ATWINC15x0

Transport Layer Security (TLS) User's Guide

Introduction

This user's guide describes the ATWINC1500 Wi-Fi Network Controller to build state-of-the-art Internet of Things (IoT) applications.

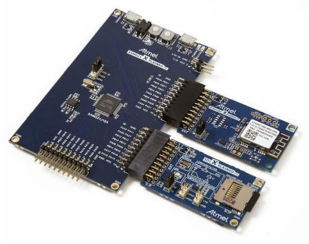
The following topics will be covered:

- How examples are organized
- Target board information
- Instructions for each example
- TLS 1.2 supported cipher suites
- Certificate Installation on ATWINC1500
- ATECC508 crypto device support

Prerequisites

- Hardware Prerequisites:
  - SAM D21 Xplained Pro Evaluation Kit
  - ATWINC1500 extension
  - Micro-USB Cable (Micro-A/Micro-B)
- Software Prerequisites:
  - Atmel Studio 7.0
  - Wi-Fi® TLS TCP Server application

Figure 1. SAM D21 XSTK Board Demo Setup



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1. Overview

The ATWINC1500 features an embedded low-memory footprint TLS protocol stack bundled within the ATWINC1500 firmware.

The following features are supported:

- TLS versions TLS1.0, TLS1.1 and TLS1.2
- TLS client operation with TLS client authentication
- TLS server mode

The TLS stack has a simple application interface. TLS functionality is abstracted by the socket interface of the ATWINC1500, thereby hiding the implementation complexity from the application developer and minimizing the porting effort of plain TCP code to TLS.

1.1 TLS Supported Ciphers

ATWINC1500 supports the following cipher suites (for both Client and Server modes):

1. TLS_DHE_RSA_WITH_AES_128_GCM_SHA256
2. TLS_RSA_WITH_AES_128_GCM_SHA256
3. TLS_DHE_RSA_WITH_AES_128_CBC_SHA
4. TLS_DHE_RSA_WITH_AES_128_CBC_SHA256
5. TLS_RSA_WITH_AES_128_CBC_SHA
6. TLS_RSA_WITH_AES_128_CBC_SHA256

Optionally supports ECC cipher suites:

1. TLS_ECDHE_RSA_WITH_AES_128_GCM_SHA256
2. TLS_ECDHE_RSA_WITH_AES_128_CBC_SHA
3. TLS_ECDHE_RSA_WITH_AES_128_CBC_SHA256
4. TLS_ECDHE_ECDSA_WITH_AES_128_GCM_SHA256
5. TLS_ECDHE_ ECDSA _WITH_AES_128_CBC_SHA256

1.2 TLS Certificate Store on ATWINC1500 Stacked Flash

For proper operation of both the TLS server and TLS client authentication, the ATWINC1500 device must have a certificate/private key pair assigned to it.

An 8KB flash area is reserved for storing the TLS certificates starting from offset 20KB in the ATWINC1500 stacked flash.

1.3 TLS Certificate Constraints

For TLS server and TLS client authentication, ATWINC1500 accepts the following certificate types:

- RSA certificates with a key size no greater than 2048 bits
- ECDSA certificates for NIST P256 EC Curve (secp256r1) only (conditionally supported)

2. TLS Certificate Installation

TLS certificate data is installed on the ATWINC1500 stacked flash by using either the `image_builder.exe` tool or the dedicated tool `tls_cert_flash_tool.exe`.

The following subsections describe both approaches.

Note: The `tls_cert_flash_tool` is invoked from `download_all.bat` after the firmware image is downloaded to the flash (like the `root_certificate_downloader` tool). So, the `download_all.bat` may be edited to change this behavior or change the file paths.

2.1 Certificate Installation (`tls_cert_flash_tool` Write)

The `tls_cert_flash_tool` writes the certificate data on the ATWINC1500 stacked flash directly (similar to the `root_certificate_downloader` tool). It patches an existing ATWINC1500 binary firmware image file.

By default, the tool writes to the flash. If a firmware image file is specified, the tool will patch the provided image file.

