ESP8266 SSL User Manual

Version 1.1

Espressif Systems IOT Team

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1. Preambles

Herein we introduce ESP8266 SDK SSL user manual, includes that ESP8266 runs as SSL server and ESP8266 runs as SSL client.

SSL function requires a lot of RAM memory, users need to make sure that there is enough space before running the application. If SSL buffer is set to be 8KB by `espconn_secure_set_size`, SSL function requires 22KB at least, it depends on the size of certificate from SSL server.

More information about ESP8266 is on BBS：http://bbs.espressif.com/

2. ESP8266 as SSL server

Sample code of ESP8266 running as SSL server is in IOT_Demo marked with `#define SERVER_SSL_ENABLE`. Espressif Systems offers a script "**makefile.sh**" to generate the ".h" header files which are needed when ESP8266 running as SSL server.

CA verify function default to be disabled, user can enable it by `espconn_secure_ca_enable`.

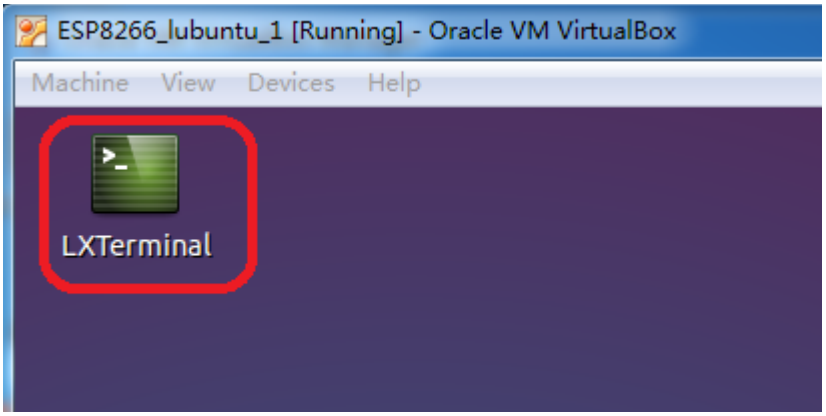
2.1. Generate certificate

(1) Copy script "makefile.sh" to the shared folder of virtual box lubuntu.

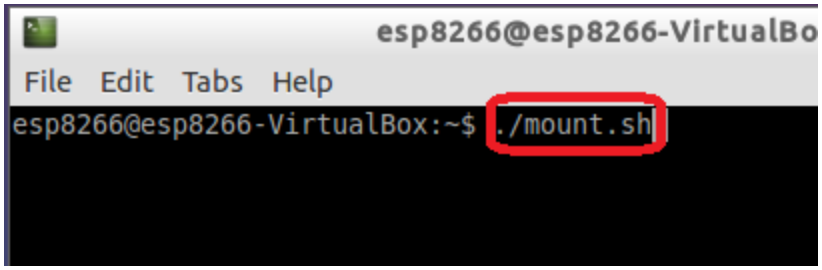
- How to set up the lubuntu compile environment, please refer to BBS： http://bbs.espressif.com/viewtopic.php?f=21&t=86

