutls_certificate_verify_flags` enumerations.

This function will verify self signature in the certificate request and return its status.

Returns: On success, GNUTLS_E_SUCCESS (0) is returned, GNUTLS_E_PK_SIG_VERIFY_FAILED if verification failed, otherwise a negative error value.

gnutls_x509_cert_check_hostname

```
int gnutls_x509_cert_check_hostname (gnutls_x509_cert_t cert, [Function]
                                     const char * hostname)
```

cert: should contain an `gnutls_x509_cert_t` structure

hostname: A null terminated string that contains a DNS name

This function will check if the given certificate's subject matches the given hostname. This is a basic implementation of the matching described in RFC2818 (HTTPS), which takes into account wildcards, and the DNSName/IPAddress subject alternative name PKIX extension.

Returns: non (0) for a successful match, and (0) on failure.

gnutls_x509_cert_check_issuer

```
int gnutls_x509_cert_check_issuer (gnutls_x509_cert_t cert,          [Function]
                                   gnutls_x509_cert_t issuer)
```

cert: is the certificate to be checked

issuer: is the certificate of a possible issuer

This function will check if the given certificate was issued by the given issuer.

Returns: It will return true (1) if the given certificate is issued by the given issuer, and false (0) if not. A negative error code is returned in case of an error.

gnutls_x509_cert_check_revocation

```
int gnutls_x509_cert_check_revocation (gnutls_x509_cert_t cert,    [Function]
                                         const gnutls_x509_crl_t *crl_list, int crl_list_length)
```

cert: should contain a `gnutls_x509_cert_t` structure

crl_list: should contain a list of `gnutls_x509_crl_t` structures

crl_list_length: the length of the *crl_list*

This function will return check if the given certificate is revoked. It is assumed that the CRLs have been verified before.

Returns: 0 if the certificate is NOT revoked, and 1 if it is. A negative error code is returned on error.

gnutls_x509_cert_cpy_crl_dist_points

```
int gnutls_x509_cert_cpy_crl_dist_points (gnutls_x509_cert_t dst,  [Function]
                                           gnutls_x509_cert_t src)
```

dst: a certificate of type `gnutls_x509_cert_t`

src: the certificate where the dist points will be copied from

This function will copy the CRL distribution points certificate extension, from the source to the destination certificate. This may be useful to copy from a CA certificate to issued ones.

Returns: On success, `GNUTLS_E_SUCCESS` (0) is returned, otherwise a negative error value.

gnutls_x509_cert_deinit

```
void gnutls_x509_cert_deinit (gnutls_x509_cert_t cert)           [Function]
```

cert: The structure to be deinitialized

This function will deinitialize a certificate structure.

gnutls_x509_cert_export

```
int gnutls_x509_cert_export (gnutls_x509_cert_t cert,            [Function]
                              gnutls_x509_cert_fmt_t format, void *output_data, size_t *
                              output_data_size)
```

cert: Holds the certificate

format: the format of output params. One of PEM or DER.

output_data: will contain a certificate PEM or DER encoded

output_data_size: holds the size of output_data (and will be replaced by the actual size of parameters)

This function will export the certificate to DER or PEM format.

If the buffer provided is not long enough to hold the output, then **output_data_size* is updated and `GNUTLS_E_SHORT_MEMORY_BUFFER` will be returned.

If the structure is PEM encoded, it will have a header of "BEGIN CERTIFICATE".

Return value: In case of failure a negative error code will be returned, and 0 on success.

gnutls_x509_cert_get_activation_time

`time_t gnutls_x509_cert_get_activation_time (gnutls_x509_cert_t cert)` [Function]

cert: should contain a `gnutls_x509_cert_t` structure

This function will return the time this Certificate was or will be activated.

Returns: activation time, or (time_t)-1 on error.

gnutls_x509_cert_get_authority_key_id

`int gnutls_x509_cert_get_authority_key_id (gnutls_x509_cert_t cert, void *ret, size_t *ret_size, unsigned int *critical)` [Function]

cert: should contain a `gnutls_x509_cert_t` structure

ret: The place where the identifier will be copied

ret_size: Holds the size of the result field.

critical: will be non (0) if the extension is marked as critical (may be null)

This function will return the X.509v3 certificate authority's key identifier. This is obtained by the X.509 Authority Key identifier extension field (2.5.29.35). Note that this function only returns the keyIdentifier field of the extension.

Returns: On success, `GNUTLS_E_SUCCESS` (0) is returned, otherwise a negative error value.

gnutls_x509_cert_get_basic_constraints

`int gnutls_x509_cert_get_basic_constraints (gnutls_x509_cert_t cert, unsigned int *critical, int *ca, int *pathlen)` [Function]

cert: should contain a `gnutls_x509_cert_t` structure

critical: will be non (0) if the extension is marked as critical

ca: pointer to output integer indicating CA status, may be NULL, value is 1 if the certificate CA flag is set, 0 otherwise.

pathlen: pointer to output integer indicating path length (may be NULL), non-negative error codes indicate a present pathLenConstraint field and the actual value, -1 indicate that the field is absent.

This function will read the certificate's basic constraints, and return the certificates CA status. It reads the basicConstraints X.509 extension (2.5.29.19).

Return value: If the certificate is a CA a positive value will be returned, or (0) if the certificate does not have CA flag set. A negative error code may be returned in case of errors. If the certificate does not contain the basicConstraints extension GNUTLS_E_REQUESTED_DATA_NOT_AVAILABLE will be returned.

gnutls_x509_cert_get_ca_status

```
int gnutls_x509_cert_get_ca_status (gnutls_x509_cert_t cert,          [Function]
                                   unsigned int * critical)
```

cert: should contain a `gnutls_x509_cert_t` structure

critical: will be non (0) if the extension is marked as critical

This function will return certificates CA status, by reading the basicConstraints X.509 extension (2.5.29.19). If the certificate is a CA a positive value will be returned, or (0) if the certificate does not have CA flag set.

Use `gnutls_x509_cert_get_basic_constraints()` if you want to read the pathLen-Constraint field too.

Returns: A negative error code may be returned in case of parsing error. If the certificate does not contain the basicConstraints extension GNUTLS_E_REQUESTED_DATA_NOT_AVAILABLE will be returned.

gnutls_x509_cert_get_crl_dist_points

```
int gnutls_x509_cert_get_crl_dist_points (gnutls_x509_cert_t      [Function]
                                           cert, unsigned int seq, void * ret, size_t * ret_size, unsigned int *
                                           reason_flags, unsigned int * critical)
```

cert: should contain a `gnutls_x509_cert_t` structure

seq: specifies the sequence number of the distribution point (0 for the first one, 1 for the second etc.)

ret: is the place where the distribution point will be copied to

ret_size: holds the size of *ret*.

reason_flags: Revocation reasons flags.

critical: will be non (0) if the extension is marked as critical (may be null)

This function retrieves the CRL distribution points (2.5.29.31), contained in the given certificate in the X509v3 Certificate Extensions.

reason_flags should be an ORed sequence of GNUTLS_CRL_REASON_UNUSED, GNUTLS_CRL_REASON_KEY_COMPROMISE, GNUTLS_CRL_REASON_CA_COMPROMISE, GNUTLS_CRL_REASON_AFFILIATION_CHANGED, GNUTLS_CRL_REASON_SUPERSEDED, GNUTLS_CRL_REASON_CESSATION_OF_OPERATION, GNUTLS_CRL_REASON_CERTIFICATE_HOLD, GNUTLS_CRL_REASON_PRIVILEGE_WITHDRAWN, GNUTLS_CRL_REASON_AA_COMPROMISE, or (0) for all possible reasons.

Returns: GNUTLS_E_SHORT_MEMORY_BUFFER and updates *ret_size* if *ret_size* is not enough to hold the distribution point, or the type of the distribution point if everything was ok. The type is one of the enumerated `gnutls_x509_subject_alt_name_t`.

If the certificate does not have an Alternative name with the specified sequence number then `GNUTLS_E_REQUESTED_DATA_NOT_AVAILABLE` is returned.

`gnutls_x509_cert_get_dn_by_oid`

```
int gnutls_x509_cert_get_dn_by_oid (gnutls_x509_cert_t cert, const [Function]
    char * oid, int indx, unsigned int raw_flag, void * buf, size_t *
    sizeof_buf)
```

cert: should contain a `gnutls_x509_cert_t` structure

oid: holds an Object Identified in null terminated string

indx: In case multiple same OIDs exist in the RDN, this specifies which to send. Use (0) to get the first one.

raw_flag: If non (0) returns the raw DER data of the DN part.

buf: a pointer where the DN part will be copied (may be null).

sizeof_buf: initially holds the size of `buf`

This function will extract the part of the name of the Certificate subject specified by the given OID. The output, if the raw flag is not used, will be encoded as described in RFC2253. Thus a string that is ASCII or UTF-8 encoded, depending on the certificate data.

Some helper macros with popular OIDs can be found in `gnutls/x509.h`. If raw flag is (0), this function will only return known OIDs as text. Other OIDs will be DER encoded, as described in RFC2253 – in hex format with a `'\#'` prefix. You can check about known OIDs using `gnutls_x509_dn_oid_known()`.

If `buf` is null then only the size will be filled.

Returns: `GNUTLS_E_SHORT_MEMORY_BUFFER` if the provided buffer is not long enough, and in that case the `*sizeof_buf` will be updated with the required size. On success 0 is returned.

`gnutls_x509_cert_get_dn_oid`

```
int gnutls_x509_cert_get_dn_oid (gnutls_x509_cert_t cert, int indx, [Function]
    void * oid, size_t * sizeof_oid)
```

cert: should contain a `gnutls_x509_cert_t` structure

indx: This specifies which OID to return. Use (0) to get the first one.

oid: a pointer to a buffer to hold the OID (may be null)

sizeof_oid: initially holds the size of `oid`

This function will extract the OIDs of the name of the Certificate subject specified by the given index.

If `oid` is null then only the size will be filled.

Returns: `GNUTLS_E_SHORT_MEMORY_BUFFER` if the provided buffer is not long enough, and in that case the `*sizeof_oid` will be updated with the required size. On success 0 is returned.

gnutls_x509_cert_get_dn

int gnutls_x509_cert_get_dn (*gnutls_x509_cert_t* *cert*, *char* * *buf*, [Function]
size_t * *sizeof_buf*)

cert: should contain a *gnutls_x509_cert_t* structure

buf: a pointer to a structure to hold the name (may be null)

sizeof_buf: initially holds the size of *buf*

This function will copy the name of the Certificate in the provided buffer. The name will be in the form "C=xxxx,O=yyyy,CN=zzzz" as described in RFC2253. The output string will be ASCII or UTF-8 encoded, depending on the certificate data.

If *buf* is null then only the size will be filled.

Returns: GNUTLS_E_SHORT_MEMORY_BUFFER if the provided buffer is not long enough, and in that case the **sizeof_buf* will be updated with the required size. On success 0 is returned.

gnutls_x509_cert_get_expiration_time

time_t gnutls_x509_cert_get_expiration_time (*gnutls_x509_cert_t* [Function]
cert)

cert: should contain a *gnutls_x509_cert_t* structure

This function will return the time this Certificate was or will be expired.

Returns: expiration time, or (time_t)-1 on error.

gnutls_x509_cert_get_extension_by_oid

int gnutls_x509_cert_get_extension_by_oid (*gnutls_x509_cert_t* [Function]
cert, *const char* * *oid*, *int* *indx*, *void* * *buf*, *size_t* * *sizeof_buf*, *unsigned*
int * *critical*)

cert: should contain a *gnutls_x509_cert_t* structure

oid: holds an Object Identified in null terminated string

indx: In case multiple same OIDs exist in the extensions, this specifies which to send. Use (0) to get the first one.

buf: a pointer to a structure to hold the name (may be null)

sizeof_buf: initially holds the size of *buf*

critical: will be non (0) if the extension is marked as critical

This function will return the extension specified by the OID in the certificate. The extensions will be returned as binary data DER encoded, in the provided buffer.

Returns: On success, GNUTLS_E_SUCCESS (0) is returned, otherwise a negative error code is returned. If the certificate does not contain the specified extension GNUTLS_E_REQUESTED_DATA_NOT_AVAILABLE will be returned.

gnutls_x509_cert_get_extension_data

```
int gnutls_x509_cert_get_extension_data (gnutls_x509_cert_t cert, [Function]
    int indx, void * data, size_t * sizeof_data)
```

cert: should contain a `gnutls_x509_cert_t` structure

indx: Specifies which extension OID to send. Use (0) to get the first one.

data: a pointer to a structure to hold the data (may be null)

sizeof_data: initially holds the size of *oid*

This function will return the requested extension data in the certificate. The extension data will be stored as a string in the provided buffer.

Use `gnutls_x509_cert_get_extension_info()` to extract the OID and critical flag. Use `gnutls_x509_cert_get_extension_by_oid()` instead, if you want to get data indexed by the extension OID rather than sequence.

Returns: On success, `GNUTLS_E_SUCCESS` (0) is returned, otherwise a negative error code is returned. If you have reached the last extension available `GNUTLS_E_REQUESTED_DATA_NOT_AVAILABLE` will be returned.

gnutls_x509_cert_get_extension_info

```
int gnutls_x509_cert_get_extension_info (gnutls_x509_cert_t cert, [Function]
    int indx, void * oid, size_t * sizeof_oid, int * critical)
```

cert: should contain a `gnutls_x509_cert_t` structure

indx: Specifies which extension OID to send. Use (0) to get the first one.

oid: a pointer to a structure to hold the OID

sizeof_oid: initially holds the maximum size of *oid*, on return holds actual size of *oid*.

critical: output variable with critical flag, may be NULL.

This function will return the requested extension OID in the certificate, and the critical flag for it. The extension OID will be stored as a string in the provided buffer. Use `gnutls_x509_cert_get_extension_data()` to extract the data.

If the buffer provided is not long enough to hold the output, then **sizeof_oid* is updated and `GNUTLS_E_SHORT_MEMORY_BUFFER` will be returned.

Returns: On success, `GNUTLS_E_SUCCESS` (0) is returned, otherwise a negative error code is returned. If you have reached the last extension available `GNUTLS_E_REQUESTED_DATA_NOT_AVAILABLE` will be returned.

gnutls_x509_cert_get_extension_oid

```
int gnutls_x509_cert_get_extension_oid (gnutls_x509_cert_t cert, [Function]
    int indx, void * oid, size_t * sizeof_oid)
```

cert: should contain a `gnutls_x509_cert_t` structure

indx: Specifies which extension OID to send. Use (0) to get the first one.

oid: a pointer to a structure to hold the OID (may be null)

sizeof_oid: initially holds the size of *oid*

This function will return the requested extension OID in the certificate. The extension OID will be stored as a string in the provided buffer.

Returns: On success, `GNUTLS_E_SUCCESS` (0) is returned, otherwise a negative error code is returned. If you have reached the last extension available `GNUTLS_E_REQUESTED_DATA_NOT_AVAILABLE` will be returned.

`gnutls_x509_cert_get_fingerprint`

```
int gnutls_x509_cert_get_fingerprint (gnutls_x509_cert_t cert,          [Function]
                                     gnutls_digest_algorithm_t algo, void * buf, size_t * sizeof_buf)
```

cert: should contain a `gnutls_x509_cert_t` structure

algo: is a digest algorithm

buf: a pointer to a structure to hold the fingerprint (may be null)

sizeof_buf: initially holds the size of *buf*

This function will calculate and copy the certificate's fingerprint in the provided buffer. If the buffer is null then only the size will be filled.

Returns: `GNUTLS_E_SHORT_MEMORY_BUFFER` if the provided buffer is not long enough, and in that case the **sizeof_buf* will be updated with the required size. On success 0 is returned.

`gnutls_x509_cert_get_issuer_alt_name2`

```
int gnutls_x509_cert_get_issuer_alt_name2 (gnutls_x509_cert_t          [Function]
                                             cert, unsigned int seq, void * ret, size_t * ret_size, unsigned int *
                                             ret_type, unsigned int * critical)
```

cert: should contain a `gnutls_x509_cert_t` structure

seq: specifies the sequence number of the alt name (0 for the first one, 1 for the second etc.)

ret: is the place where the alternative name will be copied to

ret_size: holds the size of *ret*.

ret_type: holds the type of the alternative name (one of `gnutls_x509_subject_alt_name_t`).

critical: will be non (0) if the extension is marked as critical (may be null)

This function will return the alternative names, contained in the given certificate. It is the same as `gnutls_x509_cert_get_issuer_alt_name()` except for the fact that it will return the type of the alternative name in *ret_type* even if the function fails for some reason (i.e. the buffer provided is not enough).

Returns: the alternative issuer name type on success, one of the enumerated `gnutls_x509_subject_alt_name_t`. It will return `GNUTLS_E_SHORT_MEMORY_BUFFER` if *ret_size* is not large enough to hold the value. In that case *ret_size* will be updated with the required size. If the certificate does not have an Alternative name with the specified sequence number then `GNUTLS_E_REQUESTED_DATA_NOT_AVAILABLE` is returned.

Since: 2.10.0

gnutls_x509_cert_get_issuer_alt_name

```
int gnutls_x509_cert_get_issuer_alt_name (gnutls_x509_cert_t [Function]
    cert, unsigned int seq, void * ret, size_t * ret_size, unsigned int *
    critical)
```

cert: should contain a `gnutls_x509_cert_t` structure

seq: specifies the sequence number of the alt name (0 for the first one, 1 for the second etc.)

ret: is the place where the alternative name will be copied to

ret_size: holds the size of *ret*.

critical: will be non (0) if the extension is marked as critical (may be null)

This function retrieves the Issuer Alternative Name (2.5.29.18), contained in the given certificate in the X509v3 Certificate Extensions.

When the SAN type is `otherName`, it will extract the data in the `otherName`'s value field, and `GNUTLS_SAN_OTHERNAME` is returned. You may use `gnutls_x509_cert_get_subject_alt_othername_oid()` to get the corresponding OID and the "virtual" SAN types (e.g., `GNUTLS_SAN_OTHERNAME_XMPP`).

If an `otherName` OID is known, the data will be decoded. Otherwise the returned data will be DER encoded, and you will have to decode it yourself. Currently, only the RFC 3920 `id-on-xmppAddr` Issuer AltName is recognized.

Returns: the alternative issuer name type on success, one of the enumerated `gnutls_x509_subject_alt_name_t`. It will return `GNUTLS_E_SHORT_MEMORY_BUFFER` if *ret_size* is not large enough to hold the value. In that case *ret_size* will be updated with the required size. If the certificate does not have an Alternative name with the specified sequence number then `GNUTLS_E_REQUESTED_DATA_NOT_AVAILABLE` is returned.

Since: 2.10.0

gnutls_x509_cert_get_issuer_alt_othername_oid

```
int gnutls_x509_cert_get_issuer_alt_othername_oid [Function]
    (gnutls_x509_cert_t cert, unsigned int seq, void * ret, size_t * ret_size)
```

cert: should contain a `gnutls_x509_cert_t` structure

seq: specifies the sequence number of the alt name (0 for the first one, 1 for the second etc.)

ret: is the place where the `otherName` OID will be copied to

ret_size: holds the size of *ret*.

This function will extract the type OID of an `otherName` Subject Alternative Name, contained in the given certificate, and return the type as an enumerated element.

This function is only useful if `gnutls_x509_cert_get_issuer_alt_name()` returned `GNUTLS_SAN_OTHERNAME`.

Returns: the alternative issuer name type on success, one of the enumerated `gnutls_x509_subject_alt_name_t`. For supported OIDs, it will return one of the virtual (`GNUTLS_SAN_OTHERNAME_*`) types, e.g. `GNUTLS_SAN_OTHERNAME_XMPP`,

and `GNUTLS_SAN_OTHERNAME` for unknown OIDs. It will return `GNUTLS_E_SHORT_MEMORY_BUFFER` if `ret_size` is not large enough to hold the value. In that case `ret_size` will be updated with the required size. If the certificate does not have an Alternative name with the specified sequence number and with the `otherName` type then `GNUTLS_E_REQUESTED_DATA_NOT_AVAILABLE` is returned.

Since: 2.10.0

`gnutls_x509_cert_get_issuer_dn_by_oid`

```
int gnutls_x509_cert_get_issuer_dn_by_oid (gnutls_x509_cert_t cert, const char * oid, int indx, unsigned int raw_flag, void * buf, size_t * sizeof_buf) [Function]
```

cert: should contain a `gnutls_x509_cert_t` structure

oid: holds an Object Identified in null terminated string

indx: In case multiple same OIDs exist in the RDN, this specifies which to send. Use (0) to get the first one.

raw_flag: If non (0) returns the raw DER data of the DN part.

buf: a pointer to a structure to hold the name (may be null)

sizeof_buf: initially holds the size of *buf*

This function will extract the part of the name of the Certificate issuer specified by the given OID. The output, if the raw flag is not used, will be encoded as described in RFC2253. Thus a string that is ASCII or UTF-8 encoded, depending on the certificate data.

Some helper macros with popular OIDs can be found in `gnutls/x509.h`. If raw flag is (0), this function will only return known OIDs as text. Other OIDs will be DER encoded, as described in RFC2253 – in hex format with a `'\#'` prefix. You can check about known OIDs using `gnutls_x509_dn_oid_known()`.

If *buf* is null then only the size will be filled.

Returns: `GNUTLS_E_SHORT_MEMORY_BUFFER` if the provided buffer is not long enough, and in that case the **sizeof_buf* will be updated with the required size. On success 0 is returned.