2.1.1 Syntax

The following figure describes the usage of the <`Write`> command.

```
Write X.509 Certificate chain on WINC Device Flash or a given WINC firmware
image file
 [Usage]: tls_cert_flash_tool.exe write [options]
 where options are:
 -key file      Private key in PEM format (RSA Keys only). It MUST NOT be
                encrypted.
 -nokey         The private key is not present. This is meaningful if a the
                private key is hidden into a secure hardware. This is the
                typical case of using ECC508 for ECC secure key storage
 -cert file     X.509 Certificate file in PEM or DER format. The certificate
                SHALL contain the public key associated with the given
                private key (If the private key is given).
 -cadir path    [Optional] Path to a folder containing the intermediate CAs
                and the Root CA of the given certificate.
 -fwimg path    [Optional] Path to the firmware binary image file.
                If this option is not given, the keys shall be written
                directly on the WINC Device Flash
 -erase         Erase the certificate store before writing. If this option is
                not given, the new certificate data is appended to the
                certificate store

  Examples
    tls_cert_flash_tool.exe Write -key rsa.key -cert rsa.cer -erase
    tls_cert_flash_tool.exe Write -nokey -cert ecdsa.cer -cadir CADir
    tls_cert_flash_tool.exe Write -key rsa.key -cert rsa.cer -cadir CADir
    tls_cert_flash_tool.exe Write -key rsa.key -cert rsa.cer -fwimg
m2m_aio_3a0.bin
```

2.1.2 Command Line Parameters

Option	Type	M/C/O	Description
-erase	—	O	Clear the TLS certificate section before writing the supplied data. If this option is not specified, the TLS Certificate section will be updated (the new certificate data is appended to the section).
-key <file>	File in PEM format	C	Private key file for the device. The tool can parse only RSA private keys. This is a conditional option (it MUST exist for an RSA certificate chain).
-nokey	—	C	No private key file is supplied to the tool. This is the useful when using a secure storage for private keys (the case of ATECC508).
-cert <file>	File in PEM or DER format	M	An X.509 end user certificate issued for the ATWINC1500 device. It must be associated with the given private key file (the certificate binds the public key that corresponds to the given private key).
-cadir <dir>	Folder	O	A directory (or folder) containing intermediate CA certificates and/or the Root CA certificate of the ATWINC1500 certificate chain(s).
-fwimg <file>	FW Bin IMG	O	Specifies a ATWINC1500 firmware All-in-One (AIO) image file (m2m_aio_3a0.bin) to patch. If this option is not specified, the tool will attempt to write on the ATWINC1500 stacked flash.

Note: For certificate chains with a depth larger than 1 (the End User Certificate is signed with an intermediate CA certificate rather than the Root Certificate directly), the -cadir option must be given with the directory containing the valid Intermediate CA certificate file(s). If this is not done, the connection may be refused by the server when TLS client authentication is used.

2.1.3 Typical Usage Scenarios

The `tls_cert_flash_tool` is not designed as a general purpose certificate conversion tool. It is intended to support the following use cases:

1. RSA authentication only (i.e., an RSA certificate with its private key is installed)
2. ECDSA authentication only (i.e., an ECDSA certificate is installed)
3. Both RSA and ECDSA are supported on the device, and therefore both certificates are installed

The following subsections illustrate using the tool in the three cases.

2.1.3.1 RSA Authentication Only

Install an RSA Certificate along with its private key (write directly on the ATWINC1500 stacked flash).

```
tls_cert_flash_tool.exe WRITE -key rsa.key -cert rsa.cer –cadir CA –erase
```

Install an RSA Certificate along with its private key (patch an existing ATWINC1500 device firmware image file).

```
tls_cert_flash_tool.exe write -key rsa.key -cert rsa.cer –erase –fwimg
m2m_aio_3a0.bin
```

2.1.3.2 ECDSA Authentication Only

Install an ECDSA certificate with no private key supplied (write directly on the ATWINC1500 stacked flash).

```
tls_cert_flash_tool.exe write -nokey -cert ecdsa.cer –cadir CA –erase
```