(2) Mount the shared folder

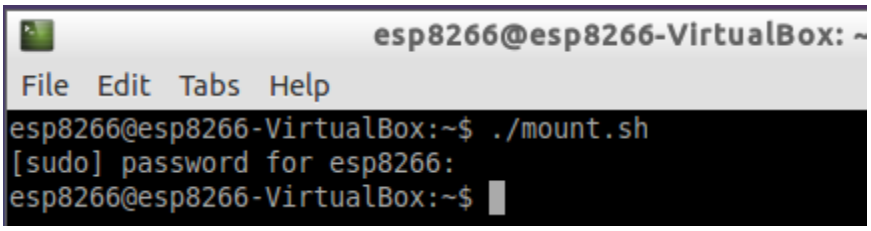
- Open "LXTerminal" in virtual box



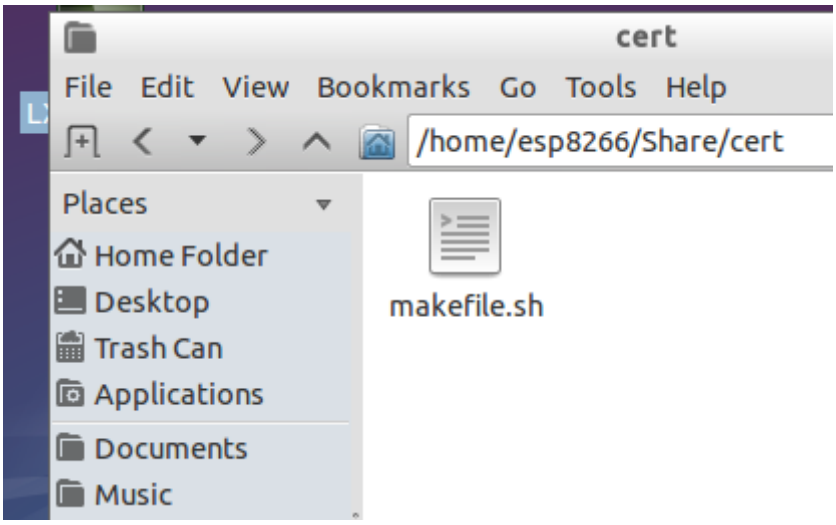
- input command `./mount.sh`



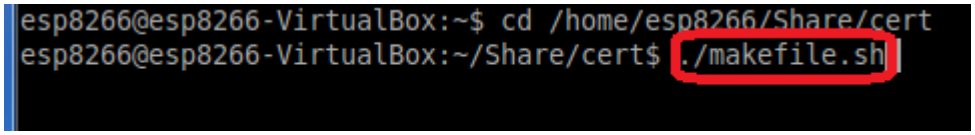
- input password: **espressif**



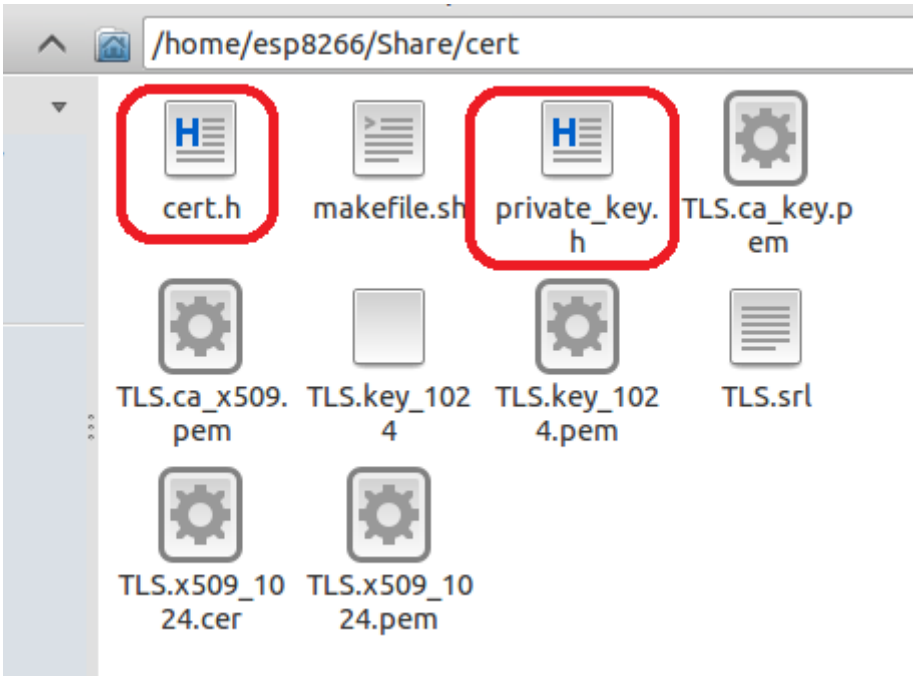
(3) Open shared folder in virtual box, and get script "makefile.sh" there.



(4) Input command `./makefile.sh` to run script "makefile.sh" there.



Generate `cert.h` and `private_key.h`, using these 2 header files according to IOT_Demo:



Notice:

- IP address in script "makefile.sh" need to be user's actual SSL server IP

```
cat > certs.conf << EOF
[ req ]
distinguished_name     = req_distinguished_name
prompt                 = no

[ req_distinguished_name ]
 O                      = $PROJECT_NAME
 CN                     = 127.0.0.1
EOF
```