`gnutls_x509_cert_get_issuer_dn_oid`

```
int gnutls_x509_cert_get_issuer_dn_oid (gnutls_x509_cert_t cert, int indx, void * oid, size_t * sizeof_oid) [Function]
```

cert: should contain a `gnutls_x509_cert_t` structure

indx: This specifies which OID to return. Use (0) to get the first one.

oid: a pointer to a buffer to hold the OID (may be null)

sizeof_oid: initially holds the size of *oid*

This function will extract the OIDs of the name of the Certificate issuer specified by the given index.

If *oid* is null then only the size will be filled.

Returns: GNUTLS_E_SHORT_MEMORY_BUFFER if the provided buffer is not long enough, and in that case the `*sizeof_oid` will be updated with the required size. On success 0 is returned.

`gnutls_x509_cert_get_issuer_dn`

```
int gnutls_x509_cert_get_issuer_dn (gnutls_x509_cert_t cert, char * buf, size_t * sizeof_buf) [Function]
```

cert: should contain a `gnutls_x509_cert_t` structure

buf: a pointer to a structure to hold the name (may be null)

sizeof_buf: initially holds the size of *buf*

This function will copy the name of the Certificate issuer in the provided buffer. The name will be in the form "C=xxxx,O=yyyy,CN=zzzz" as described in RFC2253. The output string will be ASCII or UTF-8 encoded, depending on the certificate data.

If *buf* is null then only the size will be filled.

Returns: GNUTLS_E_SHORT_MEMORY_BUFFER if the provided buffer is not long enough, and in that case the `*sizeof_buf` will be updated with the required size. On success 0 is returned.

`gnutls_x509_cert_get_issuer_unique_id`

```
int gnutls_x509_cert_get_issuer_unique_id (gnutls_x509_cert_t crt, char * buf, size_t * sizeof_buf) [Function]
```

crt: Holds the certificate

buf: user allocated memory buffer, will hold the unique id

sizeof_buf: size of user allocated memory buffer (on input), will hold actual size of the unique ID on return.

This function will extract the issuerUniqueID value (if present) for the given certificate.

If the user allocated memory buffer is not large enough to hold the full subjectUniqueID, then a GNUTLS_E_SHORT_MEMORY_BUFFER error will be returned, and `sizeof_buf` will be set to the actual length.

Returns: GNUTLS_E_SUCCESS on success, otherwise a negative error code.

`gnutls_x509_cert_get_issuer`

```
int gnutls_x509_cert_get_issuer (gnutls_x509_cert_t cert, gnutls_x509_dn_t * dn) [Function]
```

cert: should contain a `gnutls_x509_cert_t` structure

dn: output variable with pointer to opaque DN

Return the Certificate's Issuer DN as an opaque data type. You may use `gnutls_x509_dn_get_rdn_ava()` to decode the DN.

Note that *dn* should be treated as constant. Because it points into the *cert* object, you may not deallocate *cert* and continue to access *dn*.

Returns: Returns 0 on success, or an error code.

gnutls_x509_cert_get_key_id

```
int gnutls_x509_cert_get_key_id (gnutls_x509_cert_t cert, unsigned int flags, unsigned char * output_data, size_t * output_data_size) [Function]
```

cert: Holds the certificate

flags: should be 0 for now

output_data: will contain the key ID

output_data_size: holds the size of *output_data* (and will be replaced by the actual size of parameters)

This function will return a unique ID the depends on the public key parameters. This ID can be used in checking whether a certificate corresponds to the given private key.

If the buffer provided is not long enough to hold the output, then **output_data_size* is updated and `GNUTLS_E_SHORT_MEMORY_BUFFER` will be returned. The output will normally be a SHA-1 hash output, which is 20 bytes.

Return value: In case of failure a negative error code will be returned, and 0 on success.

gnutls_x509_cert_get_key_purpose_oid

```
int gnutls_x509_cert_get_key_purpose_oid (gnutls_x509_cert_t cert, int indx, void * oid, size_t * sizeof_oid, unsigned int * critical) [Function]
```

cert: should contain a `gnutls_x509_cert_t` structure

indx: This specifies which OID to return. Use (0) to get the first one.

oid: a pointer to a buffer to hold the OID (may be null)

sizeof_oid: initially holds the size of *oid*

critical: output flag to indicate criticality of extension

This function will extract the key purpose OIDs of the Certificate specified by the given index. These are stored in the Extended Key Usage extension (2.5.29.37) See the `GNUTLS_KP_*` definitions for human readable names.

If *oid* is null then only the size will be filled.

Returns: `GNUTLS_E_SHORT_MEMORY_BUFFER` if the provided buffer is not long enough, and in that case the **sizeof_oid* will be updated with the required size. On success 0 is returned.

gnutls_x509_cert_get_key_usage

```
int gnutls_x509_cert_get_key_usage (gnutls_x509_cert_t cert, unsigned int * key_usage, unsigned int * critical) [Function]
```

cert: should contain a `gnutls_x509_cert_t` structure

key_usage: where the key usage bits will be stored

critical: will be non (0) if the extension is marked as critical

This function will return certificate's key usage, by reading the keyUsage X.509 extension (2.5.29.15). The key usage value will ORed values of the: `GNUTLS_KEY_DIGITAL_SIGNATURE`, `GNUTLS_KEY_NON_REPUDIATION`,

GNUTLS_KEY_KEY_ENCIPHERMENT, GNUTLS_KEY_DATA_ENCIPHERMENT, GNUTLS_KEY_KEY_AGREEMENT, GNUTLS_KEY_KEY_CERT_SIGN, GNUTLS_KEY_CRL_SIGN, GNUTLS_KEY_ENCIPHER_ONLY, GNUTLS_KEY_DECIPHER_ONLY.

Returns: the certificate key usage, or a negative error code in case of parsing error. If the certificate does not contain the keyUsage extension GNUTLS_E_REQUESTED_DATA_NOT_AVAILABLE will be returned.

gnutls_x509_cert_get_pk_algorithm

```
int gnutls_x509_cert_get_pk_algorithm (gnutls_x509_cert_t cert,      [Function]
                                       unsigned int * bits)
```

cert: should contain a `gnutls_x509_cert_t` structure

bits: if bits is non null it will hold the size of the parameters' in bits

This function will return the public key algorithm of an X.509 certificate.

If bits is non null, it should have enough size to hold the parameters size in bits. For RSA the bits returned is the modulus. For DSA the bits returned are of the public exponent.

Returns: a member of the `gnutls_pk_algorithm_t` enumeration on success, or a negative error code on error.

gnutls_x509_cert_get_pk_dsa_raw

```
int gnutls_x509_cert_get_pk_dsa_raw (gnutls_x509_cert_t crt,      [Function]
                                       gnutls_datum_t * p, gnutls_datum_t * q, gnutls_datum_t * g, gnutls_datum_t * y)
```

crt: Holds the certificate

p: will hold the p

q: will hold the q

g: will hold the g

y: will hold the y

This function will export the DSA public key's parameters found in the given certificate. The new parameters will be allocated using `gnutls_malloc()` and will be stored in the appropriate datum.

Returns: GNUTLS_E_SUCCESS on success, otherwise a negative error code.

gnutls_x509_cert_get_pk_rsa_raw

```
int gnutls_x509_cert_get_pk_rsa_raw (gnutls_x509_cert_t crt,      [Function]
                                       gnutls_datum_t * m, gnutls_datum_t * e)
```

crt: Holds the certificate

m: will hold the modulus

e: will hold the public exponent

This function will export the RSA public key's parameters found in the given structure. The new parameters will be allocated using `gnutls_malloc()` and will be stored in the appropriate datum.

Returns: GNUTLS_E_SUCCESS on success, otherwise a negative error code.

gnutls_x509_cert_get_preferred_hash_algorithm

```
int gnutls_x509_cert_get_preferred_hash_algorithm (Function]
      (gnutls_x509_cert_t cert, gnutls_digest_algorithm_t * hash, unsigned int *
      mand)
```

cert: Holds the certificate

hash: The result of the call with the hash algorithm used for signature

mand: If non (0) it means that the algorithm MUST use this hash. May be NULL.

This function will read the certificate and return the appropriate digest algorithm to use for signing with this certificate. Some certificates (i.e. DSA might not be able to sign without the preferred algorithm).

Deprecated: Please use `gnutls_pubkey_get_preferred_hash_algorithm()`.

Returns: the 0 if the hash algorithm is found. A negative error code is returned on error.

Since: 2.11.0

gnutls_x509_cert_get_proxy

```
int gnutls_x509_cert_get_proxy (gnutls_x509_cert_t cert, unsigned [Function]
      int * critical, int * pathlen, char ** policyLanguage, char ** policy,
      size_t * sizeof_policy)
```

cert: should contain a `gnutls_x509_cert_t` structure

critical: will be non (0) if the extension is marked as critical

pathlen: pointer to output integer indicating path length (may be NULL), non-negative error codes indicate a present `pCPathLenConstraint` field and the actual value, -1 indicate that the field is absent.

policyLanguage: output variable with OID of policy language

policy: output variable with policy data

sizeof_policy: output variable size of policy data

This function will get information from a proxy certificate. It reads the `ProxyCertInfo X.509` extension (1.3.6.1.5.5.7.1.14).

Returns: On success, `GNUTLS_E_SUCCESS` (0) is returned, otherwise a negative error code is returned.

gnutls_x509_cert_get_raw_dn

```
int gnutls_x509_cert_get_raw_dn (gnutls_x509_cert_t cert, [Function]
      gnutls_datum_t * start)
```

cert: should contain a `gnutls_x509_cert_t` structure

start: will hold the starting point of the DN

This function will return a pointer to the DER encoded DN structure and the length.

Returns: On success, `GNUTLS_E_SUCCESS` (0) is returned, otherwise a negative error value. or a negative error code on error.

gnutls_x509_cert_get_raw_issuer_dn

```
int gnutls_x509_cert_get_raw_issuer_dn (gnutls_x509_cert_t cert,      [Function]
    gnutls_datum_t * start)
```

cert: should contain a `gnutls_x509_cert_t` structure

start: will hold the starting point of the DN

This function will return a pointer to the DER encoded DN structure and the length.

Returns: On success, `GNUTLS_E_SUCCESS` (0) is returned, otherwise a negative error value or a negative error code on error.

gnutls_x509_cert_get_serial

```
int gnutls_x509_cert_get_serial (gnutls_x509_cert_t cert, void *    [Function]
    result, size_t * result_size)
```

cert: should contain a `gnutls_x509_cert_t` structure

result: The place where the serial number will be copied

result_size: Holds the size of the result field.

This function will return the X.509 certificate's serial number. This is obtained by the X509 Certificate serialNumber field. Serial is not always a 32 or 64bit number. Some CAs use large serial numbers, thus it may be wise to handle it as something opaque.

Returns: On success, `GNUTLS_E_SUCCESS` (0) is returned, otherwise a negative error value.

gnutls_x509_cert_get_signature_algorithm

```
int gnutls_x509_cert_get_signature_algorithm (gnutls_x509_cert_t    [Function]
    cert)
```

cert: should contain a `gnutls_x509_cert_t` structure

This function will return a value of the `gnutls_sign_algorithm_t` enumeration that is the signature algorithm that has been used to sign this certificate.

Returns: a `gnutls_sign_algorithm_t` value, or a negative error code on error.

gnutls_x509_cert_get_signature

```
int gnutls_x509_cert_get_signature (gnutls_x509_cert_t cert, char * [Function]
    sig, size_t * sizeof_sig)
```

cert: should contain a `gnutls_x509_cert_t` structure

sig: a pointer where the signature part will be copied (may be null).

sizeof_sig: initially holds the size of `sig`

This function will extract the signature field of a certificate.

Returns: On success, `GNUTLS_E_SUCCESS` (0) is returned, otherwise a negative error value. and a negative error code on error.

gnutls_x509_cert_get_subject_alt_name2

```
int gnutls_x509_cert_get_subject_alt_name2 (gnutls_x509_cert_t [Function]
      cert, unsigned int seq, void *ret, size_t *ret_size, unsigned int *
      ret_type, unsigned int *critical)
```

cert: should contain a `gnutls_x509_cert_t` structure

seq: specifies the sequence number of the alt name (0 for the first one, 1 for the second etc.)

ret: is the place where the alternative name will be copied to

ret_size: holds the size of *ret*.

ret_type: holds the type of the alternative name (one of `gnutls_x509_subject_alt_name_t`).

critical: will be non (0) if the extension is marked as critical (may be null)

This function will return the alternative names, contained in the given certificate. It is the same as `gnutls_x509_cert_get_subject_alt_name()` except for the fact that it will return the type of the alternative name in *ret_type* even if the function fails for some reason (i.e. the buffer provided is not enough).

Returns: the alternative subject name type on success, one of the enumerated `gnutls_x509_subject_alt_name_t`. It will return `GNUTLS_E_SHORT_MEMORY_BUFFER` if *ret_size* is not large enough to hold the value. In that case *ret_size* will be updated with the required size. If the certificate does not have an Alternative name with the specified sequence number then `GNUTLS_E_REQUESTED_DATA_NOT_AVAILABLE` is returned.

gnutls_x509_cert_get_subject_alt_name

```
int gnutls_x509_cert_get_subject_alt_name (gnutls_x509_cert_t [Function]
      cert, unsigned int seq, void *ret, size_t *ret_size, unsigned int *
      critical)
```

cert: should contain a `gnutls_x509_cert_t` structure

seq: specifies the sequence number of the alt name (0 for the first one, 1 for the second etc.)

ret: is the place where the alternative name will be copied to

ret_size: holds the size of *ret*.

critical: will be non (0) if the extension is marked as critical (may be null)

This function retrieves the Alternative Name (2.5.29.17), contained in the given certificate in the X509v3 Certificate Extensions.

When the SAN type is `otherName`, it will extract the data in the `otherName`'s value field, and `GNUTLS_SAN_OTHERNAME` is returned. You may use `gnutls_x509_cert_get_subject_alt_othername_oid()` to get the corresponding OID and the "virtual" SAN types (e.g., `GNUTLS_SAN_OTHERNAME_XMPP`).

If an `otherName` OID is known, the data will be decoded. Otherwise the returned data will be DER encoded, and you will have to decode it yourself. Currently, only the RFC 3920 `id-on-xmppAddr` SAN is recognized.

Returns: the alternative subject name type on success, one of the enumerated `gnutls_x509_subject_alt_name_t`. It will return `GNUTLS_E_SHORT_MEMORY_BUFFER`

if `ret_size` is not large enough to hold the value. In that case `ret_size` will be updated with the required size. If the certificate does not have an Alternative name with the specified sequence number then `GNUTLS_E_REQUESTED_DATA_NOT_AVAILABLE` is returned.

`gnutls_x509_cert_get_subject_alt_othername_oid`

```
int gnutls_x509_cert_get_subject_alt_othername_oid      [Function]
    (gnutls_x509_cert_t cert, unsigned int seq, void * ret, size_t * ret_size)
```

cert: should contain a `gnutls_x509_cert_t` structure

seq: specifies the sequence number of the alt name (0 for the first one, 1 for the second etc.)

ret: is the place where the otherName OID will be copied to

ret_size: holds the size of *ret*.

This function will extract the type OID of an otherName Subject Alternative Name, contained in the given certificate, and return the type as an enumerated element.

This function is only useful if `gnutls_x509_cert_get_subject_alt_name()` returned `GNUTLS_SAN_OTHERNAME`.

Returns: the alternative subject name type on success, one of the enumerated `gnutls_x509_subject_alt_name_t`. For supported OIDs, it will return one of the virtual (`GNUTLS_SAN_OTHERNAME_*`) types, e.g. `GNUTLS_SAN_OTHERNAME_XMPP`, and `GNUTLS_SAN_OTHERNAME` for unknown OIDs. It will return `GNUTLS_E_SHORT_MEMORY_BUFFER` if `ret_size` is not large enough to hold the value. In that case `ret_size` will be updated with the required size. If the certificate does not have an Alternative name with the specified sequence number and with the otherName type then `GNUTLS_E_REQUESTED_DATA_NOT_AVAILABLE` is returned.

`gnutls_x509_cert_get_subject_key_id`

```
int gnutls_x509_cert_get_subject_key_id (gnutls_x509_cert_t cert,      [Function]
    void * ret, size_t * ret_size, unsigned int * critical)
```

cert: should contain a `gnutls_x509_cert_t` structure

ret: The place where the identifier will be copied

ret_size: Holds the size of the result field.

critical: will be non (0) if the extension is marked as critical (may be null)

This function will return the X.509v3 certificate's subject key identifier. This is obtained by the X.509 Subject Key identifier extension field (2.5.29.14).

Returns: On success, `GNUTLS_E_SUCCESS` (0) is returned, otherwise a negative error value.

`gnutls_x509_cert_get_subject_unique_id`

```
int gnutls_x509_cert_get_subject_unique_id (gnutls_x509_cert_t      [Function]
    crt, char * buf, size_t * sizeof_buf)
```

crt: Holds the certificate

buf: user allocated memory buffer, will hold the unique id

sizeof_buf: size of user allocated memory buffer (on input), will hold actual size of the unique ID on return.

This function will extract the subjectUniqueID value (if present) for the given certificate.

If the user allocated memory buffer is not large enough to hold the full subjectUniqueID, then a GNUTLS_E_SHORT_MEMORY_BUFFER error will be returned, and *sizeof_buf* will be set to the actual length.

Returns: GNUTLS_E_SUCCESS on success, otherwise a negative error code.

gnutls_x509_cert_get_subject

```
int gnutls_x509_cert_get_subject (gnutls_x509_cert_t cert,          [Function]
                                gnutls_dn_t * dn)
```

cert: should contain a gnutls_x509_cert_t structure

dn: output variable with pointer to opaque DN.

Return the Certificate's Subject DN as an opaque data type. You may use `gnutls_x509_dn_get_rdn_ava()` to decode the DN.

Note that *dn* should be treated as constant. Because it points into the *cert* object, you may not deallocate *cert* and continue to access *dn*.

Returns: Returns 0 on success, or an error code.

gnutls_x509_cert_get_verify_algorithm

```
int gnutls_x509_cert_get_verify_algorithm (gnutls_x509_cert_t      [Function]
                                           crt, const gnutls_datum_t * signature, gnutls_digest_algorithm_t * hash)
```

crt: Holds the certificate

signature: contains the signature

hash: The result of the call with the hash algorithm used for signature

This function will read the certificate and the signed data to determine the hash algorithm used to generate the signature.

Deprecated: Use `gnutls_pubkey_get_verify_algorithm()` instead.

Returns: the 0 if the hash algorithm is found. A negative error code is returned on error.

Since: 2.8.0

gnutls_x509_cert_get_version

```
int gnutls_x509_cert_get_version (gnutls_x509_cert_t cert)      [Function]
```

cert: should contain a gnutls_x509_cert_t structure

This function will return the version of the specified Certificate.

Returns: version of certificate, or a negative error code on error.

gnutls_x509_cert_import

`int gnutls_x509_cert_import (gnutls_x509_cert_t cert, const gnutls_datum_t * data, gnutls_x509_cert_fmt_t format)` [Function]

cert: The structure to store the parsed certificate.

data: The DER or PEM encoded certificate.

format: One of DER or PEM

This function will convert the given DER or PEM encoded Certificate to the native `gnutls_x509_cert_t` format. The output will be stored in *cert*.

If the Certificate is PEM encoded it should have a header of "X509 CERTIFICATE", or "CERTIFICATE".

Returns: On success, `GNUTLS_E_SUCCESS` (0) is returned, otherwise a negative error value.

gnutls_x509_cert_init

`int gnutls_x509_cert_init (gnutls_x509_cert_t * cert)` [Function]

cert: The structure to be initialized

This function will initialize an X.509 certificate structure.

Returns: On success, `GNUTLS_E_SUCCESS` (0) is returned, otherwise a negative error value.

gnutls_x509_cert_list_import2

`int gnutls_x509_cert_list_import2 (gnutls_x509_cert_t ** certs, unsigned int * size, const gnutls_datum_t * data, gnutls_x509_cert_fmt_t format, unsigned int flags)` [Function]

certs: The structures to store the parsed certificate. Must not be initialized.

size: It will contain the size of the list.

data: The PEM encoded certificate.

format: One of DER or PEM.

flags: must be (0) or an OR'd sequence of `gnutls_certificate_import_flags`.

This function will convert the given PEM encoded certificate list to the native `gnutls_x509_cert_t` format. The output will be stored in *certs*. They will be automatically initialized.

If the Certificate is PEM encoded it should have a header of "X509 CERTIFICATE", or "CERTIFICATE".

Returns: the number of certificates read or a negative error value.

gnutls_x509_cert_list_import

`int gnutls_x509_cert_list_import (gnutls_x509_cert_t * certs, unsigned int * cert_max, const gnutls_datum_t * data, gnutls_x509_cert_fmt_t format, unsigned int flags)` [Function]

certs: The structures to store the parsed certificate. Must not be initialized.

cert_max: Initially must hold the maximum number of certs. It will be updated with the number of certs available.

data: The PEM encoded certificate.

format: One of DER or PEM.

flags: must be (0) or an OR'd sequence of `gnutls_certificate_import_flags`.

This function will convert the given PEM encoded certificate list to the native `gnutls_x509_cert_t` format. The output will be stored in `certs`. They will be automatically initialized.

If the Certificate is PEM encoded it should have a header of "X509 CERTIFICATE", or "CERTIFICATE".

Returns: the number of certificates read or a negative error value.

gnutls_x509_cert_list_verify

```
int gnutls_x509_cert_list_verify (const gnutls_x509_cert_t * cert_list, int cert_list_length, const gnutls_x509_cert_t * CA_list, int CA_list_length, const gnutls_x509_crl_t * CRL_list, int CRL_list_length, unsigned int flags, unsigned int * verify) [Function]
```

cert_list: is the certificate list to be verified

cert_list_length: holds the number of certificate in *cert_list*

CA_list: is the CA list which will be used in verification

CA_list_length: holds the number of CA certificate in *CA_list*

CRL_list: holds a list of CRLs.