Install an ECDSA certificate (patch an existing ATWINC1500 device firmware image file).

```
tls_cert_flash_tool.exe -nokey -cert ecdsa.cer –cadir CA –erase –fwimg
m2m_aio_3a0.bin
```

2.1.3.3 Both ECDSA and RSA Authentication

```
tls_cert_flash_tool.exe write -key rsa.key -cert rsa.cer –cadir CA –erase
```

```
tls_cert_flash_tool.exe write -nokey -cert ecdsa.cer –cadir CA
```

2.2 Certificate Read (`tls_cert_flash_tool` Read)

```
Read X.509 Certificate chain from WINC Device Flash or a given WINC firmware
image file

 [Usage]: tls_cert_flash_tool.exe read [options]
 where options are:
 -rsa           Print WINC Device RSA certificate (if any)
 -ecdsa         Print WINC Device ECDSA certificate (if any)
 -dir           List all files in the WINC TLS Certificate Store associated
                with the selected authentication (rsa or ecdsa or both)
 -fwimg path    [Optional] Path to the firmware binary image file.
                If this option is not given, the certificates shall be read
                directly from the WINC Device Flash
 -out path      A path to a directory where the certificates will be saved.
This
                option forces the certificates to be written in files. If
this option
                is not specified, the certificates shall be printed on
standard out.
 -all           Dump all certificates in the WINC certificate chain
provisioned on WINC
                (if any) in addition to the WINC Device certificate.
 -privkey       Print the RSA private key (if -rsa option is given) to the
standard out.
                The RSA private dumping is off by default.

  Examples
    tls_cert_flash_tool.exe read -rsa -privkey -dir
    tls_cert_flash_tool.exe read -rsa -all
    tls_cert_flash_tool.exe read -rsa -out C:/Certs/
    tls_cert_flash_tool.exe read -rsa -ecdsa -dir-fwimg m2m_aio_3a0.bin
```

Option	Type	M/C/O	Description
-rsa	—	O	Print the ATWINC1500 device RSA certificate
-ecdsa	—	O	Print the ATWINC1500 device ECDSA certificate
-dir	—	O	List all files in the ATWINC1500 TLS certificate store associated with the selected authentication (RSA or ECDSA or both)
-out <dir>	Path to a folder	O	A directory (or folder) in which the tool will write the certificate files
-all	—	O	A directory (or folder) containing intermediate CA certificates and/or the Root CA certificate of the ATWINC1500 certificate chain(s)

-fwimg <file>	FW Bin IMG	O	Specifies a ATWINC1500 firmware All-in-One (AIO) image file (m2m_aio_3a0.bin) to patch. If this option is not specified, the tool will attempt to write on the ATWINC1500 stacked flash
-privkey	—	O	Force private key printing. If not specified, the private key will not be printed

2.3 Using image_builder Tool to Install Certificates

The `image_builder` tool can compile the TLS certificate data into the ATWINC1500 firmware image file when it builds the All-in-One image (*m2m_aio_3a0.bin*).