- Script "makefile.sh" default to use 1024bit encryption algorithm, if user needs to use 512bit encryption algorithm, please revise script "makefile.sh", change the 1024 to 512.

```
# private key generation
openssl genrsa -out TLS.ca_key.pem 1024
openssl genrsa -out TLS.key_1024.pem 1024

# convert private keys into DER format
openssl rsa -in TLS.key_1024.pem -out TLS.key_1024 -outform DER

# cert requests
openssl req -out TLS.ca_x509.req -key TLS.ca_key.pem -new \
            -config ./ca_cert.conf
openssl req -out TLS.x509_1024.req -key TLS.key_1024.pem -new \
            -config ./certs.conf

# generate the actual certs.
openssl x509 -req -in TLS.ca_x509.req -out TLS.ca_x509.pem \
            -sha1 -days 5000 -signkey TLS.ca_key.pem
openssl x509 -req -in TLS.x509_1024.req -out TLS.x509_1024.pem \
            -sha1 -CAcreateserial -days 5000 \
            -CA TLS.ca_x509.pem -CAkey TLS.ca_key.pem

# some cleanup
rm TLS*.req
rm *.conf

openssl x509 -in TLS.ca_x509.pem -outform DER -out TLS.ca_x509.cer
openssl x509 -in TLS.x509_1024.pem -outform DER -out TLS.x509_1024.cer

#
# Generate the certificates and keys for encrypt.
#
```

- Certificates generated above is issued by Espressif Systems, not CA. So if users need CA verify, there are 2 methods :
  - Add `TLS.ca_x509.cer` which generated as above into SSL client's trust anchor, then generate `esp_ca_cert.bin` by script "**make_cert.py**" according to **3.1 Generate CA Certificate**, and download `esp_ca_cert.bin` into flash
  - Using CA certificate to generate `cert.h` and `private_key.h`, this needs user to revise script "**makefile.sh**" themselves. Then generate `esp_ca_cert.bin` by script "**make_cert.py**" according to **3.1 Generate CA Certificate**, and download `esp_ca_cert.bin` into flash

3. ESP8266 as SSL client

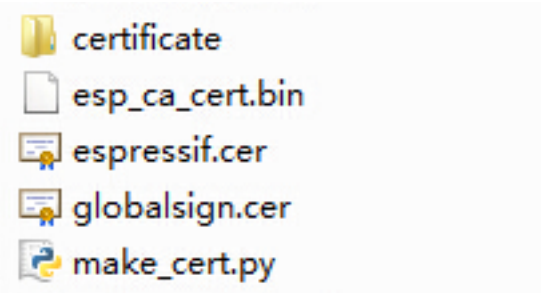
Sample code of ESP8266 running as SSL client is in IOT_Demo marked with `#define CLIENT_SSL_ENABLE`. Espressif Systems offers a script "**make_cert.py**" to generate CA certificate.

CA verify function default to be disabled, user can enable it by `espconn_secure_ca_enable`.

3.1. Generate CA Certificate

(1) Put script "make_cert.py" and CA certificate into the same folder.

(2) Run script "make_cert.py" to generate `esp_ca_cert.bin` which contains all CA certificates (2 CA certificates at most) in the same folder. Download address of `esp_ca_cert.bin` depends on `espconn_secure_ca_enable`.



3.2. CA Verify

STEP 1: ESP8266 connects to server, read `esp_ca_cert.bin` from flash, get the corresponding SSL ctx. Only 2 CA certificates is allowed at most.

STEP 2: ESP8266 starts TLS handshake, get certificate from SSL server, check with the CA in step 1:

- if CA check fail, connection break;
- if succeed, CA verify pass.

4. Software APIs

SSL related APIs are different from normal TCP APIs, so please don't mixed use. In SSL connection, only APIs below can be called:

- espconn_secure_XXX APIs which are SSL related APIs
- `espconn_regist_XXX` APIs to register callbacks
- `espconn_port` to get an available port

Herein we only introduce `espconn_secure_XXX` APIs, more details about software APIs, please refer to documentation "2C-ESP8266__SDK__Programming Guide"

Here is a demo of SSL connection on BBS http://bbs.espressif.com/viewtopic.php?f=21&t=389

4.1. espconn_secure_ca_disable

Function:

Disable SSL CA (certificate authenticate) function

Note:

- CA function is disabled by default,
- If user want to call this API, please call it before
  `espconn_secure_accept` (ESP8266 as TCP SSL server) or
  `espconn_secure_connect` (ESP8266 as TCP SSL client)

Prototype:

```
bool espconn_secure_ca_disable (uint8 level)
```

Parameter:

`uint8 level` : set configuration for ESP8266 SSL server/client:

- `0x01` SSL client;
- `0x02` SSL server;
- `0x03` both SSL client and SSL server