CRL_list_length: the length of CRL list.

flags: Flags that may be used to change the verification algorithm. Use OR of the `gnutls_certificate_verify_flags` enumerations.

verify: will hold the certificate verification output.

This function will try to verify the given certificate list and return its status. If no flags are specified (0), this function will use the basicConstraints (2.5.29.19) PKIX extension. This means that only a certificate authority is allowed to sign a certificate.

You must also check the peer's name in order to check if the verified certificate belongs to the actual peer.

The certificate verification output will be put in `verify` and will be one or more of the `gnutls_certificate_status_t` enumerated elements bitwise or'd. For a more detailed verification status use `gnutls_x509_cert_verify()` per list element.

Returns: On success, `GNUTLS_E_SUCCESS` (0) is returned, otherwise a negative error value.

gnutls_x509_cert_print

```
int gnutls_x509_cert_print (gnutls_x509_cert_t cert, gnutls_certificate_print_formats_t format, gnutls_datum_t * out) [Function]
```

cert: The structure to be printed

format: Indicate the format to use

out: Newly allocated datum with (0) terminated string.

This function will pretty print a X.509 certificate, suitable for display to a human.

If the format is `GNUTLS_CRT_PRINT_FULL` then all fields of the certificate will be output, on multiple lines. The `GNUTLS_CRT_PRINT_ONELINE` format will generate one line with some selected fields, which is useful for logging purposes.

The output *out* needs to be deallocate using `gnutls_free()`.

Returns: On success, `GNUTLS_E_SUCCESS` (0) is returned, otherwise a negative error value.

`gnutls_x509_cert_privkey_sign`

```
int gnutls_x509_cert_privkey_sign (gnutls_x509_cert_t cert,           [Function]
                                   gnutls_x509_cert_t issuer, gnutls_privkey_t issuer_key,
                                   gnutls_digest_algorithm_t dig, unsigned int flags)
```

cert: a certificate of type `gnutls_x509_cert_t`

issuer: is the certificate of the certificate issuer

issuer_key: holds the issuer's private key

dig: The message digest to use, `GNUTLS_DIG_SHA1` is a safe choice

flags: must be 0

This function will sign the certificate with the issuer's private key, and will copy the issuer's information into the certificate.

This must be the last step in a certificate generation since all the previously set parameters are now signed.

Returns: On success, `GNUTLS_E_SUCCESS` (0) is returned, otherwise a negative error value.

`gnutls_x509_cert_set_activation_time`

```
int gnutls_x509_cert_set_activation_time (gnutls_x509_cert_t      [Function]
                                           cert, time_t act_time)
```

cert: a certificate of type `gnutls_x509_cert_t`

act_time: The actual time

This function will set the time this Certificate was or will be activated.

Returns: On success, `GNUTLS_E_SUCCESS` (0) is returned, otherwise a negative error value.

`gnutls_x509_cert_set_authority_key_id`

```
int gnutls_x509_cert_set_authority_key_id (gnutls_x509_cert_t    [Function]
                                             cert, const void * id, size_t id_size)
```

cert: a certificate of type `gnutls_x509_cert_t`

id: The key ID

id_size: Holds the size of the serial field.

This function will set the X.509 certificate's authority key ID extension. Only the `keyIdentifier` field can be set with this function.

Returns: On success, GNUTLS_E_SUCCESS (0) is returned, otherwise a negative error value.

gnutls_x509_cert_set_basic_constraints

```
int gnutls_x509_cert_set_basic_constraints (gnutls_x509_cert_t      [Function]
      crt, unsigned int ca, int pathLenConstraint)
```

crt: a certificate of type `gnutls_x509_cert_t`

ca: true(1) or false(0). Depending on the Certificate authority status.

pathLenConstraint: non-negative error codes indicate maximum length of path, and negative error codes indicate that the pathLenConstraints field should not be present.

This function will set the basicConstraints certificate extension.

Returns: On success, GNUTLS_E_SUCCESS (0) is returned, otherwise a negative error value.

gnutls_x509_cert_set_ca_status

```
int gnutls_x509_cert_set_ca_status (gnutls_x509_cert_t crt,      [Function]
      unsigned int ca)
```

crt: a certificate of type `gnutls_x509_cert_t`

ca: true(1) or false(0). Depending on the Certificate authority status.

This function will set the basicConstraints certificate extension. Use `gnutls_x509_cert_set_basic_constraints()` if you want to control the pathLenConstraint field too.

Returns: On success, GNUTLS_E_SUCCESS (0) is returned, otherwise a negative error value.

gnutls_x509_cert_set_crl_dist_points2

```
int gnutls_x509_cert_set_crl_dist_points2 (gnutls_x509_cert_t      [Function]
      crt, gnutls_x509_subject_alt_name_t type, const void * data, unsigned int
      data_size, unsigned int reason_flags)
```

crt: a certificate of type `gnutls_x509_cert_t`

type: is one of the `gnutls_x509_subject_alt_name_t` enumerations

data: The data to be set

data_size: The data size

reason_flags: revocation reasons

This function will set the CRL distribution points certificate extension.

Returns: On success, GNUTLS_E_SUCCESS (0) is returned, otherwise a negative error value.

Since: 2.6.0

gnutls_x509_cert_set_crl_dist_points

```
int gnutls_x509_cert_set_crl_dist_points (gnutls_x509_cert_t crt, [Function]
    gnutls_x509_subject_alt_name_t type, const void * data_string, unsigned
    int reason_flags)
```

crt: a certificate of type `gnutls_x509_cert_t`

type: is one of the `gnutls_x509_subject_alt_name_t` enumerations

data_string: The data to be set

reason_flags: revocation reasons

This function will set the CRL distribution points certificate extension.

Returns: On success, `GNUTLS_E_SUCCESS` (0) is returned, otherwise a negative error value.

gnutls_x509_cert_set_crq_extensions

```
int gnutls_x509_cert_set_crq_extensions (gnutls_x509_cert_t crt, [Function]
    gnutls_x509_crq_t crq)
```

crt: a certificate of type `gnutls_x509_cert_t`

crq: holds a certificate request

This function will set extensions from the given request to the certificate.

Returns: On success, `GNUTLS_E_SUCCESS` (0) is returned, otherwise a negative error value.

Since: 2.8.0

gnutls_x509_cert_set_crq

```
int gnutls_x509_cert_set_crq (gnutls_x509_cert_t crt, [Function]
    gnutls_x509_crq_t crq)
```

crt: a certificate of type `gnutls_x509_cert_t`

crq: holds a certificate request

This function will set the name and public parameters as well as the extensions from the given certificate request to the certificate. Only RSA keys are currently supported.

Returns: On success, `GNUTLS_E_SUCCESS` (0) is returned, otherwise a negative error value.

gnutls_x509_cert_set_dn_by_oid

```
int gnutls_x509_cert_set_dn_by_oid (gnutls_x509_cert_t crt, const [Function]
    char * oid, unsigned int raw_flag, const void * name, unsigned int
    sizeof_name)
```

crt: a certificate of type `gnutls_x509_cert_t`

oid: holds an Object Identifier in a null terminated string

raw_flag: must be 0, or 1 if the data are DER encoded

name: a pointer to the name

sizeof_name: holds the size of `name`

This function will set the part of the name of the Certificate subject, specified by the given OID. The input string should be ASCII or UTF-8 encoded.

Some helper macros with popular OIDs can be found in `gnutls/x509.h`. With this function you can only set the known OIDs. You can test for known OIDs using `gnutls_x509_dn_oid_known()`. For OIDs that are not known (by gnutls) you should properly DER encode your data, and call this function with `raw_flag` set.

Returns: On success, `GNUTLS_E_SUCCESS` (0) is returned, otherwise a negative error value.

`gnutls_x509_cert_set_expiration_time`

```
int gnutls_x509_cert_set_expiration_time (gnutls_x509_cert_t      [Function]
    cert, time_t exp_time)
```

cert: a certificate of type `gnutls_x509_cert_t`

exp_time: The actual time

This function will set the time this Certificate will expire.

Returns: On success, `GNUTLS_E_SUCCESS` (0) is returned, otherwise a negative error value.

`gnutls_x509_cert_set_extension_by_oid`

```
int gnutls_x509_cert_set_extension_by_oid (gnutls_x509_cert_t  [Function]
    cert, const char * oid, const void * buf, size_t sizeof_buf, unsigned int
    critical)
```

cert: a certificate of type `gnutls_x509_cert_t`

oid: holds an Object Identified in null terminated string

buf: a pointer to a DER encoded data

sizeof_buf: holds the size of *buf*

critical: should be non (0) if the extension is to be marked as critical

This function will set an the extension, by the specified OID, in the certificate. The extension data should be binary data DER encoded.

Returns: On success, `GNUTLS_E_SUCCESS` (0) is returned, otherwise a negative error value.

`gnutls_x509_cert_set_issuer_dn_by_oid`

```
int gnutls_x509_cert_set_issuer_dn_by_oid (gnutls_x509_cert_t  [Function]
    cert, const char * oid, unsigned int raw_flag, const void * name, unsigned
    int sizeof_name)
```

cert: a certificate of type `gnutls_x509_cert_t`

oid: holds an Object Identifier in a null terminated string

raw_flag: must be 0, or 1 if the data are DER encoded

name: a pointer to the name

sizeof_name: holds the size of *name*

This function will set the part of the name of the Certificate issuer, specified by the given OID. The input string should be ASCII or UTF-8 encoded.

Some helper macros with popular OIDs can be found in `gnutls/x509.h`. With this function you can only set the known OIDs. You can test for known OIDs using `gnutls_x509_dn_oid_known()`. For OIDs that are not known (by gnutls) you should properly DER encode your data, and call this function with `raw_flag` set.

Normally you do not need to call this function, since the signing operation will copy the signer's name as the issuer of the certificate.

Returns: On success, `GNUTLS_E_SUCCESS (0)` is returned, otherwise a negative error value.

`gnutls_x509_cert_set_key_purpose_oid`

```
int gnutls_x509_cert_set_key_purpose_oid (gnutls_x509_cert_t cert, const void * oid, unsigned int critical) [Function]
```

cert: a certificate of type `gnutls_x509_cert_t`

oid: a pointer to a null terminated string that holds the OID

critical: Whether this extension will be critical or not

This function will set the key purpose OIDs of the Certificate. These are stored in the Extended Key Usage extension (2.5.29.37) See the `GNUTLS_KP_*` definitions for human readable names.

Subsequent calls to this function will append OIDs to the OID list.

Returns: On success, `GNUTLS_E_SUCCESS (0)` is returned, otherwise a negative error code is returned.

`gnutls_x509_cert_set_key_usage`

```
int gnutls_x509_cert_set_key_usage (gnutls_x509_cert_t cert, unsigned int usage) [Function]
```

cert: a certificate of type `gnutls_x509_cert_t`

usage: an ORed sequence of the `GNUTLS_KEY_*` elements.

This function will set the keyUsage certificate extension.

Returns: On success, `GNUTLS_E_SUCCESS (0)` is returned, otherwise a negative error value.

`gnutls_x509_cert_set_key`

```
int gnutls_x509_cert_set_key (gnutls_x509_cert_t cert, gnutls_x509_privkey_t key) [Function]
```

cert: a certificate of type `gnutls_x509_cert_t`

key: holds a private key

This function will set the public parameters from the given private key to the certificate. Only RSA keys are currently supported.

Returns: On success, `GNUTLS_E_SUCCESS (0)` is returned, otherwise a negative error value.

gnutls_x509_cert_set_proxy_dn

```
int gnutls_x509_cert_set_proxy_dn (gnutls_x509_cert_t crt, [Function]
    gnutls_x509_cert_t eecrt, unsigned int raw_flag, const void * name, unsigned
    int sizeof_name)
```

crt: a gnutls_x509_cert_t structure with the new proxy cert

eecrt: the end entity certificate that will be issuing the proxy

raw_flag: must be 0, or 1 if the CN is DER encoded

name: a pointer to the CN name, may be NULL (but MUST then be added later)

sizeof_name: holds the size of *name*

This function will set the subject in *crt* to the end entity's *eecrt* subject name, and add a single Common Name component *name* of size *sizeof_name*. This corresponds to the required proxy certificate naming style. Note that if *name* is NULL, you MUST set it later by using `gnutls_x509_cert_set_dn_by_oid()` or similar.

Returns: On success, GNUTLS_E_SUCCESS (0) is returned, otherwise a negative error value.

gnutls_x509_cert_set_proxy

```
int gnutls_x509_cert_set_proxy (gnutls_x509_cert_t crt, int [Function]
    pathLenConstraint, const char * policyLanguage, const char * policy,
    size_t sizeof_policy)
```

crt: a certificate of type gnutls_x509_cert_t

pathLenConstraint: non-negative error codes indicate maximum length of path, and negative error codes indicate that the pathLenConstraints field should not be present.

policyLanguage: OID describing the language of *policy*.

policy: opaque byte array with policy language, can be NULL

sizeof_policy: size of *policy*.

This function will set the proxyCertInfo extension.

Returns: On success, GNUTLS_E_SUCCESS (0) is returned, otherwise a negative error value.

gnutls_x509_cert_set_serial

```
int gnutls_x509_cert_set_serial (gnutls_x509_cert_t cert, const void [Function]
    * serial, size_t serial_size)
```

cert: a certificate of type gnutls_x509_cert_t

serial: The serial number

serial_size: Holds the size of the serial field.

This function will set the X.509 certificate's serial number. Serial is not always a 32 or 64bit number. Some CAs use large serial numbers, thus it may be wise to handle it as something opaque.

Returns: On success, GNUTLS_E_SUCCESS (0) is returned, otherwise a negative error value.

gnutls_x509_cert_set_subject_alt_name

```
int gnutls_x509_cert_set_subject_alt_name (gnutls_x509_cert_t cert,
                                           gnutls_x509_subject_alt_name_t type,
                                           const void * data, unsigned int
                                           data_size, unsigned int flags)
```

[Function]

cert: a certificate of type `gnutls_x509_cert_t`

type: is one of the `gnutls_x509_subject_alt_name_t` enumerations

data: The data to be set

data_size: The size of data to be set

flags: `GNUTLS_FSAN_SET` to clear previous data or `GNUTLS_FSAN_APPEND` to append.

This function will set the subject alternative name certificate extension. It can set the following types:

Returns: On success, `GNUTLS_E_SUCCESS` (0) is returned, otherwise a negative error value.

Since: 2.6.0

gnutls_x509_cert_set_subject_alternative_name

```
int gnutls_x509_cert_set_subject_alternative_name (gnutls_x509_cert_t cert,
                                                    gnutls_x509_subject_alt_name_t type,
                                                    const char * data_string)
```

[Function]

cert: a certificate of type `gnutls_x509_cert_t`

type: is one of the `gnutls_x509_subject_alt_name_t` enumerations

data_string: The data to be set, a (0) terminated string

This function will set the subject alternative name certificate extension. This function assumes that data can be expressed as a null terminated string.

The name of the function is unfortunate since it is inconsistent with `gnutls_x509_cert_get_subject_alt_name()`.

Returns: On success, `GNUTLS_E_SUCCESS` (0) is returned, otherwise a negative error value.

gnutls_x509_cert_set_subject_key_id

```
int gnutls_x509_cert_set_subject_key_id (gnutls_x509_cert_t cert,
                                           const void * id, size_t id_size)
```

[Function]

cert: a certificate of type `gnutls_x509_cert_t`

id: The key ID

id_size: Holds the size of the serial field.

This function will set the X.509 certificate's subject key ID extension.

Returns: On success, `GNUTLS_E_SUCCESS` (0) is returned, otherwise a negative error value.

gnutls_x509_cert_set_version

```
int gnutls_x509_cert_set_version (gnutls_x509_cert_t crt, unsigned [Function]
    int version)
```

crt: a certificate of type `gnutls_x509_cert_t`

version: holds the version number. For X.509v1 certificates must be 1.

This function will set the version of the certificate. This must be one for X.509 version 1, and so on. Plain certificates without extensions must have version set to one.

To create well-formed certificates, you must specify version 3 if you use any certificate extensions. Extensions are created by functions such as `gnutls_x509_cert_set_subject_alt_name()` or `gnutls_x509_cert_set_key_usage()`.

Returns: On success, `GNUTLS_E_SUCCESS (0)` is returned, otherwise a negative error value.

gnutls_x509_cert_sign2

```
int gnutls_x509_cert_sign2 (gnutls_x509_cert_t crt, gnutls_x509_cert_t [Function]
    issuer, gnutls_x509_privkey_t issuer_key, gnutls_digest_algorithm_t dig,
    unsigned int flags)
```

crt: a certificate of type `gnutls_x509_cert_t`

issuer: is the certificate of the certificate issuer

issuer_key: holds the issuer's private key

dig: The message digest to use, `GNUTLS_DIG_SHA1` is a safe choice

flags: must be 0

This function will sign the certificate with the issuer's private key, and will copy the issuer's information into the certificate.

This must be the last step in a certificate generation since all the previously set parameters are now signed.

Returns: On success, `GNUTLS_E_SUCCESS (0)` is returned, otherwise a negative error value.

gnutls_x509_cert_sign

```
int gnutls_x509_cert_sign (gnutls_x509_cert_t crt, gnutls_x509_cert_t [Function]
    issuer, gnutls_x509_privkey_t issuer_key)
```

crt: a certificate of type `gnutls_x509_cert_t`

issuer: is the certificate of the certificate issuer

issuer_key: holds the issuer's private key

This function is the same as `gnutls_x509_cert_sign2()` with no flags, and SHA1 as the hash algorithm.

Returns: On success, `GNUTLS_E_SUCCESS (0)` is returned, otherwise a negative error value.

gnutls_x509_cert_verify_data

```
int gnutls_x509_cert_verify_data (gnutls_x509_cert_t cert, unsigned [Function]
    int flags, const gnutls_datum_t * data, const gnutls_datum_t * signature)
```

cert: Holds the certificate

flags: should be 0 for now

data: holds the data to be signed

signature: contains the signature

This function will verify the given signed data, using the parameters from the certificate.

Deprecated. Please use `gnutls_pubkey_verify_data()`.

Returns: In case of a verification failure `GNUTLS_E_PK_SIG_VERIFY_FAILED` is returned, and a positive code on success.

gnutls_x509_cert_verify_hash

```
int gnutls_x509_cert_verify_hash (gnutls_x509_cert_t cert, unsigned [Function]
    int flags, const gnutls_datum_t * hash, const gnutls_datum_t * signature)
```

cert: Holds the certificate

flags: should be 0 for now

hash: holds the hash digest to be verified

signature: contains the signature

This function will verify the given signed digest, using the parameters from the certificate.

Deprecated. Please use `gnutls_pubkey_verify_data()`.

Returns: In case of a verification failure `GNUTLS_E_PK_SIG_VERIFY_FAILED` is returned, and a positive code on success.

gnutls_x509_cert_verify

```
int gnutls_x509_cert_verify (gnutls_x509_cert_t cert, const [Function]
    gnutls_x509_cert_t * CA_list, int CA_list_length, unsigned int flags,
    unsigned int * verify)
```

cert: is the certificate to be verified

CA_list: is one certificate that is considered to be trusted one

CA_list_length: holds the number of CA certificate in *CA_list*

flags: Flags that may be used to change the verification algorithm. Use OR of the `gnutls_certificate_verify_flags` enumerations.

verify: will hold the certificate verification output.

This function will try to verify the given certificate and return its status.

Returns: On success, `GNUTLS_E_SUCCESS` (0) is returned, otherwise a negative error value.

gnutls_x509_dn_deinit

`void gnutls_x509_dn_deinit (gnutls_x509_dn_t dn)` [Function]

dn: a DN opaque object pointer.

This function deallocates the DN object as returned by `gnutls_x509_dn_import()`.

Since: 2.4.0

gnutls_x509_dn_export

`int gnutls_x509_dn_export (gnutls_x509_dn_t dn, gnutls_x509_cert_fmt_t format, void * output_data, size_t * output_data_size)` [Function]

dn: Holds the opaque DN object

format: the format of output params. One of PEM or DER.

output_data: will contain a DN PEM or DER encoded

output_data_size: holds the size of *output_data* (and will be replaced by the actual size of parameters)

This function will export the DN to DER or PEM format.

If the buffer provided is not long enough to hold the output, then `*output_data_size` is updated and `GNUTLS_E_SHORT_MEMORY_BUFFER` will be returned.

If the structure is PEM encoded, it will have a header of "BEGIN NAME".

Returns: On success, `GNUTLS_E_SUCCESS` (0) is returned, otherwise a negative error value.

gnutls_x509_dn_get_rdn_ava

`int gnutls_x509_dn_get_rdn_ava (gnutls_x509_dn_t dn, int irdn, int iava, gnutls_x509_ava_st * ava)` [Function]

dn: input variable with opaque DN pointer

irdn: index of RDN

iava: index of AVA.

ava: Pointer to structure which will hold output information.

Get pointers to data within the DN.

Note that *ava* will contain pointers into the *dn* structure, so you should not modify any data or deallocate it. Note also that the DN in turn points into the original certificate structure, and thus you may not deallocate the certificate and continue to access *dn*.

Returns: Returns 0 on success, or an error code.

gnutls_x509_dn_import

`int gnutls_x509_dn_import (gnutls_x509_dn_t dn, const gnutls_datum_t * data)` [Function]

dn: the structure that will hold the imported DN

data: should contain a DER encoded RDN sequence

This function parses an RDN sequence and stores the result to a `gnutls_x509_dn_t` structure. The structure must have been initialized with `gnutls_x509_dn_init()`. You may use `gnutls_x509_dn_get_rdn_ava()` to decode the DN.