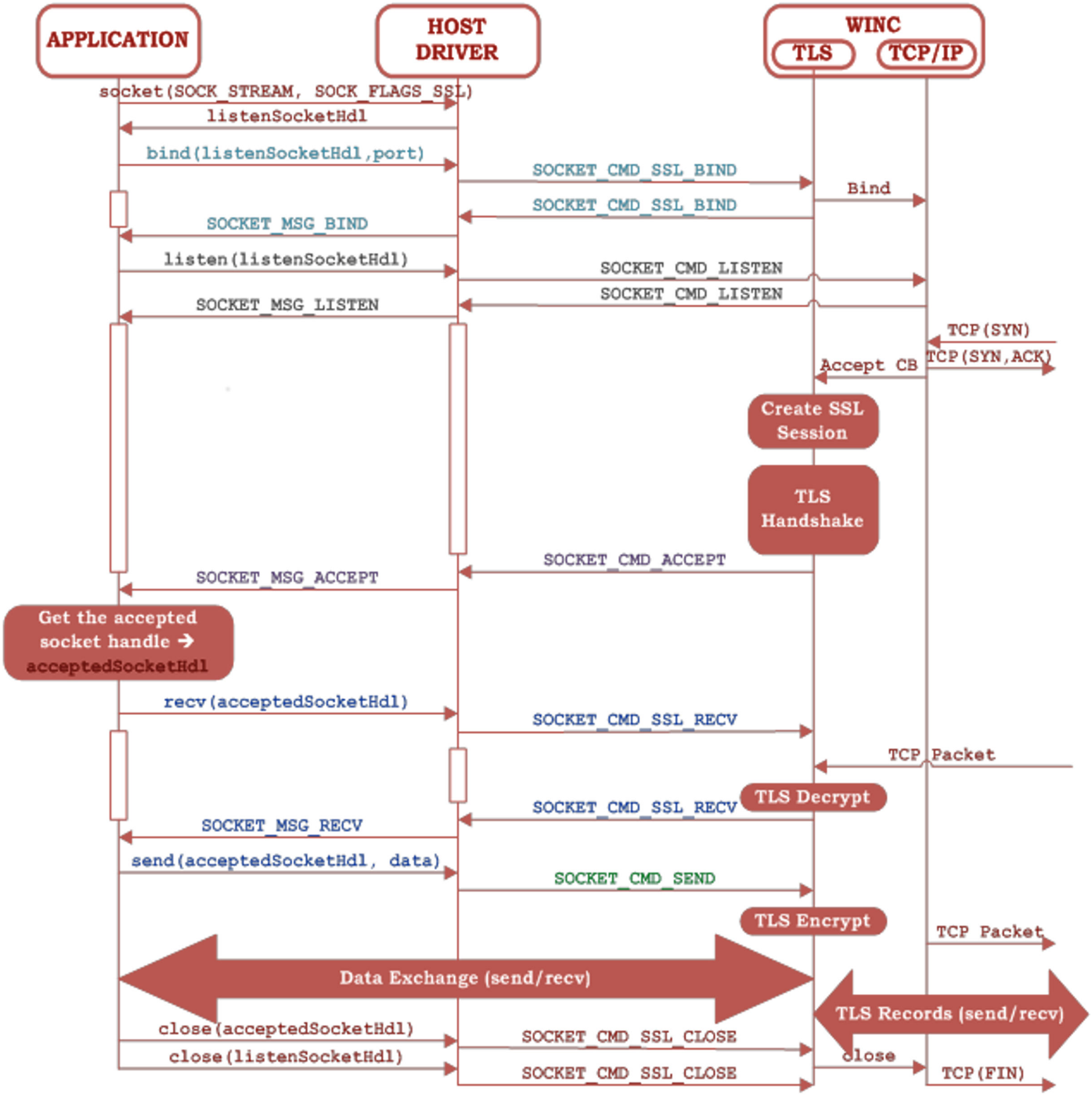
ATWINC1500 sample certificates are available in ASF under the “WINC1500_FIRMWARE_UPDATE_PROJECT\src\firmware\tls_cert_store” for demo purposes.

3. TLS Server APIs

From the application's point of view, the TLS functionality is wrapped behind the socket APIs. This hides the complexity of TLS from the application, which can use the TLS in the same fashion as that of the TCP (non-TLS) server. The main difference between TLS sockets and regular TCP sockets is that the application sets the `SOCKET_FLAGS_SSL` while creating the TLS server listening socket. The detailed sequence of the TLS connection establishment is described in the figure below.

For proper TLS server operation, ensure that both the `SOCKET_FLAGS_SSL` flag and the correct port number are set in the TLS server application. For instance, an HTTP server application cannot use flags while calling the socket API function and bind to port 80. The same application source code becomes an HTTPS server application if you use the flag `SOCKET_FLAGS_SSL` and change the port number to bind to port 443.

Figure 3-1. TLS Server Connection Flow



4. Document Version History

Revision A (April 2017)

- Initial release.

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