Return:

true : succeed
false : fail

4.2. espconn_secure_ca_enable

Function:

Enable SSL CA (certificate authenticate) function

Note:

- CA function is disabled by default
- If user want to call this API, please call it before espconn_secure_accept (ESP8266 as TCP SSL server) or espconn_secure_connect (ESP8266 as TCP SSL client)

Prototype:

```
bool espconn_secure_ca_enable (uint8 level, uint16 flash_sector)
```

Parameter:

uint8 level : set configuration for ESP8266 SSL server/client:

0x01 SSL client;

0x02 SSL server;

0x03 both SSL client and SSL server

uint16 flash_sector : flash sector in which CA (esp_ca_cert.bin) is downloaded. For example, flash_sector is 0x3B, then esp_ca_cert.bin need to download into flash 0x3B000

Return:

true : succeed

false : fail

4.3. espconn_secure_accept

Function:

Creates an SSL TCP server.

Note:

- Only created one SSL server is allowed, this API can be called only once, and only one SSL client is allowed to connect.

- If SSL encrypted packet size is larger than ESP8266 SSL buffer size (default 2KB, set by espconn_secure_set_size), SSL connection will fail, will enter espconn_reconnect_callback

Prototype:

sint8 espconn_secure_accept(struct espconn *espconn)

Parameter:

struct espconn *espconn : corresponding connected control block structure

Return:

0 : succeed

Non-0 : error code

ESPCONN_MEM – Out of memory

ESPCONN_ISCONN – Already connected

ESPCONN_ARG – illegal argument, can't find TCP connection according to structure espconn

4.4. espconn_secure_set_size

Function:

Set buffer size of encrypted data (SSL)

Note:

Buffer size default to be 2Kbytes. If need to change, please call this API before espconn_secure_accept (ESP8266 as TCP SSL server) or espconn_secure_connect (ESP8266 as TCP SSL client)

Prototype:

bool espconn_secure_set_size (uint8 level, uint16 size)

Parameters:

uint8 level : set buffer for ESP8266 SSL server/client:

0x01 SSL client;

0x02 SSL server;

```
                    0x03  both SSL client and SSL server
    uint16 size : buffer size, range: 1 ~ 8192, unit: byte, default is
    2048

Return:
    true   : succeed
    false  : fail
```

4.5. espconn_secure_get_size

```
Function:
    Get buffer size of encrypted data (SSL)

Prototype:
    sint16 espconn_secure_get_size (uint8 level)

Parameters:
    uint8 level : buffer for ESP8266 SSL server/client:
                    0x01  SSL client;
                    0x02  SSL server;
                    0x03  both SSL client and SSL server

Return:
    buffer size
```

4.6. espconn_secure_connect

```
Function:
    Secure connect (SSL) to a TCP server (ESP8266 is acting as TCP
    client.)

Note:
    • Only one connection is allowed when ESP8266 as SSL client, please
      call espconn_secure_disconnect first, if you want to create
      another SSL connection.
```

- If SSL encrypted packet size is larger than ESP8266 SSL buffer size (default 2KB, set by espconn_secure_set_size), SSL connection will fail, will enter espconn_reconnect_callback

Prototype:

```
sint8 espconn_secure_connect (struct espconn *espconn)
```

Parameters:

struct espconn *espconn : corresponding connected control block structure

Return:

0 : succeed

Non-0 : error code

ESPCONN_MEM – Out of memory

ESPCONN_ISCONN – Already connected

ESPCONN_ARG – illegal argument, can't find TCP connection according to structure espconn

4.7. espconn_secure_send

Function: send encrypted data (SSL)

Note:

Please call espconn_secure_send after espconn_sent_callback of the pre-packet.

Prototype:

```
sint8 espconn_secure_send (
        struct espconn *espconn,
        uint8 *psent,
        uint16 length
)
```

Parameters:

struct espconn *espconn : corresponding connected control block structure

uint8 *psent : sent data pointer

uint16 length : sent data length

Return:

0 : succeed

Non-0 : error code ESPCONN_ARG – illegal argument, can't find TCP connection according to structure espconn

4.8. espconn_secure_disconnect

Function: secure TCP disconnection(SSL)

Prototype:

```
sint8 espconn_secure_disconnect(struct espconn *espconn)
```

Parameters:

struct espconn *espconn : corresponding connected control block structure

Return:

0 : succeed

Non-0 : error code ESPCONN_ARG – illegal argument, can't find TCP connection according to structure espconn