Returns: On success, `GNUTLS_E_SUCCESS (0)` is returned, otherwise a negative error value.

Since: 2.4.0

`gnutls_x509_dn_init`

`int gnutls_x509_dn_init (gnutls_x509_dn_t * dn)` [Function]
dn: the object to be initialized

This function initializes a `gnutls_x509_dn_t` structure.

The object returned must be deallocated using `gnutls_x509_dn_deinit()`.

Returns: On success, `GNUTLS_E_SUCCESS (0)` is returned, otherwise a negative error value.

Since: 2.4.0

`gnutls_x509_dn_oid_known`

`int gnutls_x509_dn_oid_known (const char * oid)` [Function]
oid: holds an Object Identifier in a null terminated string

This function will inform about known DN OIDs. This is useful since functions like `gnutls_x509_cert_set_dn_by_oid()` use the information on known OIDs to properly encode their input. Object Identifiers that are not known are not encoded by these functions, and their input is stored directly into the ASN.1 structure. In that case of unknown OIDs, you have the responsibility of DER encoding your data.

Returns: 1 on known OIDs and 0 otherwise.

`gnutls_x509_privkey_cpy`

`int gnutls_x509_privkey_cpy (gnutls_x509_privkey_t dst,` [Function]
 `gnutls_x509_privkey_t src)`

dst: The destination key, which should be initialized.

src: The source key

This function will copy a private key from source to destination key. Destination has to be initialized.

Returns: On success, `GNUTLS_E_SUCCESS (0)` is returned, otherwise a negative error value.

`gnutls_x509_privkey_deinit`

`void gnutls_x509_privkey_deinit (gnutls_x509_privkey_t key)` [Function]
key: The structure to be deinitialized

This function will deinitialize a private key structure.

gnutls_x509_privkey_export_dsa_raw

```
int gnutls_x509_privkey_export_dsa_raw (gnutls_x509_privkey_t      [Function]
    key, gnutls_datum_t * p, gnutls_datum_t * q, gnutls_datum_t * g,
    gnutls_datum_t * y, gnutls_datum_t * x)
```

key: a structure that holds the DSA parameters

p: will hold the p

q: will hold the q

g: will hold the g

y: will hold the y

x: will hold the x

This function will export the DSA private key's parameters found in the given structure. The new parameters will be allocated using `gnutls_malloc()` and will be stored in the appropriate datum.

Returns: On success, GNUTLS_E_SUCCESS (0) is returned, otherwise a negative error value.

gnutls_x509_privkey_export_ecc_raw

```
int gnutls_x509_privkey_export_ecc_raw (gnutls_x509_privkey_t      [Function]
    key, gnutls_ecc_curve_t * curve, gnutls_datum_t * x, gnutls_datum_t * y,
    gnutls_datum_t * k)
```

key: a structure that holds the rsa parameters

curve: will hold the curve

x: will hold the x coordinate

y: will hold the y coordinate

k: will hold the private key

This function will export the ECC private key's parameters found in the given structure. The new parameters will be allocated using `gnutls_malloc()` and will be stored in the appropriate datum.

Returns: On success, GNUTLS_E_SUCCESS (0) is returned, otherwise a negative error value.

gnutls_x509_privkey_export_pkcs8

```
int gnutls_x509_privkey_export_pkcs8 (gnutls_x509_privkey_t      [Function]
    key, gnutls_x509_crt_fmt_t format, const char * password, unsigned int
    flags, void * output_data, size_t * output_data_size)
```

key: Holds the key

format: the format of output params. One of PEM or DER.

password: the password that will be used to encrypt the key.

flags: an ORed sequence of `gnutls_pkcs_encrypt_flags_t`

output_data: will contain a private key PEM or DER encoded

output_data_size: holds the size of *output_data* (and will be replaced by the actual size of parameters)

This function will export the private key to a PKCS8 structure. Both RSA and DSA keys can be exported. For DSA keys we use PKCS 11 definitions. If the flags do not specify the encryption cipher, then the default 3DES (PBES2) will be used.

The *password* can be either ASCII or UTF-8 in the default PBES2 encryption schemas, or ASCII for the PKCS12 schemas.

If the buffer provided is not long enough to hold the output, then **output_data_size* is updated and `GNUTLS_E_SHORT_MEMORY_BUFFER` will be returned.

If the structure is PEM encoded, it will have a header of "BEGIN ENCRYPTED PRIVATE KEY" or "BEGIN PRIVATE KEY" if encryption is not used.

Return value: In case of failure a negative error code will be returned, and 0 on success.

`gnutls_x509_privkey_export_rsa_raw2`

```
int gnutls_x509_privkey_export_rsa_raw2 (gnutls_x509_privkey_t [Function]
    key, gnutls_datum_t * m, gnutls_datum_t * e, gnutls_datum_t * d,
    gnutls_datum_t * p, gnutls_datum_t * q, gnutls_datum_t * u, gnutls_datum_t
    * e1, gnutls_datum_t * e2)
```

key: a structure that holds the rsa parameters

m: will hold the modulus

e: will hold the public exponent

d: will hold the private exponent

p: will hold the first prime (p)

q: will hold the second prime (q)

u: will hold the coefficient

e1: will hold $e1 = d \bmod (p-1)$

e2: will hold $e2 = d \bmod (q-1)$

This function will export the RSA private key's parameters found in the given structure. The new parameters will be allocated using `gnutls_malloc()` and will be stored in the appropriate datum.

Returns: On success, `GNUTLS_E_SUCCESS` (0) is returned, otherwise a negative error value.

`gnutls_x509_privkey_export_rsa_raw`

```
int gnutls_x509_privkey_export_rsa_raw (gnutls_x509_privkey_t [Function]
    key, gnutls_datum_t * m, gnutls_datum_t * e, gnutls_datum_t * d,
    gnutls_datum_t * p, gnutls_datum_t * q, gnutls_datum_t * u)
```

key: a structure that holds the rsa parameters

m: will hold the modulus

e: will hold the public exponent

d: will hold the private exponent

p: will hold the first prime (p)
q: will hold the second prime (q)
u: will hold the coefficient

This function will export the RSA private key's parameters found in the given structure. The new parameters will be allocated using `gnutls_malloc()` and will be stored in the appropriate datum.

Returns: On success, `GNUTLS_E_SUCCESS` (0) is returned, otherwise a negative error value.

gnutls_x509_privkey_export

```
int gnutls_x509_privkey_export (gnutls_x509_privkey_t key,           [Function]
                               gnutls_x509_crt_fmt_t format, void * output_data, size_t *
                               output_data_size)
```

key: Holds the key

format: the format of output params. One of PEM or DER.

output_data: will contain a private key PEM or DER encoded

output_data_size: holds the size of *output_data* (and will be replaced by the actual size of parameters)

This function will export the private key to a PKCS1 structure for RSA keys, or an integer sequence for DSA keys. The DSA keys are in the same format with the parameters used by openssl.

If the buffer provided is not long enough to hold the output, then `*output_data_size` is updated and `GNUTLS_E_SHORT_MEMORY_BUFFER` will be returned.

If the structure is PEM encoded, it will have a header of "BEGIN RSA PRIVATE KEY".

Returns: On success, `GNUTLS_E_SUCCESS` (0) is returned, otherwise a negative error value.

gnutls_x509_privkey_fix

```
int gnutls_x509_privkey_fix (gnutls_x509_privkey_t key)           [Function]
    key: Holds the key
```

This function will recalculate the secondary parameters in a key. In RSA keys, this can be the coefficient and exponent1,2.

Returns: On success, `GNUTLS_E_SUCCESS` (0) is returned, otherwise a negative error value.

gnutls_x509_privkey_generate

```
int gnutls_x509_privkey_generate (gnutls_x509_privkey_t key,     [Function]
                                   gnutls_pk_algorithm_t algo, unsigned int bits, unsigned int flags)
```

key: should contain a `gnutls_x509_privkey_t` structure

algo: is one of RSA or DSA.

bits: the size of the modulus

flags: unused for now. Must be 0.

This function will generate a random private key. Note that this function must be called on an empty private key.

Do not set the number of bits directly, use `gnutls_sec_param_to_pk_bits()`.

Returns: On success, `GNUTLS_E_SUCCESS` (0) is returned, otherwise a negative error value.

`gnutls_x509_privkey_get_key_id`

```
int gnutls_x509_privkey_get_key_id (gnutls_x509_privkey_t key,      [Function]
    unsigned int flags, unsigned char * output_data, size_t *
    output_data_size)
```

key: Holds the key

flags: should be 0 for now

output_data: will contain the key ID

output_data_size: holds the size of *output_data* (and will be replaced by the actual size of parameters)

This function will return a unique ID the depends on the public key parameters. This ID can be used in checking whether a certificate corresponds to the given key.

If the buffer provided is not long enough to hold the output, then **output_data_size* is updated and `GNUTLS_E_SHORT_MEMORY_BUFFER` will be returned. The output will normally be a SHA-1 hash output, which is 20 bytes.

Returns: On success, `GNUTLS_E_SUCCESS` (0) is returned, otherwise a negative error value.

`gnutls_x509_privkey_get_pk_algorithm`

```
int gnutls_x509_privkey_get_pk_algorithm (gnutls_x509_privkey_t [Function]
    key)
```

key: should contain a `gnutls_x509_privkey_t` structure

This function will return the public key algorithm of a private key.

Returns: a member of the `gnutls_pk_algorithm_t` enumeration on success, or a negative error code on error.

`gnutls_x509_privkey_import_dsa_raw`

```
int gnutls_x509_privkey_import_dsa_raw (gnutls_x509_privkey_t [Function]
    key, const gnutls_datum_t * p, const gnutls_datum_t * q, const
    gnutls_datum_t * g, const gnutls_datum_t * y, const gnutls_datum_t * x)
```

key: The structure to store the parsed key

p: holds the p

q: holds the q

g: holds the g

y: holds the y

x: holds the x

This function will convert the given DSA raw parameters to the native `gnutls_x509_privkey_t` format. The output will be stored in `key`.

Returns: On success, `GNUTLS_E_SUCCESS` (0) is returned, otherwise a negative error value.

`gnutls_x509_privkey_import_ecc_raw`

```
int gnutls_x509_privkey_import_ecc_raw (gnutls_x509_privkey_t      [Function]
    key, gnutls_ecc_curve_t curve, const gnutls_datum_t * x, const
    gnutls_datum_t * y, const gnutls_datum_t * k)
```

`key`: The structure to store the parsed key

`curve`: holds the curve

`x`: holds the x

`y`: holds the y

`k`: holds the k

This function will convert the given DSA raw parameters to the native `gnutls_x509_privkey_t` format. The output will be stored in `key`.

Returns: On success, `GNUTLS_E_SUCCESS` (0) is returned, otherwise a negative error value.

`gnutls_x509_privkey_import_pkcs8`

```
int gnutls_x509_privkey_import_pkcs8 (gnutls_x509_privkey_t      [Function]
    key, const gnutls_datum_t * data, gnutls_x509_crt_fmt_t format, const char
    * password, unsigned int flags)
```

`key`: The structure to store the parsed key

`data`: The DER or PEM encoded key.

`format`: One of DER or PEM

`password`: the password to decrypt the key (if it is encrypted).

`flags`: 0 if encrypted or `GNUTLS_PKCS_PLAIN` if not encrypted.

This function will convert the given DER or PEM encoded PKCS8 2.0 encrypted key to the native `gnutls_x509_privkey_t` format. The output will be stored in `key`. Both RSA and DSA keys can be imported, and flags can only be used to indicate an unencrypted key.

The `password` can be either ASCII or UTF-8 in the default PBES2 encryption schemas, or ASCII for the PKCS12 schemas.

If the Certificate is PEM encoded it should have a header of "ENCRYPTED PRIVATE KEY", or "PRIVATE KEY". You only need to specify the flags if the key is DER encoded, since in that case the encryption status cannot be auto-detected.

Returns: On success, `GNUTLS_E_SUCCESS` (0) is returned, otherwise a negative error value.

gnutls_x509_privkey_import_rsa_raw2

```
int gnutls_x509_privkey_import_rsa_raw2 (gnutls_x509_privkey_t      [Function]
    key, const gnutls_datum_t * m, const gnutls_datum_t * e, const
    gnutls_datum_t * d, const gnutls_datum_t * p, const gnutls_datum_t * q, const
    gnutls_datum_t * u, const gnutls_datum_t * e1, const gnutls_datum_t * e2)
```

key: The structure to store the parsed key

m: holds the modulus

e: holds the public exponent

d: holds the private exponent

p: holds the first prime (p)

q: holds the second prime (q)

u: holds the coefficient

e1: holds $e1 = d \bmod (p-1)$

e2: holds $e2 = d \bmod (q-1)$

This function will convert the given RSA raw parameters to the native `gnutls_x509_privkey_t` format. The output will be stored in *key*.

Returns: On success, GNUTLS_E_SUCCESS (0) is returned, otherwise a negative error value.

gnutls_x509_privkey_import_rsa_raw

```
int gnutls_x509_privkey_import_rsa_raw (gnutls_x509_privkey_t      [Function]
    key, const gnutls_datum_t * m, const gnutls_datum_t * e, const
    gnutls_datum_t * d, const gnutls_datum_t * p, const gnutls_datum_t * q, const
    gnutls_datum_t * u)
```

key: The structure to store the parsed key

m: holds the modulus

e: holds the public exponent

d: holds the private exponent

p: holds the first prime (p)

q: holds the second prime (q)

u: holds the coefficient

This function will convert the given RSA raw parameters to the native `gnutls_x509_privkey_t` format. The output will be stored in *key*.

Returns: On success, GNUTLS_E_SUCCESS (0) is returned, otherwise a negative error value.

gnutls_x509_privkey_import

```
int gnutls_x509_privkey_import (gnutls_x509_privkey_t key, const      [Function]
    gnutls_datum_t * data, gnutls_x509_crt_fmt_t format)
```

key: The structure to store the parsed key

data: The DER or PEM encoded certificate.

format: One of DER or PEM

This function will convert the given DER or PEM encoded key to the native `gnutls_x509_privkey_t` format. The output will be stored in `key`.

If the key is PEM encoded it should have a header of "RSA PRIVATE KEY", or "DSA PRIVATE KEY".

Returns: On success, `GNUTLS_E_SUCCESS` (0) is returned, otherwise a negative error value.

`gnutls_x509_privkey_init`

`int gnutls_x509_privkey_init (gnutls_x509_privkey_t * key)` [Function]

key: The structure to be initialized

This function will initialize an private key structure.

Returns: On success, `GNUTLS_E_SUCCESS` (0) is returned, otherwise a negative error value.

`gnutls_x509_privkey_sec_param`

`gnutls_sec_param_t gnutls_x509_privkey_sec_param (gnutls_x509_privkey_t key)` [Function]

key: a key structure

This function will return the security parameter appropriate with this private key.

Returns: On success, a valid security parameter is returned otherwise `GNUTLS_SEC_PARAM_UNKNOWN` is returned.

`gnutls_x509_privkey_sign_data`

`int gnutls_x509_privkey_sign_data (gnutls_x509_privkey_t key, gnutls_digest_algorithm_t digest, unsigned int flags, const gnutls_datum_t * data, void * signature, size_t * signature_size)` [Function]

key: Holds the key

digest: should be MD5 or SHA1

flags: should be 0 for now

data: holds the data to be signed

signature: will contain the signature

signature_size: holds the size of signature (and will be replaced by the new size)

This function will sign the given data using a signature algorithm supported by the private key. Signature algorithms are always used together with a hash functions. Different hash functions may be used for the RSA algorithm, but only SHA-1 for the DSA keys.

If the buffer provided is not long enough to hold the output, then `*signature_size` is updated and `GNUTLS_E_SHORT_MEMORY_BUFFER` will be returned.

Use `gnutls_x509_crt_get_preferred_hash_algorithm()` to determine the hash algorithm.

Returns: On success, GNUTLS_E_SUCCESS (0) is returned, otherwise a negative error value.

Deprecated: Use `gnutls_privkey_sign_data()`.

gnutls_x509_privkey_sign_hash

```
int gnutls_x509_privkey_sign_hash (gnutls_x509_privkey_t key,      [Function]
                                   const gnutls_datum_t * hash, gnutls_datum_t * signature)
```

key: Holds the key

hash: holds the data to be signed

signature: will contain newly allocated signature

This function will sign the given hash using the private key. Do not use this function directly unless you know what it is. Typical signing requires the data to be hashed and stored in special formats (e.g. BER Digest-Info for RSA).

Returns: On success, GNUTLS_E_SUCCESS (0) is returned, otherwise a negative error value.

Deprecated in: 2.12.0

gnutls_x509_rdn_get_by_oid

```
int gnutls_x509_rdn_get_by_oid (const gnutls_datum_t * idn, const [Function]
                                char * oid, int indx, unsigned int raw_flag, void * buf, size_t *
                                sizeof_buf)
```

idn: should contain a DER encoded RDN sequence

oid: an Object Identifier

indx: In case multiple same OIDs exist in the RDN indicates which to send. Use 0 for the first one.

raw_flag: If non (0) then the raw DER data are returned.

buf: a pointer to a structure to hold the peer's name

sizeof_buf: holds the size of *buf*

This function will return the name of the given Object identifier, of the RDN sequence. The name will be encoded using the rules from RFC2253.

Returns: On success, GNUTLS_E_SUCCESS (0) is returned, or GNUTLS_E_SHORT_MEMORY_BUFFER is returned and **sizeof_buf* is updated if the provided buffer is not long enough, otherwise a negative error value.

gnutls_x509_rdn_get_oid

```
int gnutls_x509_rdn_get_oid (const gnutls_datum_t * idn, int      [Function]
                              indx, void * buf, size_t * sizeof_buf)
```

idn: should contain a DER encoded RDN sequence

indx: Indicates which OID to return. Use 0 for the first one.

buf: a pointer to a structure to hold the peer's name OID

sizeof_buf: holds the size of *buf*

This function will return the specified Object identifier, of the RDN sequence.

Returns: On success, GNUTLS_E_SUCCESS (0) is returned, or GNUTLS_E_SHORT_MEMORY_BUFFER is returned and **sizeof_buf* is updated if the provided buffer is not long enough, otherwise a negative error value.

Since: 2.4.0

gnutls_x509_rdn_get

```
int gnutls_x509_rdn_get (const gnutls_datum_t * idn, char * buf,      [Function]
                       size_t * sizeof_buf)
```

idn: should contain a DER encoded RDN sequence

buf: a pointer to a structure to hold the peer's name

sizeof_buf: holds the size of *buf*

This function will return the name of the given RDN sequence. The name will be in the form "C=xxxx,O=yyyy,CN=zzzz" as described in RFC2253.

Returns: On success, GNUTLS_E_SUCCESS (0) is returned, or GNUTLS_E_SHORT_MEMORY_BUFFER is returned and **sizeof_buf* is updated if the provided buffer is not long enough, otherwise a negative error value.

gnutls_x509_trust_list_add_cas

```
int gnutls_x509_trust_list_add_cas (gnutls_x509_trust_list_t      [Function]
                                     list, const gnutls_x509_cert_t * clist, int clist_size, unsigned int flags)
```

list: The structure of the list

clist: A list of CAs

clist_size: The length of the CA list

flags: should be 0.

This function will add the given certificate authorities to the trusted list. The list of CAs must not be deinitialized during this structure's lifetime.

Returns: The number of added elements is returned.

gnutls_x509_trust_list_add_crls

```
int gnutls_x509_trust_list_add_crls (gnutls_x509_trust_list_t      [Function]
                                       list, const gnutls_x509_crl_t * crl_list, int crl_size, unsigned int
                                       flags, unsigned int verification_flags)
```

list: The structure of the list

crl_list: A list of CRLs

crl_size: The length of the CRL list

flags: if GNUTLS_TL_VERIFY_CRL is given the CRLs will be verified before being added.

verification_flags: *gnutls_certificate_verify_flags* if *flags* specifies GNUTLS_TL_VERIFY_CRL

This function will add the given certificate revocation lists to the trusted list. The list of CRLs must not be deinitialized during this structure's lifetime.

This function must be called after `gnutls_x509_trust_list_add_cas()` to allow verifying the CRLs for validity.

Returns: The number of added elements is returned.

`gnutls_x509_trust_list_add_named_cert`

```
int gnutls_x509_trust_list_add_named_cert (Function]
    (gnutls_x509_trust_list_t list, gnutls_x509_cert_t cert, const void* name,
     size_t name_size, unsigned int flags)
```

list: The structure of the list

cert: A certificate

name: An identifier for the certificate

name_size: The size of the identifier

flags: should be 0.

This function will add the given certificate to the trusted list and associate it with a name. The certificate will not be used for verification with `gnutls_x509_trust_list_verify_cert()` but only with `gnutls_x509_trust_list_verify_named_cert()`.

In principle this function can be used to set individual "server" certificates that are trusted by the user for that specific server but for no other purposes.

The certificate must not be deinitialized during the lifetime of the trusted list.

Returns: On success, `GNUTLS_E_SUCCESS` (0) is returned, otherwise a negative error value.

`gnutls_x509_trust_list_deinit`

```
void gnutls_x509_trust_list_deinit (gnutls_x509_trust_list_t list, unsigned int all) [Function]
```

list: The structure to be deinitialized

all: if non-(0) it will deinitialize all the certificates and CRLs contained in the structure.

This function will deinitialize a trust list.

`gnutls_x509_trust_list_get_issuer`

```
int gnutls_x509_trust_list_get_issuer (gnutls_x509_trust_list_t list, gnutls_x509_cert_t cert, gnutls_x509_cert_t* issuer, unsigned int flags) [Function]
```

list: The structure of the list

cert: is the certificate to find issuer for

issuer: Will hold the issuer if any. Should be treated as constant.

flags: Use (0).

This function will attempt to find the issuer of the given certificate.

Returns: On success, `GNUTLS_E_SUCCESS` (0) is returned, otherwise a negative error value.

gnutls_x509_trust_list_init

```
int gnutls_x509_trust_list_init (gnutls_x509_trust_list_t * list,      [Function]
                               unsigned int size)
```

list: The structure to be initialized

size: The size of the internal hash table. Use (0) for default size.

This function will initialize an X.509 trust list structure.

Returns: On success, GNUTLS_E_SUCCESS (0) is returned, otherwise a negative error value.

gnutls_x509_trust_list_verify_cert

```
int gnutls_x509_trust_list_verify_cert (gnutls_x509_trust_list_t      [Function]
                                         list, gnutls_x509_cert_t * cert_list, unsigned int cert_list_size,
                                         unsigned int flags, unsigned int * verify, gnutls_verify_output_function
                                         func)
```

list: The structure of the list

cert_list: is the certificate list to be verified

cert_list_size: is the certificate list size

flags: Flags that may be used to change the verification algorithm. Use OR of the gnutls_certificate_verify_flags enumerations.

verify: will hold the certificate verification output.

func: If non-null will be called on each chain element verification with the output.

This function will try to verify the given certificate and return its status.

Returns: On success, GNUTLS_E_SUCCESS (0) is returned, otherwise a negative error value.

gnutls_x509_trust_list_verify_named_cert

```
int gnutls_x509_trust_list_verify_named_cert (gnutls_x509_trust_list_t [Function]
                                               list, gnutls_x509_cert_t cert, const void * name,
                                               size_t name_size, unsigned int flags, unsigned int * verify,
                                               gnutls_verify_output_function func)
```

list: The structure of the list

cert: is the certificate to be verified

name: is the certificate's name

name_size: is the certificate's name size

flags: Flags that may be used to change the verification algorithm. Use OR of the gnutls_certificate_verify_flags enumerations.

verify: will hold the certificate verification output.

func: If non-null will be called on each chain element verification with the output.

This function will try to find a matching named certificate. If a match is found the certificate is considered valid. In addition to that this function will also check CRLs.

Returns: On success, GNUTLS_E_SUCCESS (0) is returned, otherwise a negative error value.

C.3 GnuTLS-extra Functions

These functions are only available in the GPLv3+ version of the library called `gnutls-extra`. The prototypes for this library lie in `'gnutls/extra.h'`.

`gnutls_extra_check_version`

`const char * gnutls_extra_check_version (const char * req_version)` [Function]

req_version: version string to compare with, or NULL.

Check GnuTLS Extra Library version.

See `GNUTLS_EXTRA_VERSION` for a suitable *req_version* string.

Return value: Check that the version of the library is at minimum the one given as a string in *req_version* and return the actual version string of the library; return NULL if the condition is not met. If NULL is passed to this function no check is done and only the version string is returned.

`gnutls_global_init_extra`

`int gnutls_global_init_extra (void)` [Function]

This function initializes the global state of gnutls-extra library to defaults.

Note that `gnutls_global_init()` has to be called before this function. If this function is not called then the gnutls-extra library will not be usable.

This function is not thread safe, see the discussion for `gnutls_global_init()` on how to deal with that.

Returns: On success, `GNUTLS_E_SUCCESS` (zero) is returned, otherwise an error code is returned.

C.4 OpenPGP Functions

The following functions are to be used for OpenPGP certificate handling. Their prototypes lie in `'gnutls/openpgp.h'`.

`gnutls_certificate_set_openpgp_key_file2`

`int gnutls_certificate_set_openpgp_key_file2 (gnutls_certificate_credentials_t res, const char * certfile, const char * keyfile, const char * subkey_id, gnutls_openpgp_cert_fmt_t format)` [Function]

res: the destination context to save the data.

certfile: the file that contains the public key.

keyfile: the file that contains the secret key.

subkey_id: a hex encoded subkey id

format: the format of the keys

This function is used to load OpenPGP keys into the GnuTLS credential structure. The file should contain at least one valid non encrypted subkey.

The special keyword "auto" is also accepted as *subkey_id*. In that case the `gnutls_openpgp_cert_get_auth_subkey()` will be used to retrieve the subkey.

Returns: On success, GNUTLS_E_SUCCESS (0) is returned, otherwise a negative error value.

Since: 2.4.0

gnutls_certificate_set_openpgp_key_file

```
int gnutls_certificate_set_openpgp_key_file           [Function]
    (gnutls_certificate_credentials_t res, const char * certfile, const char *
    keyfile, gnutls_openpgp_cert_fmt_t format)
```

res: the destination context to save the data.

certfile: the file that contains the public key.

keyfile: the file that contains the secret key.

format: the format of the keys

This function is used to load OpenPGP keys into the GnuTLS credentials structure. The file should contain at least one valid non encrypted subkey.

Returns: On success, GNUTLS_E_SUCCESS (0) is returned, otherwise a negative error value.

gnutls_certificate_set_openpgp_key_mem2

```
int gnutls_certificate_set_openpgp_key_mem2         [Function]
    (gnutls_certificate_credentials_t res, const gnutls_datum_t * cert, const
    gnutls_datum_t * key, const char * subkey_id, gnutls_openpgp_cert_fmt_t
    format)
```

res: the destination context to save the data.

cert: the datum that contains the public key.

key: the datum that contains the secret key.

subkey_id: a hex encoded subkey id

format: the format of the keys

This function is used to load OpenPGP keys into the GnuTLS credentials structure. The datum should contain at least one valid non encrypted subkey.

The special keyword "auto" is also accepted as *subkey_id*. In that case the `gnutls_openpgp_cert_get_auth_subkey()` will be used to retrieve the subkey.

Returns: On success, GNUTLS_E_SUCCESS (0) is returned, otherwise a negative error value.

Since: 2.4.0

gnutls_certificate_set_openpgp_key_mem

```
int gnutls_certificate_set_openpgp_key_mem         [Function]
    (gnutls_certificate_credentials_t res, const gnutls_datum_t * cert, const
    gnutls_datum_t * key, gnutls_openpgp_cert_fmt_t format)
```

res: the destination context to save the data.

cert: the datum that contains the public key.

key: the datum that contains the secret key.

format: the format of the keys

This function is used to load OpenPGP keys into the GnuTLS credential structure. The datum should contain at least one valid non encrypted subkey.

Returns: On success, GNUTLS_E_SUCCESS (0) is returned, otherwise a negative error value.

gnutls_certificate_set_openpgp_keyring_file

```
int gnutls_certificate_set_openpgp_keyring_file           [Function]
    (gnutls_certificate_credentials_t c, const char * file,
     gnutls_openpgp_cert_fmt_t format)
```

c: A certificate credentials structure

file: filename of the keyring.

format: format of keyring.

The function is used to set keyrings that will be used internally by various OpenPGP functions. For example to find a key when it is needed for an operations. The keyring will also be used at the verification functions.

Returns: On success, GNUTLS_E_SUCCESS (0) is returned, otherwise a negative error value.

gnutls_certificate_set_openpgp_keyring_mem

```
int gnutls_certificate_set_openpgp_keyring_mem           [Function]
    (gnutls_certificate_credentials_t c, const opaque * data, size_t dlen,
     gnutls_openpgp_cert_fmt_t format)
```

c: A certificate credentials structure

data: buffer with keyring data.

dlen: length of data buffer.

format: the format of the keyring

The function is used to set keyrings that will be used internally by various OpenPGP functions. For example to find a key when it is needed for an operations. The keyring will also be used at the verification functions.

Returns: On success, GNUTLS_E_SUCCESS (0) is returned, otherwise a negative error value.

gnutls_certificate_set_openpgp_key

```
int gnutls_certificate_set_openpgp_key                   [Function]
    (gnutls_certificate_credentials_t res, gnutls_openpgp_cert_t crt,
     gnutls_openpgp_privkey_t pkey)
```

res: is a `gnutls_certificate_credentials_t` structure.

crt: contains an openpgp public key

pkey: is an openpgp private key

This function sets a certificate/private key pair in the `gnutls_certificate_credentials_t` structure. This function may be called more than once (in case multiple keys/certificates exist for the server).

Note that this function requires that the preferred key ids have been set and be used. See `gnutls_openpgp_cert_set_preferred_key_id()`. Otherwise the master key will be used.

Returns: On success, `GNUTLS_E_SUCCESS` (0) is returned, otherwise a negative error code is returned.

gnutls_openpgp_cert_check_hostname

`int gnutls_openpgp_cert_check_hostname (gnutls_openpgp_cert_t key, const char * hostname)` [Function]

key: should contain a `gnutls_openpgp_cert_t` structure

hostname: A null terminated string that contains a DNS name

This function will check if the given key's owner matches the given hostname. This is a basic implementation of the matching described in RFC2818 (HTTPS), which takes into account wildcards.

Returns: `GNUTLS_E_SUCCESS` on success, or an error code.

gnutls_openpgp_cert_deinit

`void gnutls_openpgp_cert_deinit (gnutls_openpgp_cert_t key)` [Function]

key: The structure to be initialized

This function will deinitialize a key structure.

gnutls_openpgp_cert_export

`int gnutls_openpgp_cert_export (gnutls_openpgp_cert_t key, gnutls_openpgp_cert_fmt_t format, void * output_data, size_t * output_data_size)` [Function]

key: Holds the key.

format: One of `gnutls_openpgp_cert_fmt_t` elements.

output_data: will contain the key base64 encoded or raw

output_data_size: holds the size of *output_data* (and will be replaced by the actual size of parameters)

This function will convert the given key to RAW or Base64 format. If the buffer provided is not long enough to hold the output, then `GNUTLS_E_SHORT_MEMORY_BUFFER` will be returned.

Returns: `GNUTLS_E_SUCCESS` on success, or an error code.

gnutls_openpgp_cert_get_auth_subkey

`int gnutls_openpgp_cert_get_auth_subkey (gnutls_openpgp_cert_t crt, gnutls_openpgp_keyid_t keyid, unsigned int flag)` [Function]

crt: the structure that contains the OpenPGP public key.

keyid: the struct to save the keyid.

flag: Non (0) indicates that a valid subkey is always returned.

Returns the 64-bit keyID of the first valid OpenPGP subkey marked for authentication. If flag is non (0) and no authentication subkey exists, then a valid subkey will be returned even if it is not marked for authentication. Returns the 64-bit keyID of the first valid OpenPGP subkey marked for authentication. If flag is non (0) and no authentication subkey exists, then a valid subkey will be returned even if it is not marked for authentication.

Returns: GNUTLS_E_SUCCESS on success, or an error code.

gnutls_openpgp_cert_get_creation_time

`time_t gnutls_openpgp_cert_get_creation_time` [Function]
 (*gnutls_openpgp_cert_t key*)

key: the structure that contains the OpenPGP public key.

Get key creation time.

Returns: the timestamp when the OpenPGP key was created.

gnutls_openpgp_cert_get_expiration_time

`time_t gnutls_openpgp_cert_get_expiration_time` [Function]
 (*gnutls_openpgp_cert_t key*)

key: the structure that contains the OpenPGP public key.

Get key expiration time. A value of '0' means that the key doesn't expire at all.

Returns: the time when the OpenPGP key expires.

gnutls_openpgp_cert_get_fingerprint

`int gnutls_openpgp_cert_get_fingerprint` (*gnutls_openpgp_cert_t* [Function]
 key, *void * fpr*, *size_t * fprlen*)

key: the raw data that contains the OpenPGP public key.

fpr: the buffer to save the fingerprint, must hold at least 20 bytes.

fprlen: the integer to save the length of the fingerprint.

Get key fingerprint. Depending on the algorithm, the fingerprint can be 16 or 20 bytes.

Returns: On success, 0 is returned. Otherwise, an error code.

gnutls_openpgp_cert_get_key_id

`int gnutls_openpgp_cert_get_key_id` (*gnutls_openpgp_cert_t key*, [Function]
 gnutls_openpgp_keyid_t keyid)

key: the structure that contains the OpenPGP public key.

keyid: the buffer to save the keyid.

Get key id string.

Returns: the 64-bit keyID of the OpenPGP key.

Since: 2.4.0

gnutls_openpgp_cert_get_key_usage

```
int gnutls_openpgp_cert_get_key_usage (gnutls_openpgp_cert_t key,      [Function]
                                       unsigned int * key_usage)
```

key: should contain a `gnutls_openpgp_cert_t` structure

key_usage: where the key usage bits will be stored

This function will return certificate's key usage, by checking the key algorithm. The key usage value will ORed values of the: `GNUTLS_KEY_DIGITAL_SIGNATURE`, `GNUTLS_KEY_KEY_ENCIPHERMENT`.

Returns: `GNUTLS_E_SUCCESS` on success, or an error code.

gnutls_openpgp_cert_get_name

```
int gnutls_openpgp_cert_get_name (gnutls_openpgp_cert_t key, int      [Function]
                                   idx, char * buf, size_t * sizeof_buf)
```

key: the structure that contains the OpenPGP public key.

idx: the index of the ID to extract

buf: a pointer to a structure to hold the name, may be `NULL` to only get the `sizeof_buf`.

sizeof_buf: holds the maximum size of *buf*, on return hold the actual/required size of *buf*.

Extracts the userID from the parsed OpenPGP key.

Returns: `GNUTLS_E_SUCCESS` on success, and if the index of the ID does not exist `GNUTLS_E_REQUESTED_DATA_NOT_AVAILABLE`, or an error code.

gnutls_openpgp_cert_get_pk_algorithm

```
gnutls_pk_algorithm_t gnutls_openpgp_cert_get_pk_algorithm      [Function]
(gnutls_openpgp_cert_t key, unsigned int * bits)
```

key: is an OpenPGP key

bits: if *bits* is non null it will hold the size of the parameters' in bits

This function will return the public key algorithm of an OpenPGP certificate.

If *bits* is non null, it should have enough size to hold the parameters size in bits. For RSA the bits returned is the modulus. For DSA the bits returned are of the public exponent.

Returns: a member of the `gnutls_pk_algorithm_t` enumeration on success, or `GNUTLS_PK_UNKNOWN` on error.

gnutls_openpgp_cert_get_pk_dsa_raw

```
int gnutls_openpgp_cert_get_pk_dsa_raw (gnutls_openpgp_cert_t      [Function]
                                          crt, gnutls_datum_t * p, gnutls_datum_t * q, gnutls_datum_t * g,
                                          gnutls_datum_t * y)
```

crt: Holds the certificate

p: will hold the p

q: will hold the *q*
g: will hold the *g*
y: will hold the *y*

This function will export the DSA public key's parameters found in the given certificate. The new parameters will be allocated using `gnutls_malloc()` and will be stored in the appropriate datum.

Returns: GNUTLS_E_SUCCESS on success, otherwise a negative error code.

Since: 2.4.0

`gnutls_openpgp_cert_get_pk_rsa_raw`

```
int gnutls_openpgp_cert_get_pk_rsa_raw (gnutls_openpgp_cert_t      [Function]
    crt, gnutls_datum_t * m, gnutls_datum_t * e)
```

crt: Holds the certificate

m: will hold the modulus

e: will hold the public exponent

This function will export the RSA public key's parameters found in the given structure. The new parameters will be allocated using `gnutls_malloc()` and will be stored in the appropriate datum.

Returns: GNUTLS_E_SUCCESS on success, otherwise a negative error code.

Since: 2.4.0

`gnutls_openpgp_cert_get_preferred_key_id`

```
int gnutls_openpgp_cert_get_preferred_key_id (gnutls_openpgp_cert_t key, gnutls_openpgp_keyid_t keyid) [Function]
```

key: the structure that contains the OpenPGP public key.

keyid: the struct to save the keyid.

Get preferred key id. If it hasn't been set it returns GNUTLS_E_INVALID_REQUEST.

Returns: the 64-bit preferred keyID of the OpenPGP key.

`gnutls_openpgp_cert_get_revoked_status`

```
int gnutls_openpgp_cert_get_revoked_status (gnutls_openpgp_cert_t key) [Function]
```

key: the structure that contains the OpenPGP public key.

Get revocation status of key.

Returns: true (1) if the key has been revoked, or false (0) if it has not.

Since: 2.4.0

gnutls_openpgp_cert_get_subkey_count

`int gnutls_openpgp_cert_get_subkey_count` (*gnutls_openpgp_cert_t* *key*) [Function]

key: is an OpenPGP key

This function will return the number of subkeys present in the given OpenPGP certificate.

Returns: the number of subkeys, or a negative error code on error.

Since: 2.4.0

gnutls_openpgp_cert_get_subkey_creation_time

`time_t gnutls_openpgp_cert_get_subkey_creation_time` (*gnutls_openpgp_cert_t* *key*, *unsigned int* *idx*) [Function]

key: the structure that contains the OpenPGP public key.

idx: the subkey index

Get subkey creation time.

Returns: the timestamp when the OpenPGP sub-key was created.

Since: 2.4.0

gnutls_openpgp_cert_get_subkey_expiration_time

`time_t gnutls_openpgp_cert_get_subkey_expiration_time` (*gnutls_openpgp_cert_t* *key*, *unsigned int* *idx*) [Function]

key: the structure that contains the OpenPGP public key.

idx: the subkey index

Get subkey expiration time. A value of '0' means that the key doesn't expire at all.

Returns: the time when the OpenPGP key expires.

Since: 2.4.0

gnutls_openpgp_cert_get_subkey_fingerprint

`int gnutls_openpgp_cert_get_subkey_fingerprint` (*gnutls_openpgp_cert_t* *key*, *unsigned int* *idx*, *void * fpr*, *size_t * fprlen*) [Function]

key: the raw data that contains the OpenPGP public key.

idx: the subkey index

fpr: the buffer to save the fingerprint, must hold at least 20 bytes.

fprlen: the integer to save the length of the fingerprint.

Get key fingerprint of a subkey. Depending on the algorithm, the fingerprint can be 16 or 20 bytes.

Returns: On success, 0 is returned. Otherwise, an error code.

Since: 2.4.0

gnutls_openpgp_cert_get_subkey_idx

`int gnutls_openpgp_cert_get_subkey_idx (gnutls_openpgp_cert_t key, const gnutls_openpgp_keyid_t keyid)` [Function]

key: the structure that contains the OpenPGP public key.
keyid: the keyid.
 Get subkey's index.
Returns: the index of the subkey or a negative error value.
Since: 2.4.0

gnutls_openpgp_cert_get_subkey_id

`int gnutls_openpgp_cert_get_subkey_id (gnutls_openpgp_cert_t key, unsigned int idx, gnutls_openpgp_keyid_t keyid)` [Function]

key: the structure that contains the OpenPGP public key.
idx: the subkey index
keyid: the buffer to save the keyid.
 Get the subkey's key-id.
Returns: the 64-bit keyID of the OpenPGP key.

gnutls_openpgp_cert_get_subkey_pk_algorithm

`gnutls_pk_algorithm_t gnutls_openpgp_cert_get_subkey_pk_algorithm (gnutls_openpgp_cert_t key, unsigned int idx, unsigned int * bits)` [Function]

key: is an OpenPGP key
idx: is the subkey index
bits: if bits is non null it will hold the size of the parameters' in bits
 This function will return the public key algorithm of a subkey of an OpenPGP certificate.
 If bits is non null, it should have enough size to hold the parameters size in bits. For RSA the bits returned is the modulus. For DSA the bits returned are of the public exponent.
Returns: a member of the `gnutls_pk_algorithm_t` enumeration on success, or `GNUTLS_PK_UNKNOWN` on error.
Since: 2.4.0

gnutls_openpgp_cert_get_subkey_pk_dsa_raw

`int gnutls_openpgp_cert_get_subkey_pk_dsa_raw (gnutls_openpgp_cert_t crt, unsigned int idx, gnutls_datum_t * p, gnutls_datum_t * q, gnutls_datum_t * g, gnutls_datum_t * y)` [Function]

crt: Holds the certificate
idx: Is the subkey index
p: will hold the p

q: will hold the *q*
g: will hold the *g*
y: will hold the *y*

This function will export the DSA public key's parameters found in the given certificate. The new parameters will be allocated using `gnutls_malloc()` and will be stored in the appropriate datum.

Returns: GNUTLS_E_SUCCESS on success, otherwise a negative error code.

Since: 2.4.0

gnutls_openpgp_cert_get_subkey_pk_rsa_raw

```
int gnutls_openpgp_cert_get_subkey_pk_rsa_raw           [Function]
    (gnutls_openpgp_cert_t crt, unsigned int idx, gnutls_datum_t * m,
     gnutls_datum_t * e)
```

crt: Holds the certificate

idx: Is the subkey index

m: will hold the modulus

e: will hold the public exponent

This function will export the RSA public key's parameters found in the given structure. The new parameters will be allocated using `gnutls_malloc()` and will be stored in the appropriate datum.

Returns: GNUTLS_E_SUCCESS on success, otherwise a negative error code.

Since: 2.4.0

gnutls_openpgp_cert_get_subkey_revoked_status

```
int gnutls_openpgp_cert_get_subkey_revoked_status      [Function]
    (gnutls_openpgp_cert_t key, unsigned int idx)
```

key: the structure that contains the OpenPGP public key.

idx: is the subkey index

Get subkey revocation status. A negative error code indicates an error.

Returns: true (1) if the key has been revoked, or false (0) if it has not.

Since: 2.4.0

gnutls_openpgp_cert_get_subkey_usage

```
int gnutls_openpgp_cert_get_subkey_usage (gnutls_openpgp_cert_t  [Function]
    key, unsigned int idx, unsigned int * key_usage)
```

key: should contain a `gnutls_openpgp_cert_t` structure

idx: the subkey index

key_usage: where the key usage bits will be stored

This function will return certificate's key usage, by checking the key algorithm. The key usage value will ORed values of GNUTLS_KEY_DIGITAL_SIGNATURE or GNUTLS_KEY_KEY_ENCIIPHERMENT.

A negative error code may be returned in case of parsing error.

Returns: key usage value.

Since: 2.4.0

gnutls_openpgp_cert_get_version

int `gnutls_openpgp_cert_get_version` (*gnutls_openpgp_cert_t* **key**) [Function]
key: the structure that contains the OpenPGP public key.

Extract the version of the OpenPGP key.

Returns: the version number is returned, or a negative error code on errors.

gnutls_openpgp_cert_import

int `gnutls_openpgp_cert_import` (*gnutls_openpgp_cert_t* **key**, *const* [Function]
gnutls_datum_t * **data**, *gnutls_openpgp_cert_fmt_t* **format**)

key: The structure to store the parsed key.

data: The RAW or BASE64 encoded key.

format: One of `gnutls_openpgp_cert_fmt_t` elements.

This function will convert the given RAW or Base64 encoded key to the native `gnutls_openpgp_cert_t` format. The output will be stored in 'key'.

Returns: `GNUTLS_E_SUCCESS` on success, or an error code.

gnutls_openpgp_cert_init

int `gnutls_openpgp_cert_init` (*gnutls_openpgp_cert_t* * **key**) [Function]
key: The structure to be initialized

This function will initialize an OpenPGP key structure.

Returns: `GNUTLS_E_SUCCESS` on success, or an error code.

gnutls_openpgp_cert_print

int `gnutls_openpgp_cert_print` (*gnutls_openpgp_cert_t* **cert**, [Function]
gnutls_certificate_print_formats_t **format**, *gnutls_datum_t* * **out**)

cert: The structure to be printed

format: Indicate the format to use

out: Newly allocated datum with (0) terminated string.

This function will pretty print an OpenPGP certificate, suitable for display to a human.

The format should be (0) for future compatibility.

The output `out` needs to be deallocate using `gnutls_free()`.

Returns: `GNUTLS_E_SUCCESS` on success, or an error code.

gnutls_openpgp_cert_set_preferred_key_id

`int gnutls_openpgp_cert_set_preferred_key_id` [Function]

(*gnutls_openpgp_cert_t* *key*, *const gnutls_openpgp_keyid_t* *keyid*)

key: the structure that contains the OpenPGP public key.

keyid: the selected keyid

This allows setting a preferred key id for the given certificate. This key will be used by functions that involve key handling.

Returns: On success, GNUTLS_E_SUCCESS (0) is returned, otherwise a negative error code is returned.

gnutls_openpgp_cert_verify_ring

`int gnutls_openpgp_cert_verify_ring` (*gnutls_openpgp_cert_t* *key*, [Function]

gnutls_openpgp_keyring_t *keyring*, *unsigned int* *flags*, *unsigned int* *
verify)

key: the structure that holds the key.

keyring: holds the keyring to check against

flags: unused (should be 0)

verify: will hold the certificate verification output.

Verify all signatures in the key, using the given set of keys (*keyring*).

The key verification output will be put in *verify* and will be one or more of the `gnutls_certificate_status_t` enumerated elements bitwise or'd.

Returns: GNUTLS_E_SUCCESS on success, or an error code.

gnutls_openpgp_cert_verify_self

`int gnutls_openpgp_cert_verify_self` (*gnutls_openpgp_cert_t* *key*, [Function]

unsigned int *flags*, *unsigned int* * *verify*)

key: the structure that holds the key.

flags: unused (should be 0)

verify: will hold the key verification output.

Verifies the self signature in the key. The key verification output will be put in *verify* and will be one or more of the `gnutls_certificate_status_t` enumerated elements bitwise or'd.

Returns: GNUTLS_E_SUCCESS on success, or an error code.

gnutls_openpgp_keyring_check_id

`int gnutls_openpgp_keyring_check_id` (*gnutls_openpgp_keyring_t* [Function]

ring, *const gnutls_openpgp_keyid_t* *keyid*, *unsigned int* *flags*)

ring: holds the keyring to check against

keyid: will hold the keyid to check for.

flags: unused (should be 0)

Check if a given key ID exists in the keyring.

Returns: GNUTLS_E_SUCCESS on success (if keyid exists) and a negative error code on failure.

gnutls_openpgp_keyring_deinit

```
void gnutls_openpgp_keyring_deinit (gnutls_openpgp_keyring_t      [Function]
                                     keyring)
```

keyring: The structure to be initialized

This function will deinitialize a keyring structure.

gnutls_openpgp_keyring_get_cert_count

```
int gnutls_openpgp_keyring_get_cert_count      [Function]
    (gnutls_openpgp_keyring_t ring)
```

ring: is an OpenPGP key ring

This function will return the number of OpenPGP certificates present in the given keyring.

Returns: the number of subkeys, or a negative error code on error.

gnutls_openpgp_keyring_get_cert

```
int gnutls_openpgp_keyring_get_cert (gnutls_openpgp_keyring_t      [Function]
                                     ring, unsigned int idx, gnutls_openpgp_cert_t * cert)
```

ring: Holds the keyring.

idx: the index of the certificate to export

cert: An uninitialized `gnutls_openpgp_cert_t` structure

This function will extract an OpenPGP certificate from the given keyring. If the index given is out of range GNUTLS_E_REQUESTED_DATA_NOT_AVAILABLE will be returned. The returned structure needs to be deinit.

Returns: GNUTLS_E_SUCCESS on success, or an error code.

gnutls_openpgp_keyring_import

```
int gnutls_openpgp_keyring_import (gnutls_openpgp_keyring_t      [Function]
                                     keyring, const gnutls_datum_t * data, gnutls_openpgp_cert_fmt_t format)
```

keyring: The structure to store the parsed key.

data: The RAW or BASE64 encoded keyring.

format: One of `gnutls_openpgp_keyring_fmt` elements.

This function will convert the given RAW or Base64 encoded keyring to the native `gnutls_openpgp_keyring_t` format. The output will be stored in 'keyring'.

Returns: GNUTLS_E_SUCCESS on success, or an error code.

gnutls_openpgp_keyring_init

`int gnutls_openpgp_keyring_init (gnutls_openpgp_keyring_t *
keyring)` [Function]

keyring: The structure to be initialized

This function will initialize an keyring structure.

Returns: GNUTLS_E_SUCCESS on success, or an error code.

gnutls_openpgp_privkey_deinit

`void gnutls_openpgp_privkey_deinit (gnutls_openpgp_privkey_t
key)` [Function]

key: The structure to be initialized

This function will deinitialize a key structure.

gnutls_openpgp_privkey_export_dsa_raw

`int gnutls_openpgp_privkey_export_dsa_raw (gnutls_openpgp_privkey_t pkey, gnutls_datum_t * p, gnutls_datum_t * q,
gnutls_datum_t * g, gnutls_datum_t * y, gnutls_datum_t * x)` [Function]

pkey: Holds the certificate

p: will hold the p

q: will hold the q

g: will hold the g

y: will hold the y

x: will hold the x

This function will export the DSA private key's parameters found in the given certificate. The new parameters will be allocated using `gnutls_malloc()` and will be stored in the appropriate datum.

Returns: GNUTLS_E_SUCCESS on success, otherwise a negative error code.

Since: 2.4.0

gnutls_openpgp_privkey_export_rsa_raw

`int gnutls_openpgp_privkey_export_rsa_raw (gnutls_openpgp_privkey_t pkey, gnutls_datum_t * m, gnutls_datum_t * e,
gnutls_datum_t * d, gnutls_datum_t * p, gnutls_datum_t * q, gnutls_datum_t
* u)` [Function]

pkey: Holds the certificate

m: will hold the modulus

e: will hold the public exponent

d: will hold the private exponent

p: will hold the first prime (p)

q: will hold the second prime (q)

u: will hold the coefficient

This function will export the RSA private key's parameters found in the given structure. The new parameters will be allocated using `gnutls_malloc()` and will be stored in the appropriate datum.

Returns: GNUTLS_E_SUCCESS on success, otherwise a negative error code.

Since: 2.4.0

gnutls_openpgp_privkey_export_subkey_dsa_raw

```
int gnutls_openpgp_privkey_export_subkey_dsa_raw           [Function]
    (gnutls_openpgp_privkey_t pkey, unsigned int idx, gnutls_datum_t * p,
     gnutls_datum_t * q, gnutls_datum_t * g, gnutls_datum_t * y, gnutls_datum_t
     * x)
```

pkey: Holds the certificate

idx: Is the subkey index

p: will hold the p

q: will hold the q

g: will hold the g

y: will hold the y

x: will hold the x

This function will export the DSA private key's parameters found in the given certificate. The new parameters will be allocated using `gnutls_malloc()` and will be stored in the appropriate datum.

Returns: GNUTLS_E_SUCCESS on success, otherwise a negative error code.

Since: 2.4.0

gnutls_openpgp_privkey_export_subkey_rsa_raw

```
int gnutls_openpgp_privkey_export_subkey_rsa_raw         [Function]
    (gnutls_openpgp_privkey_t pkey, unsigned int idx, gnutls_datum_t * m,
     gnutls_datum_t * e, gnutls_datum_t * d, gnutls_datum_t * p, gnutls_datum_t
     * q, gnutls_datum_t * u)
```

pkey: Holds the certificate

idx: Is the subkey index

m: will hold the modulus

e: will hold the public exponent

d: will hold the private exponent

p: will hold the first prime (p)

q: will hold the second prime (q)

u: will hold the coefficient

This function will export the RSA private key's parameters found in the given structure. The new parameters will be allocated using `gnutls_malloc()` and will be stored in the appropriate datum.

Returns: GNUTLS_E_SUCCESS on success, otherwise a negative error code.

Since: 2.4.0

gnutls_openpgp_privkey_export

```
int gnutls_openpgp_privkey_export (gnutls_openpgp_privkey_t [Function]
    key, gnutls_openpgp_cert_fmt_t format, const char * password, unsigned int
    flags, void * output_data, size_t * output_data_size)
```

key: Holds the key.

format: One of `gnutls_openpgp_cert_fmt_t` elements.

password: the password that will be used to encrypt the key. (unused for now)

flags: (0) for future compatibility

output_data: will contain the key base64 encoded or raw

output_data_size: holds the size of *output_data* (and will be replaced by the actual size of parameters)

This function will convert the given key to RAW or Base64 format. If the buffer provided is not long enough to hold the output, then `GNUTLS_E_SHORT_MEMORY_BUFFER` will be returned.

Returns: `GNUTLS_E_SUCCESS` on success, or an error code.

Since: 2.4.0

gnutls_openpgp_privkey_get_fingerprint

```
int gnutls_openpgp_privkey_get_fingerprint [Function]
    (gnutls_openpgp_privkey_t key, void * fpr, size_t * fprlen)
```

key: the raw data that contains the OpenPGP secret key.

fpr: the buffer to save the fingerprint, must hold at least 20 bytes.

fprlen: the integer to save the length of the fingerprint.

Get the fingerprint of the OpenPGP key. Depends on the algorithm, the fingerprint can be 16 or 20 bytes.

Returns: On success, 0 is returned, or an error code.

Since: 2.4.0

gnutls_openpgp_privkey_get_key_id

```
int gnutls_openpgp_privkey_get_key_id (gnutls_openpgp_privkey_t [Function]
    key, gnutls_openpgp_keyid_t keyid)
```

key: the structure that contains the OpenPGP secret key.

keyid: the buffer to save the keyid.

Get key-id.

Returns: the 64-bit keyID of the OpenPGP key.

Since: 2.4.0

gnutls_openpgp_privkey_get_pk_algorithm

`gnutls_pk_algorithm_t` [Function]

`gnutls_openpgp_privkey_get_pk_algorithm (gnutls_openpgp_privkey_t key, unsigned int * bits)`

key: is an OpenPGP key

bits: if bits is non null it will hold the size of the parameters' in bits

This function will return the public key algorithm of an OpenPGP certificate.

If bits is non null, it should have enough size to hold the parameters size in bits. For RSA the bits returned is the modulus. For DSA the bits returned are of the public exponent.

Returns: a member of the `gnutls_pk_algorithm_t` enumeration on success, or a negative error code on error.

Since: 2.4.0

gnutls_openpgp_privkey_get_preferred_key_id

`int gnutls_openpgp_privkey_get_preferred_key_id` [Function]

`(gnutls_openpgp_privkey_t key, gnutls_openpgp_keyid_t keyid)`

key: the structure that contains the OpenPGP public key.

keyid: the struct to save the keyid.

Get the preferred key-id for the key.

Returns: the 64-bit preferred keyID of the OpenPGP key, or if it hasn't been set it returns `GNUTLS_E_INVALID_REQUEST`.

gnutls_openpgp_privkey_get_revoked_status

`int gnutls_openpgp_privkey_get_revoked_status` [Function]

`(gnutls_openpgp_privkey_t key)`

key: the structure that contains the OpenPGP private key.

Get revocation status of key.

Returns: true (1) if the key has been revoked, or false (0) if it has not, or a negative error code indicates an error.

Since: 2.4.0

gnutls_openpgp_privkey_get_subkey_count

`int gnutls_openpgp_privkey_get_subkey_count` [Function]

`(gnutls_openpgp_privkey_t key)`

key: is an OpenPGP key

This function will return the number of subkeys present in the given OpenPGP certificate.

Returns: the number of subkeys, or a negative error code on error.

Since: 2.4.0

gnutls_openpgp_privkey_get_subkey_creation_time

`time_t gnutls_openpgp_privkey_get_subkey_creation_time` [Function]
(*gnutls_openpgp_privkey_t* *key*, *unsigned int* *idx*)
key: the structure that contains the OpenPGP private key.
idx: the subkey index
Get subkey creation time.
Returns: the timestamp when the OpenPGP key was created.
Since: 2.4.0

gnutls_openpgp_privkey_get_subkey_expiration_time

`time_t gnutls_openpgp_privkey_get_subkey_expiration_time` [Function]
(*gnutls_openpgp_privkey_t* *key*, *unsigned int* *idx*)
key: the structure that contains the OpenPGP private key.
idx: the subkey index
Get subkey expiration time. A value of '0' means that the key doesn't expire at all.
Returns: the time when the OpenPGP key expires.
Since: 2.4.0

gnutls_openpgp_privkey_get_subkey_fingerprint

`int gnutls_openpgp_privkey_get_subkey_fingerprint` [Function]
(*gnutls_openpgp_privkey_t* *key*, *unsigned int* *idx*, *void * fpr*, *size_t * fprlen*)
key: the raw data that contains the OpenPGP secret key.
idx: the subkey index
fpr: the buffer to save the fingerprint, must hold at least 20 bytes.
fprlen: the integer to save the length of the fingerprint.
Get the fingerprint of an OpenPGP subkey. Depends on the algorithm, the fingerprint can be 16 or 20 bytes.
Returns: On success, 0 is returned, or an error code.
Since: 2.4.0

gnutls_openpgp_privkey_get_subkey_idx

`int gnutls_openpgp_privkey_get_subkey_idx` [Function]
(*gnutls_openpgp_privkey_t* *key*, *const gnutls_openpgp_keyid_t* *keyid*)
key: the structure that contains the OpenPGP private key.
keyid: the keyid.
Get index of subkey.
Returns: the index of the subkey or a negative error value.
Since: 2.4.0

gnutls_openpgp_privkey_get_subkey_id

`int gnutls_openpgp_privkey_get_subkey_id` [Function]
 (`gnutls_openpgp_privkey_t key`, `unsigned int idx`, `gnutls_openpgp_keyid_t keyid`)

key: the structure that contains the OpenPGP secret key.

idx: the subkey index

keyid: the buffer to save the keyid.

Get the key-id for the subkey.

Returns: the 64-bit keyID of the OpenPGP key.

Since: 2.4.0

gnutls_openpgp_privkey_get_subkey_pk_algorithm

`gnutls_pk_algorithm_t` [Function]
`gnutls_openpgp_privkey_get_subkey_pk_algorithm`
 (`gnutls_openpgp_privkey_t key`, `unsigned int idx`, `unsigned int * bits`)

key: is an OpenPGP key

idx: is the subkey index

bits: if bits is non null it will hold the size of the parameters' in bits

This function will return the public key algorithm of a subkey of an OpenPGP certificate.

If bits is non null, it should have enough size to hold the parameters size in bits. For RSA the bits returned is the modulus. For DSA the bits returned are of the public exponent.

Returns: a member of the `gnutls_pk_algorithm_t` enumeration on success, or a negative error code on error.

Since: 2.4.0

gnutls_openpgp_privkey_get_subkey_revoked_status

`int gnutls_openpgp_privkey_get_subkey_revoked_status` [Function]
 (`gnutls_openpgp_privkey_t key`, `unsigned int idx`)

key: the structure that contains the OpenPGP private key.

idx: is the subkey index

Get revocation status of key.

Returns: true (1) if the key has been revoked, or false (0) if it has not, or a negative error code indicates an error.

Since: 2.4.0

gnutls_openpgp_privkey_import

`int gnutls_openpgp_privkey_import` [Function]
 (`gnutls_openpgp_privkey_t key`, `const gnutls_datum_t * data`, `gnutls_openpgp_cert_fmt_t format`, `const char * password`, `unsigned int flags`)

key: The structure to store the parsed key.

data: The RAW or BASE64 encoded key.

format: One of `gnutls_openpgp_crt_fmt_t` elements.

password: not used for now

flags: should be (0)

This function will convert the given RAW or Base64 encoded key to the native `gnutls_openpgp_privkey_t` format. The output will be stored in 'key'.

Returns: `GNUTLS_E_SUCCESS` on success, or an error code.

`gnutls_openpgp_privkey_init`

`int gnutls_openpgp_privkey_init (gnutls_openpgp_privkey_t * key)` [Function]

key: The structure to be initialized

This function will initialize an OpenPGP key structure.

Returns: `GNUTLS_E_SUCCESS` on success, or an error code.

`gnutls_openpgp_privkey_sec_param`

`gnutls_sec_param_t gnutls_openpgp_privkey_sec_param` [Function]

(`gnutls_openpgp_privkey_t key`)

key: a key structure

This function will return the security parameter appropriate with this private key.

Returns: On success, a valid security parameter is returned otherwise `GNUTLS_SEC_PARAM_UNKNOWN` is returned.

`gnutls_openpgp_privkey_set_preferred_key_id`

`int gnutls_openpgp_privkey_set_preferred_key_id` [Function]

(`gnutls_openpgp_privkey_t key, const gnutls_openpgp_keyid_t keyid`)

key: the structure that contains the OpenPGP public key.

keyid: the selected keyid

This allows setting a preferred key id for the given certificate. This key will be used by functions that involve key handling.

Returns: On success, 0 is returned, or an error code.

`gnutls_openpgp_privkey_sign_hash`

`int gnutls_openpgp_privkey_sign_hash (gnutls_openpgp_privkey_t` [Function]

`key, const gnutls_datum_t * hash, gnutls_datum_t * signature)`

key: Holds the key

hash: holds the data to be signed

signature: will contain newly allocated signature

This function will sign the given hash using the private key. You should use `gnutls_openpgp_privkey_set_preferred_key_id()` before calling this function to set the subkey to use.

Returns: On success, `GNUTLS_E_SUCCESS` (0) is returned, otherwise a negative error value.

Deprecated: Use `gnutls_privkey_sign_hash()` instead.

gnutls_openpgp_set_rcv_key_function

`void gnutls_openpgp_set_rcv_key_function` (*gnutls_session_t* *session*, *gnutls_openpgp_rcv_key_func* *func*) [Function]

session: a TLS session

func: the callback

This function will set a key retrieval function for OpenPGP keys. This callback is only useful in server side, and will be used if the peer sent a key fingerprint instead of a full key.

Appendix D Supported Ciphersuites in GnuTLS

Available cipher suites:

TLS_ANON_DH_ARCFOUR_MD5	0x00 0x18	SSL3.0
TLS_ANON_DH_3DES_EDE_CBC_SHA1	0x00 0x1B	SSL3.0
TLS_ANON_DH_AES_128_CBC_SHA1	0x00 0x34	SSL3.0
TLS_ANON_DH_AES_256_CBC_SHA1	0x00 0x3A	SSL3.0
TLS_ANON_DH_CAMELLIA_128_CBC_SHA1	0x00 0x46	TLS1.0
TLS_ANON_DH_CAMELLIA_256_CBC_SHA1	0x00 0x89	TLS1.0
TLS_ANON_DH_AES_128_CBC_SHA256	0x00 0x6C	TLS1.2
TLS_ANON_DH_AES_256_CBC_SHA256	0x00 0x6D	TLS1.2
TLS_PSK_SHA_ARCFOUR_SHA1	0x00 0x8A	TLS1.0
TLS_PSK_SHA_3DES_EDE_CBC_SHA1	0x00 0x8B	TLS1.0
TLS_PSK_SHA_AES_128_CBC_SHA1	0x00 0x8C	TLS1.0
TLS_PSK_SHA_AES_256_CBC_SHA1	0x00 0x8D	TLS1.0
TLS_PSK_AES_128_CBC_SHA256	0x00 0xAE	TLS1.0
TLS_PSK_AES_128_GCM_SHA256	0x00 0xA8	TLS1.2
TLS_PSK_NULL_SHA256	0x00 0xB0	TLS1.0
TLS_DHE_PSK_SHA_ARCFOUR_SHA1	0x00 0x8E	TLS1.0
TLS_DHE_PSK_SHA_3DES_EDE_CBC_SHA1	0x00 0x8F	TLS1.0
TLS_DHE_PSK_SHA_AES_128_CBC_SHA1	0x00 0x90	TLS1.0
TLS_DHE_PSK_SHA_AES_256_CBC_SHA1	0x00 0x91	TLS1.0
TLS_DHE_PSK_AES_128_CBC_SHA256	0x00 0xB2	TLS1.0
TLS_DHE_PSK_AES_128_GCM_SHA256	0x00 0xAA	TLS1.2
TLS_DHE_PSK_NULL_SHA256	0x00 0xB4	TLS1.0
TLS_SRP_SHA_3DES_EDE_CBC_SHA1	0xC0 0x1A	TLS1.0
TLS_SRP_SHA_AES_128_CBC_SHA1	0xC0 0x1D	TLS1.0
TLS_SRP_SHA_AES_256_CBC_SHA1	0xC0 0x20	TLS1.0
TLS_SRP_SHA_DSS_3DES_EDE_CBC_SHA1	0xC0 0x1C	TLS1.0
TLS_SRP_SHA_RSA_3DES_EDE_CBC_SHA1	0xC0 0x1B	TLS1.0
TLS_SRP_SHA_DSS_AES_128_CBC_SHA1	0xC0 0x1F	TLS1.0
TLS_SRP_SHA_RSA_AES_128_CBC_SHA1	0xC0 0x1E	TLS1.0
TLS_SRP_SHA_DSS_AES_256_CBC_SHA1	0xC0 0x22	TLS1.0
TLS_SRP_SHA_RSA_AES_256_CBC_SHA1	0xC0 0x21	TLS1.0
TLS_DHE_DSS_ARCFOUR_SHA1	0x00 0x66	TLS1.0
TLS_DHE_DSS_3DES_EDE_CBC_SHA1	0x00 0x13	SSL3.0
TLS_DHE_DSS_AES_128_CBC_SHA1	0x00 0x32	SSL3.0
TLS_DHE_DSS_AES_256_CBC_SHA1	0x00 0x38	SSL3.0
TLS_DHE_DSS_CAMELLIA_128_CBC_SHA1	0x00 0x44	TLS1.0
TLS_DHE_DSS_CAMELLIA_256_CBC_SHA1	0x00 0x87	TLS1.0
TLS_DHE_DSS_AES_128_CBC_SHA256	0x00 0x40	TLS1.2
TLS_DHE_DSS_AES_256_CBC_SHA256	0x00 0x6A	TLS1.2
TLS_DHE_RSA_3DES_EDE_CBC_SHA1	0x00 0x16	SSL3.0
TLS_DHE_RSA_AES_128_CBC_SHA1	0x00 0x33	SSL3.0
TLS_DHE_RSA_AES_256_CBC_SHA1	0x00 0x39	SSL3.0
TLS_DHE_RSA_CAMELLIA_128_CBC_SHA1	0x00 0x45	TLS1.0
TLS_DHE_RSA_CAMELLIA_256_CBC_SHA1	0x00 0x88	TLS1.0

TLS_DHE_RSA_AES_128_CBC_SHA256	0x00 0x67	TLS1.2
TLS_DHE_RSA_AES_256_CBC_SHA256	0x00 0x6B	TLS1.2
TLS_RSA_NULL_MD5	0x00 0x01	SSL3.0
TLS_RSA_NULL_SHA1	0x00 0x02	SSL3.0
TLS_RSA_NULL_SHA256	0x00 0x3B	TLS1.2
TLS_RSA_EXPORT_ARCFOUR_40_MD5	0x00 0x03	SSL3.0
TLS_RSA_ARCFOUR_SHA1	0x00 0x05	SSL3.0
TLS_RSA_ARCFOUR_MD5	0x00 0x04	SSL3.0
TLS_RSA_3DES_EDE_CBC_SHA1	0x00 0x0A	SSL3.0
TLS_RSA_AES_128_CBC_SHA1	0x00 0x2F	SSL3.0
TLS_RSA_AES_256_CBC_SHA1	0x00 0x35	SSL3.0
TLS_RSA_CAMELLIA_128_CBC_SHA1	0x00 0x41	TLS1.0
TLS_RSA_CAMELLIA_256_CBC_SHA1	0x00 0x84	TLS1.0
TLS_RSA_AES_128_CBC_SHA256	0x00 0x3C	TLS1.2
TLS_RSA_AES_256_CBC_SHA256	0x00 0x3D	TLS1.2
TLS_RSA_AES_128_GCM_SHA256	0x00 0x9C	TLS1.2
TLS_DHE_RSA_AES_128_GCM_SHA256	0x00 0x9E	TLS1.2
TLS_DHE_DSS_AES_128_GCM_SHA256	0x00 0xA2	TLS1.2
TLS_DH_ANON_AES_128_GCM_SHA256	0x00 0xA6	TLS1.2
TLS_ECDH_ANON_NULL_SHA	0xC0 0x15	TLS1.0
TLS_ECDH_ANON_3DES_EDE_CBC_SHA	0xC0 0x17	TLS1.0
TLS_ECDH_ANON_AES_128_CBC_SHA	0xC0 0x18	TLS1.0
TLS_ECDH_ANON_AES_256_CBC_SHA	0xC0 0x19	TLS1.0
TLS_ECDHE_RSA_NULL_SHA	0xC0 0x10	TLS1.0
TLS_ECDHE_RSA_3DES_EDE_CBC_SHA	0xC0 0x12	TLS1.0
TLS_ECDHE_RSA_AES_128_CBC_SHA	0xC0 0x13	TLS1.0
TLS_ECDHE_RSA_AES_256_CBC_SHA	0xC0 0x14	TLS1.0
TLS_ECDHE_ECDSA_NULL_SHA	0xC0 0x06	TLS1.0
TLS_ECDHE_ECDSA_3DES_EDE_CBC_SHA	0xC0 0x08	TLS1.0
TLS_ECDHE_ECDSA_AES_128_CBC_SHA	0xC0 0x09	TLS1.0
TLS_ECDHE_ECDSA_AES_256_CBC_SHA	0xC0 0x0A	TLS1.0
TLS_ECDHE_ECDSA_AES_128_CBC_SHA256	0xC0 0x23	TLS1.2
TLS_ECDHE_RSA_AES_128_CBC_SHA256	0xC0 0x27	TLS1.2
TLS_ECDHE_ECDSA_AES_128_GCM_SHA256	0xC0 0x2B	TLS1.2
TLS_ECDHE_RSA_AES_128_GCM_SHA256	0xC0 0x2F	TLS1.2
TLS_ECDHE_PSK_3DES_EDE_CBC_SHA	0xC0 0x34	TLS1.0
TLS_ECDHE_PSK_AES_128_CBC_SHA	0xC0 0x35	TLS1.0
TLS_ECDHE_PSK_AES_256_CBC_SHA	0xC0 0x36	TLS1.0
TLS_ECDHE_PSK_AES_128_CBC_SHA256	0xC0 0x37	TLS1.0
TLS_ECDHE_PSK_AES_256_CBC_SHA384	0xC0 0x38	TLS1.0
TLS_ECDHE_PSK_NULL_SHA256	0xC0 0x3A	TLS1.0
TLS_ECDHE_PSK_NULL_SHA384	0xC0 0x3B	TLS1.0
TLS_ECDHE_ECDSA_AES_256_GCM_SHA384	0xC0 0x2E	TLS1.2
TLS_ECDHE_RSA_AES_256_GCM_SHA384	0xC0 0x30	TLS1.2
TLS_ECDHE_ECDSA_AES_256_CBC_SHA384	0xC0 0x24	TLS1.2

Available certificate types:

- X.509
- OPENPGP

Available protocols:

- SSL3.0
- TLS1.0
- TLS1.1
- TLS1.2
- DTLS1.0

Available ciphers:

- AES-256-CBC
- AES-192-CBC
- AES-128-CBC
- AES-128-GCM
- 3DES-CBC
- DES-CBC
- ARCFOUR-128
- ARCFOUR-40
- RC2-40
- CAMELLIA-256-CBC
- CAMELLIA-128-CBC
- IDEA-PGP-CFB
- 3DES-PGP-CFB
- CAST5-PGP-CFB
- BLOWFISH-PGP-CFB
- SAFER-SK128-PGP-CFB
- AES-128-PGP-CFB
- AES-192-PGP-CFB
- AES-256-PGP-CFB
- TWOFISH-PGP-CFB
- NULL

Available MAC algorithms:

- SHA1
- MD5
- SHA256
- SHA384
- SHA512
- SHA224
- AEAD

- MD2
- RIPEMD160
- MAC-NULL

Available key exchange methods:

- ANON-DH
- ANON-ECDH
- RSA
- RSA-EXPORT
- DHE-RSA
- ECDHE-RSA
- ECDHE-ECDSA
- DHE-DSS
- SRP-DSS
- SRP-RSA
- SRP
- PSK
- DHE-PSK
- ECDHE-PSK

Available public key algorithms:

- RSA
- DSA
- ECC

Available public key signature algorithms:

- RSA-SHA1
- RSA-SHA224
- RSA-SHA256
- RSA-SHA384
- RSA-SHA512
- RSA-RMD160
- DSA-SHA1
- DSA-SHA224
- DSA-SHA256
- RSA-MD5
- RSA-MD2
- ECDSA-SHA1
- ECDSA-SHA224
- ECDSA-SHA256
- ECDSA-SHA384

- ECDSA-SHA512

Available compression methods:

- DEFLATE
- NULL

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Function and Data Index

gnutls_alert_get.....	152	gnutls_certificate_set_retrieve_function	161
gnutls_alert_get_name.....	152	gnutls_certificate_set_retrieve_function2	160
gnutls_alert_get_strname.....	152	gnutls_certificate_set_rsa_export_params	161
gnutls_alert_send.....	153	gnutls_certificate_set_verify_flags.....	162
gnutls_alert_send_appropriate.....	152	gnutls_certificate_set_verify_function..	162
gnutls_anon_allocate_client_credentials	153	gnutls_certificate_set_verify_limits....	162
gnutls_anon_allocate_server_credentials	153	gnutls_certificate_set_x509_crl.....	163
gnutls_anon_free_client_credentials.....	153	gnutls_certificate_set_x509_crl_file....	162
gnutls_anon_free_server_credentials.....	153	gnutls_certificate_set_x509_crl_mem.....	163
gnutls_anon_set_params_function.....	154	gnutls_certificate_set_x509_key.....	164
gnutls_anon_set_server_dh_params.....	154	gnutls_certificate_set_x509_key_file....	163
gnutls_anon_set_server_params_function..	154	gnutls_certificate_set_x509_key_mem.....	164
gnutls_auth_client_get_type.....	154	gnutls_certificate_set_x509_simple_pkcs12_	165
gnutls_auth_get_type.....	154	file.....	165
gnutls_auth_server_get_type.....	155	gnutls_certificate_set_x509_simple_pkcs12_	165
gnutls_bye.....	155	mem.....	165
gnutls_certificate_activation_time_peers	156	gnutls_certificate_set_x509_trust.....	166
gnutls_certificate_allocate_credentials	156	gnutls_certificate_set_x509_trust_file..	166
gnutls_certificate_client_get_request_	156	gnutls_certificate_set_x509_trust_mem...	166
status.....	156	gnutls_certificate_type_get.....	167
gnutls_certificate_client_set_retrieve_	156	gnutls_certificate_type_get_id.....	167
function.....	156	gnutls_certificate_type_get_name.....	167
gnutls_certificate_expiration_time_peers	157	gnutls_certificate_type_list.....	167
gnutls_certificate_free_ca_names.....	157	gnutls_certificate_type_set_priority....	168
gnutls_certificate_free_cas.....	157	gnutls_certificate_verify_flags.....	31
gnutls_certificate_free_credentials.....	157	gnutls_certificate_verify_peers2.....	168
gnutls_certificate_free_crls.....	158	gnutls_check_version.....	168
gnutls_certificate_free_keys.....	158	gnutls_cipher_add_auth.....	168
gnutls_certificate_get_issuer.....	158	gnutls_cipher_decrypt.....	169
gnutls_certificate_get_ours.....	158	gnutls_cipher_decrypt2.....	169
gnutls_certificate_get_peers.....	158	gnutls_cipher_deinit.....	169
gnutls_certificate_send_x509_rdn_sequence	159	gnutls_cipher_encrypt.....	170
gnutls_certificate_server_set_request...	159	gnutls_cipher_encrypt2.....	169
gnutls_certificate_server_set_retrieve_	159	gnutls_cipher_get.....	171
function.....	159	gnutls_cipher_get_block_size.....	170
gnutls_certificate_set_dh_params.....	160	gnutls_cipher_get_id.....	170
gnutls_certificate_set_openpgp_key.....	320	gnutls_cipher_get_key_size.....	170
gnutls_certificate_set_openpgp_key_file	319	gnutls_cipher_get_name.....	171
gnutls_certificate_set_openpgp_key_file2	318	gnutls_cipher_init.....	171
gnutls_certificate_set_openpgp_key_mem..	319	gnutls_cipher_list.....	171
gnutls_certificate_set_openpgp_key_mem2	319	gnutls_cipher_set_iv.....	172
gnutls_certificate_set_openpgp_keyring_file	320	gnutls_cipher_set_priority.....	172
gnutls_certificate_set_openpgp_keyring_mem	320	gnutls_cipher_suite_get_name.....	172
gnutls_certificate_set_params_function..	160	gnutls_cipher_suite_info.....	172
		gnutls_cipher_tag.....	173
		gnutls_compression_get.....	173
		gnutls_compression_get_id.....	173
		gnutls_compression_get_name.....	173
		gnutls_compression_list.....	174
		gnutls_compression_set_priority.....	174
		gnutls_credentials_clear.....	174
		gnutls_credentials_set.....	174

gnutls_db_check_entry.....	175	gnutls_hash_get_len.....	188
gnutls_db_get_ptr.....	175	gnutls_hash_init.....	189
gnutls_db_remove_session.....	175	gnutls_hash_output.....	189
gnutls_db_set_cache_expiration.....	175	gnutls_hex_decode.....	190
gnutls_db_set_ptr.....	175	gnutls_hex_encode.....	190
gnutls_db_set_remove_function.....	176	gnutls_hex2bin.....	189
gnutls_db_set_retrieve_function.....	176	gnutls_hmac.....	191
gnutls_db_set_store_function.....	176	gnutls_hmac_deinit.....	190
gnutls_deinit.....	176	gnutls_hmac_fast.....	190
gnutls_dh_get_group.....	177	gnutls_hmac_get_len.....	191
gnutls_dh_get_peers_public_bits.....	177	gnutls_hmac_init.....	191
gnutls_dh_get_prime_bits.....	177	gnutls_hmac_output.....	191
gnutls_dh_get_pubkey.....	177	gnutls_init.....	192
gnutls_dh_get_secret_bits.....	178	gnutls_key_generate.....	192
gnutls_dh_params_cpy.....	178	gnutls_kx_get.....	192
gnutls_dh_params_deinit.....	178	gnutls_kx_get_id.....	192
gnutls_dh_params_export_pkcs3.....	178	gnutls_kx_get_name.....	192
gnutls_dh_params_export_raw.....	179	gnutls_kx_list.....	193
gnutls_dh_params_generate2.....	179	gnutls_kx_set_priority.....	193
gnutls_dh_params_import_pkcs3.....	179	gnutls_mac_get.....	194
gnutls_dh_params_import_raw.....	180	gnutls_mac_get_id.....	193
gnutls_dh_params_init.....	180	gnutls_mac_get_key_size.....	193
gnutls_dh_set_prime_bits.....	180	gnutls_mac_get_name.....	193
gnutls_dtls_cookie_send.....	180	gnutls_mac_list.....	194
gnutls_dtls_cookie_verify.....	181	gnutls_mac_set_priority.....	194
gnutls_dtls_get_data_mtu.....	181	gnutls_malloc.....	194
gnutls_dtls_get_mtu.....	181	gnutls_openpgp_cert_check_hostname.....	321
gnutls_dtls_prestate_set.....	181	gnutls_openpgp_cert_deinit.....	321
gnutls_dtls_set_mtu.....	182	gnutls_openpgp_cert_export.....	321
gnutls_dtls_set_timeouts.....	182	gnutls_openpgp_cert_get_auth_subkey.....	321
gnutls_ecc_curve_get.....	183	gnutls_openpgp_cert_get_creation_time.....	322
gnutls_ecc_curve_get_name.....	182	gnutls_openpgp_cert_get_expiration_time.....	322
gnutls_ecc_curve_get_size.....	182	gnutls_openpgp_cert_get_fingerprint.....	322
gnutls_error_is_fatal.....	183	gnutls_openpgp_cert_get_key_id.....	322
gnutls_error_to_alert.....	183	gnutls_openpgp_cert_get_key_usage.....	323
gnutls_extra_check_version.....	318	gnutls_openpgp_cert_get_name.....	323
gnutls_fingerprint.....	183	gnutls_openpgp_cert_get_pk_algorithm.....	323
gnutls_free.....	184	gnutls_openpgp_cert_get_pk_dsa_raw.....	323
gnutls_global_deinit.....	184	gnutls_openpgp_cert_get_pk_rsa_raw.....	324
gnutls_global_init.....	184	gnutls_openpgp_cert_get_preferred_key_id.....	324
gnutls_global_init_extra.....	318	gnutls_openpgp_cert_get_revoked_status.....	324
gnutls_global_set_audit_log_function.....	184	gnutls_openpgp_cert_get_subkey_count.....	325
gnutls_global_set_log_function.....	185	gnutls_openpgp_cert_get_subkey_creation_time.....	325
gnutls_global_set_log_level.....	185	gnutls_openpgp_cert_get_subkey_expiration_time.....	325
gnutls_global_set_mem_functions.....	185	gnutls_openpgp_cert_get_subkey_fingerprint.....	325
gnutls_global_set_mutex.....	186	gnutls_openpgp_cert_get_subkey_id.....	326
gnutls_global_set_time_function.....	186	gnutls_openpgp_cert_get_subkey_idx.....	326
gnutls_handshake.....	188	gnutls_openpgp_cert_get_subkey_pk_algorithm.....	326
gnutls_handshake_get_last_in.....	186	gnutls_openpgp_cert_get_subkey_pk_dsa_raw.....	326
gnutls_handshake_get_last_out.....	186	gnutls_openpgp_cert_get_subkey_pk_rsa_raw.....	327
gnutls_handshake_set_max_packet_length.....	187		
gnutls_handshake_set_post_client_hello_function.....	187		
gnutls_handshake_set_private_extensions.....	187		
gnutls_hash.....	189		
gnutls_hash_deinit.....	188		
gnutls_hash_fast.....	188		

gnutls_openpgp_cert_get_subkey_revoked_status	327	gnutls_pcert_import_x509	196
gnutls_openpgp_cert_get_subkey_usage	327	gnutls_pcert_import_x509_raw	195
gnutls_openpgp_cert_get_version	328	gnutls_pcert_list_import_x509_raw	196
gnutls_openpgp_cert_import	328	gnutls_pem_base64_decode	197
gnutls_openpgp_cert_init	328	gnutls_pem_base64_decode_alloc	196
gnutls_openpgp_cert_print	328	gnutls_pem_base64_encode	197
gnutls_openpgp_cert_set_preferred_key_id	329	gnutls_pem_base64_encode_alloc	197
gnutls_openpgp_cert_verify_ring	329	gnutls_perror	198
gnutls_openpgp_cert_verify_self	329	gnutls_pk_algorithm_get_name	198
gnutls_openpgp_keyring_check_id	329	gnutls_pk_bits_to_sec_param	198
gnutls_openpgp_keyring_deinit	330	gnutls_pk_get_id	198
gnutls_openpgp_keyring_get_cert	330	gnutls_pk_get_name	198
gnutls_openpgp_keyring_get_cert_count	330	gnutls_pk_list	199
gnutls_openpgp_keyring_import	330	gnutls_pkcs11_add_provider	199
gnutls_openpgp_keyring_init	331	gnutls_pkcs11_copy_secret_key	199
gnutls_openpgp_privkey_deinit	331	gnutls_pkcs11_copy_x509_cert	199
gnutls_openpgp_privkey_export	333	gnutls_pkcs11_copy_x509_privkey	200
gnutls_openpgp_privkey_export_dsa_raw	331	gnutls_pkcs11_deinit	200
gnutls_openpgp_privkey_export_rsa_raw	331	gnutls_pkcs11_delete_url	200
gnutls_openpgp_privkey_export_subkey_dsa_raw	332	gnutls_pkcs11_init	200
gnutls_openpgp_privkey_export_subkey_rsa_raw	332	gnutls_pkcs11_obj_deinit	201
gnutls_openpgp_privkey_get_fingerprint	333	gnutls_pkcs11_obj_export	201
gnutls_openpgp_privkey_get_key_id	333	gnutls_pkcs11_obj_export_url	201
gnutls_openpgp_privkey_get_pk_algorithm	334	gnutls_pkcs11_obj_get_info	201
gnutls_openpgp_privkey_get_preferred_key_id	334	gnutls_pkcs11_obj_get_type	202
gnutls_openpgp_privkey_get_revoked_status	334	gnutls_pkcs11_obj_import_url	202
gnutls_openpgp_privkey_get_subkey_count	334	gnutls_pkcs11_obj_init	202
gnutls_openpgp_privkey_get_subkey_creation_time	335	gnutls_pkcs11_obj_list_import_url	202
gnutls_openpgp_privkey_get_subkey_expiration_time	335	gnutls_pkcs11_privkey_deinit	203
gnutls_openpgp_privkey_get_subkey_fingerprint	335	gnutls_pkcs11_privkey_export_url	203
gnutls_openpgp_privkey_get_subkey_id	336	gnutls_pkcs11_privkey_get_info	203
gnutls_openpgp_privkey_get_subkey_idx	335	gnutls_pkcs11_privkey_get_pk_algorithm	203
gnutls_openpgp_privkey_get_subkey_pk_algorithm	336	gnutls_pkcs11_privkey_import_url	204
gnutls_openpgp_privkey_get_subkey_revoked_status	336	gnutls_pkcs11_privkey_init	204
gnutls_openpgp_privkey_import	336	gnutls_pkcs11_set_pin_function	204
gnutls_openpgp_privkey_init	337	gnutls_pkcs11_set_token_function	205
gnutls_openpgp_privkey_sec_param	337	gnutls_pkcs11_token_get_flags	205
gnutls_openpgp_privkey_set_preferred_key_id	337	gnutls_pkcs11_token_get_info	205
gnutls_openpgp_privkey_sign_hash	337	gnutls_pkcs11_token_get_mechanism	205
gnutls_openpgp_send_cert	194	gnutls_pkcs11_token_get_url	206
gnutls_openpgp_set_recv_key_function	338	gnutls_pkcs11_token_init	206
gnutls_pcert_deinit	195	gnutls_pkcs11_token_set_pin	206
gnutls_pcert_import_openpgp	195	gnutls_pkcs12_bag_decrypt	245
gnutls_pcert_import_openpgp_raw	195	gnutls_pkcs12_bag_deinit	245
		gnutls_pkcs12_bag_encrypt	245
		gnutls_pkcs12_bag_get_count	245
		gnutls_pkcs12_bag_get_data	245
		gnutls_pkcs12_bag_get_friendly_name	246
		gnutls_pkcs12_bag_get_key_id	246
		gnutls_pkcs12_bag_get_type	246
		gnutls_pkcs12_bag_init	246
		gnutls_pkcs12_bag_set_crl	247
		gnutls_pkcs12_bag_set_cert	247
		gnutls_pkcs12_bag_set_data	247
		gnutls_pkcs12_bag_set_friendly_name	247
		gnutls_pkcs12_bag_set_key_id	248
		gnutls_pkcs12_deinit	248
		gnutls_pkcs12_export	248

gnutls_pkcs12_generate_mac	248	gnutls_pubkey_export	216
gnutls_pkcs12_get_bag	249	gnutls_pubkey_get_key_id	217
gnutls_pkcs12_import	249	gnutls_pubkey_get_key_usage	217
gnutls_pkcs12_init	249	gnutls_pubkey_get_openpgp_key_id	217
gnutls_pkcs12_set_bag	249	gnutls_pubkey_get_pk_algorithm	218
gnutls_pkcs12_verify_mac	250	gnutls_pubkey_get_pk_dsa_raw	218
gnutls_pkcs7_deinit	250	gnutls_pubkey_get_pk_ecc_raw	218
gnutls_pkcs7_delete_crl	250	gnutls_pubkey_get_pk_rsa_raw	219
gnutls_pkcs7_delete_cert	250	gnutls_pubkey_get_preferred_hash_algorithm	219
gnutls_pkcs7_export	250	gnutls_pubkey_get_verify_algorithm	219
gnutls_pkcs7_get_crl_count	251	gnutls_pubkey_import	221
gnutls_pkcs7_get_crl_raw	251	gnutls_pubkey_import_dsa_raw	219
gnutls_pkcs7_get_cert_count	251	gnutls_pubkey_import_openpgp	220
gnutls_pkcs7_get_cert_raw	251	gnutls_pubkey_import_pkcs11	220
gnutls_pkcs7_import	252	gnutls_pubkey_import_pkcs11_url	220
gnutls_pkcs7_init	252	gnutls_pubkey_import_privkey	221
gnutls_pkcs7_set_crl	252	gnutls_pubkey_import_rsa_raw	221
gnutls_pkcs7_set_crl_raw	252	gnutls_pubkey_import_x509	221
gnutls_pkcs7_set_cert	253	gnutls_pubkey_init	222
gnutls_pkcs7_set_cert_raw	253	gnutls_pubkey_set_key_usage	222
gnutls_prf	207	gnutls_pubkey_verify_data	222
gnutls_prf_raw	206	gnutls_pubkey_verify_data2	222
gnutls_priority_deinit	208	gnutls_pubkey_verify_hash	223
gnutls_priority_init	208	gnutls_record_check_pending	223
gnutls_priority_set	209	gnutls_record_disable_padding	223
gnutls_priority_set_direct	209	gnutls_record_get_direction	223
gnutls_privkey_decrypt_data	209	gnutls_record_get_max_size	224
gnutls_privkey_deinit	209	gnutls_record_recv	224
gnutls_privkey_get_pk_algorithm	210	gnutls_record_recv_seq	224
gnutls_privkey_get_type	210	gnutls_record_send	225
gnutls_privkey_import_openpgp	210	gnutls_record_set_max_size	225
gnutls_privkey_import_pkcs11	210	gnutls_rehandshake	226
gnutls_privkey_import_x509	211	gnutls_rnd	226
gnutls_privkey_init	211	gnutls_rsa_export_get_modulus_bits	226
gnutls_privkey_sign_data	211	gnutls_rsa_export_get_pubkey	226
gnutls_privkey_sign_hash	212	gnutls_rsa_params_cpy	227
gnutls_protocol_get_id	212	gnutls_rsa_params_deinit	227
gnutls_protocol_get_name	212	gnutls_rsa_params_export_pkcs1	227
gnutls_protocol_get_version	212	gnutls_rsa_params_export_raw	227
gnutls_protocol_list	213	gnutls_rsa_params_generate2	228
gnutls_protocol_set_priority	213	gnutls_rsa_params_import_pkcs1	228
gnutls_psk_allocate_client_credentials ..	213	gnutls_rsa_params_import_raw	228
gnutls_psk_allocate_server_credentials ..	213	gnutls_rsa_params_init	229
gnutls_psk_client_get_hint	213	gnutls_safe_renegotiation_status	229
gnutls_psk_free_client_credentials	214	gnutls_sec_param_get_name	229
gnutls_psk_free_server_credentials	214	gnutls_sec_param_to_pk_bits	229
gnutls_psk_server_get_username	214	gnutls_server_name_get	230
gnutls_psk_set_client_credentials	214	gnutls_server_name_set	230
gnutls_psk_set_client_credentials_function	214	gnutls_session_channel_binding	230
gnutls_psk_set_params_function	215	gnutls_session_enable_compatibility_mode	231
gnutls_psk_set_server_credentials_file ..	215	gnutls_session_get_data	231
gnutls_psk_set_server_credentials_function	215	gnutls_session_get_data2	231
gnutls_psk_set_server_credentials_hint ..	216	gnutls_session_get_id	232
gnutls_psk_set_server_dh_params	216	gnutls_session_get_ptr	232
gnutls_psk_set_server_params_function ...	216	gnutls_session_is_resumed	232
gnutls_pubkey_deinit	216	gnutls_session_set_data	232

gnutls_session_set_ptr.....	233	gnutls_x509_crl_get_signature.....	258
gnutls_session_ticket_enable_client.....	233	gnutls_x509_crl_get_signature_algorithm	
gnutls_session_ticket_enable_server.....	233	258
gnutls_session_ticket_key_generate.....	233	gnutls_x509_crl_get_this_update.....	258
gnutls_set_default_export_priority.....	233	gnutls_x509_crl_get_version.....	258
gnutls_set_default_priority.....	234	gnutls_x509_crl_import.....	259
gnutls_sign_algorithm_get_requested.....	234	gnutls_x509_crl_init.....	259
gnutls_sign_callback_get.....	234	gnutls_x509_crl_list_import.....	259
gnutls_sign_callback_set.....	235	gnutls_x509_crl_list_import2.....	259
gnutls_sign_get_id.....	235	gnutls_x509_crl_print.....	260
gnutls_sign_get_name.....	235	gnutls_x509_crl_privkey_sign.....	260
gnutls_sign_list.....	235	gnutls_x509_crl_set_authority_key_id....	261
gnutls_srp_allocate_client_credentials..	236	gnutls_x509_crl_set_cert.....	261
gnutls_srp_allocate_server_credentials..	236	gnutls_x509_crl_set_cert_serial.....	261
gnutls_srp_base64_decode.....	236	gnutls_x509_crl_set_next_update.....	261
gnutls_srp_base64_decode_alloc.....	236	gnutls_x509_crl_set_number.....	262
gnutls_srp_base64_encode.....	237	gnutls_x509_crl_set_this_update.....	262
gnutls_srp_base64_encode_alloc.....	237	gnutls_x509_crl_set_version.....	262
gnutls_srp_free_client_credentials.....	237	gnutls_x509_crl_sign.....	263
gnutls_srp_free_server_credentials.....	237	gnutls_x509_crl_sign2.....	262
gnutls_srp_server_get_username.....	238	gnutls_x509_crl_verify.....	263
gnutls_srp_set_client_credentials.....	238	gnutls_x509_crq_deinit.....	263
gnutls_srp_set_client_credentials_function		gnutls_x509_crq_export.....	264
.....	238	gnutls_x509_crq_get_attribute_by_oid....	264
gnutls_srp_set_prime_bits.....	239	gnutls_x509_crq_get_attribute_data.....	264
gnutls_srp_set_server_credentials_file..	239	gnutls_x509_crq_get_attribute_info.....	265
gnutls_srp_set_server_credentials_function		gnutls_x509_crq_get_basic_constraints...	265
.....	239	gnutls_x509_crq_get_challenge_password..	266
gnutls_srp_verifier.....	240	gnutls_x509_crq_get_dn.....	267
gnutls_strerror.....	240	gnutls_x509_crq_get_dn_by_oid.....	266
gnutls_strerror_name.....	240	gnutls_x509_crq_get_dn_oid.....	266
gnutls_supplemental_get_name.....	241	gnutls_x509_crq_get_extension_by_oid....	267
gnutls_transport_get_ptr.....	241	gnutls_x509_crq_get_extension_data.....	267
gnutls_transport_get_ptr2.....	241	gnutls_x509_crq_get_extension_info.....	268
gnutls_transport_set_errno.....	241	gnutls_x509_crq_get_key_id.....	268
gnutls_transport_set_errno_function.....	241	gnutls_x509_crq_get_key_purpose_oid.....	269
gnutls_transport_set_ptr.....	242	gnutls_x509_crq_get_key_rsa_raw.....	269
gnutls_transport_set_ptr2.....	242	gnutls_x509_crq_get_key_usage.....	269
gnutls_transport_set_pull_function.....	242	gnutls_x509_crq_get_pk_algorithm.....	270
gnutls_transport_set_pull_timeout_function		gnutls_x509_crq_get_subject_alt_name....	270
.....	242	gnutls_x509_crq_get_subject_alt_othername_	
gnutls_transport_set_push_function.....	243	oid.....	271
gnutls_transport_set_vec_push_function..	243	gnutls_x509_crq_get_version.....	271
gnutls_x509_crl_check_issuer.....	253	gnutls_x509_crq_import.....	271
gnutls_x509_crl_deinit.....	253	gnutls_x509_crq_init.....	272
gnutls_x509_crl_export.....	254	gnutls_x509_crq_print.....	272
gnutls_x509_crl_get_authority_key_id....	254	gnutls_x509_crq_privkey_sign.....	272
gnutls_x509_crl_get_cert_count.....	254	gnutls_x509_crq_set_attribute_by_oid....	272
gnutls_x509_crl_get_cert_serial.....	254	gnutls_x509_crq_set_basic_constraints...	273
gnutls_x509_crl_get_dn_oid.....	255	gnutls_x509_crq_set_challenge_password..	273
gnutls_x509_crl_get_extension_data.....	255	gnutls_x509_crq_set_dn_by_oid.....	273
gnutls_x509_crl_get_extension_info.....	256	gnutls_x509_crq_set_key.....	275
gnutls_x509_crl_get_extension_oid.....	256	gnutls_x509_crq_set_key_purpose_oid.....	274
gnutls_x509_crl_get_issuer_dn.....	257	gnutls_x509_crq_set_key_rsa_raw.....	274
gnutls_x509_crl_get_issuer_dn_by_oid....	256	gnutls_x509_crq_set_key_usage.....	274
gnutls_x509_crl_get_next_update.....	257	gnutls_x509_crq_set_pubkey.....	243
gnutls_x509_crl_get_number.....	257	gnutls_x509_crq_set_subject_alt_name....	275
gnutls_x509_crl_get_raw_issuer_dn.....	258	gnutls_x509_crq_set_version.....	275

gnutls_x509_crq_sign.....	276	gnutls_x509 crt_import_pkcs11_url.....	244
gnutls_x509_crq_sign2.....	275	gnutls_x509 crt_init.....	294
gnutls_x509_crq_verify.....	276	gnutls_x509 crt_list_import.....	294
gnutls_x509 crt_check_hostname.....	276	gnutls_x509 crt_list_import_pkcs11.....	244
gnutls_x509 crt_check_issuer.....	277	gnutls_x509 crt_list_import2.....	294
gnutls_x509 crt_check_revocation.....	277	gnutls_x509 crt_list_verify.....	295
gnutls_x509 crt_cpy_crl_dist_points.....	277	gnutls_x509 crt_print.....	295
gnutls_x509 crt_deinit.....	277	gnutls_x509 crt_privkey_sign.....	296
gnutls_x509 crt_export.....	277	gnutls_x509 crt_set_activation_time.....	296
gnutls_x509 crt_get_activation_time.....	278	gnutls_x509 crt_set_authority_key_id.....	296
gnutls_x509 crt_get_authority_key_id.....	278	gnutls_x509 crt_set_basic_constraints...	297
gnutls_x509 crt_get_basic_constraints...	278	gnutls_x509 crt_set_ca_status.....	297
gnutls_x509 crt_get_ca_status.....	279	gnutls_x509 crt_set_crl_dist_points.....	298
gnutls_x509 crt_get_crl_dist_points.....	279	gnutls_x509 crt_set_crl_dist_points2....	297
gnutls_x509 crt_get_dn.....	281	gnutls_x509 crt_set_crq.....	298
gnutls_x509 crt_get_dn_by_oid.....	280	gnutls_x509 crt_set_crq_extensions.....	298
gnutls_x509 crt_get_dn_oid.....	280	gnutls_x509 crt_set_dn_by_oid.....	298
gnutls_x509 crt_get_expiration_time.....	281	gnutls_x509 crt_set_expiration_time.....	299
gnutls_x509 crt_get_extension_by_oid.....	281	gnutls_x509 crt_set_extension_by_oid....	299
gnutls_x509 crt_get_extension_data.....	282	gnutls_x509 crt_set_issuer_dn_by_oid....	299
gnutls_x509 crt_get_extension_info.....	282	gnutls_x509 crt_set_key.....	300
gnutls_x509 crt_get_extension_oid.....	282	gnutls_x509 crt_set_key_purpose_oid.....	300
gnutls_x509 crt_get_fingerprint.....	283	gnutls_x509 crt_set_key_usage.....	300
gnutls_x509 crt_get_issuer.....	286	gnutls_x509 crt_set_proxy.....	301
gnutls_x509 crt_get_issuer_alt_name.....	284	gnutls_x509 crt_set_proxy_dn.....	301
gnutls_x509 crt_get_issuer_alt_name2....	283	gnutls_x509 crt_set_pubkey.....	244
gnutls_x509 crt_get_issuer_alt_othername_		gnutls_x509 crt_set_serial.....	301
oid.....	284	gnutls_x509 crt_set_subject_alt_name....	302
gnutls_x509 crt_get_issuer_dn.....	286	gnutls_x509 crt_set_subject_alternative_	
gnutls_x509 crt_get_issuer_dn_by_oid....	285	name.....	302
gnutls_x509 crt_get_issuer_dn_oid.....	285	gnutls_x509 crt_set_subject_key_id.....	302
gnutls_x509 crt_get_issuer_unique_id....	286	gnutls_x509 crt_set_version.....	303
gnutls_x509 crt_get_key_id.....	287	gnutls_x509 crt_sign.....	303
gnutls_x509 crt_get_key_purpose_oid.....	287	gnutls_x509 crt_sign2.....	303
gnutls_x509 crt_get_key_usage.....	287	gnutls_x509 crt_verify.....	304
gnutls_x509 crt_get_pk_algorithm.....	288	gnutls_x509 crt_verify_data.....	304
gnutls_x509 crt_get_pk_dsa_raw.....	288	gnutls_x509 crt_verify_hash.....	304
gnutls_x509 crt_get_pk_rsa_raw.....	288	gnutls_x509 dn_deinit.....	305
gnutls_x509 crt_get_preferred_hash_		gnutls_x509 dn_export.....	305
algorithm.....	289	gnutls_x509 dn_get_rdn_ava.....	305
gnutls_x509 crt_get_proxy.....	289	gnutls_x509 dn_import.....	305
gnutls_x509 crt_get_raw_dn.....	289	gnutls_x509 dn_init.....	306
gnutls_x509 crt_get_raw_issuer_dn.....	290	gnutls_x509 dn_oid_known.....	306
gnutls_x509 crt_get_serial.....	290	gnutls_x509_privkey_cpy.....	306
gnutls_x509 crt_get_signature.....	290	gnutls_x509_privkey_deinit.....	306
gnutls_x509 crt_get_signature_algorithm		gnutls_x509_privkey_export.....	309
.....	290	gnutls_x509_privkey_export_dsa_raw.....	307
gnutls_x509 crt_get_subject.....	293	gnutls_x509_privkey_export_ecc_raw.....	307
gnutls_x509 crt_get_subject_alt_name....	291	gnutls_x509_privkey_export_pkcs8.....	307
gnutls_x509 crt_get_subject_alt_name2...	291	gnutls_x509_privkey_export_rsa_raw.....	308
gnutls_x509 crt_get_subject_alt_othername_		gnutls_x509_privkey_export_rsa_raw2....	308
oid.....	292	gnutls_x509_privkey_fix.....	309
gnutls_x509 crt_get_subject_key_id.....	292	gnutls_x509_privkey_generate.....	309
gnutls_x509 crt_get_subject_unique_id...	292	gnutls_x509_privkey_get_key_id.....	310
gnutls_x509 crt_get_verify_algorithm....	293	gnutls_x509_privkey_get_pk_algorithm....	310
gnutls_x509 crt_get_version.....	293	gnutls_x509_privkey_import.....	312
gnutls_x509 crt_import.....	294	gnutls_x509_privkey_import_dsa_raw....	310
gnutls_x509 crt_import_pkcs11.....	244	gnutls_x509_privkey_import_ecc_raw....	311

<code>gnutls_x509_privkey_import_pkcs8</code>	311	<code>gnutls_x509_trust_list_add_cas</code>	315
<code>gnutls_x509_privkey_import_rsa_raw</code>	312	<code>gnutls_x509_trust_list_add_crls</code>	315
<code>gnutls_x509_privkey_import_rsa_raw2</code>	312	<code>gnutls_x509_trust_list_add_named_cert</code>	316
<code>gnutls_x509_privkey_init</code>	313	<code>gnutls_x509_trust_list_deinit</code>	316
<code>gnutls_x509_privkey_sec_param</code>	313	<code>gnutls_x509_trust_list_get_issuer</code>	316
<code>gnutls_x509_privkey_sign_data</code>	313	<code>gnutls_x509_trust_list_init</code>	317
<code>gnutls_x509_privkey_sign_hash</code>	314	<code>gnutls_x509_trust_list_verify_cert</code>	317
<code>gnutls_x509_rdn_get</code>	315	<code>gnutls_x509_trust_list_verify_named_cert</code>	317
<code>gnutls_x509_rdn_get_by_oid</code>	314		
<code>gnutls_x509_rdn_get_oid</code>	314		

Concept Index

A

Abstract types	45
Alert protocol	11
Anonymous authentication	24

B

Bad record MAC	10
----------------------	----

C

Callback functions	5
Certificate authentication	29
Certificate requests	35
certtool	115
Channel bindings	111
Ciphersuites	339
Client Certificate authentication	16
Compression algorithms	10
Contributing	142

D

debug server	124
Digital signatures	46
Download	141

E

Error codes	144
Example programs	48
Exporting keying material	111

F

FDL, GNU Free Documentation License	344
Function reference	152

G

Generating parameters	110
gnutls-cli	120
gnutls-cli-debug	122
GnuTLS-extra functions	318
gnutls-serv	123

H

Hacking	142
Handshake protocol	12
Hardware tokens	41
HTTPS server	124

I

Installation	141
Internal architecture	130

K

key sizes	19
Keying material exporters	111

M

Maximum fragment length	17
-------------------------------	----

O

OpenPGP functions	318
OpenPGP keys	22, 40
OpenPGP server	95
OpenSSL	112

P

p11tool	128
Parameter generation	110
PCT	21
PKCS #10	35
PKCS #11 tokens	41
PKCS #12	37
PSK authentication	26
PSK client	122
PSK server	127
psktool	127

R

Record padding	10
Record protocol	7
renegotiation	18
Reporting Bugs	142
Resuming sessions	16

S

Server name indication	17
Session tickets	18
SRP authentication	25
srptool	127
SSL 2	21
Symmetric encryption algorithms	8

T

Ticket	18
--------------	----

TLS extensions 17, 18
TLS layers 6
Transport layer 6
Transport protocol 6

V

Verifying certificate paths 31

X

X.509 certificates 22, 29
X.509 Functions 245