

Application Note

AZURE_prov_X.509

Example

Version 1.0.0



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1 Introduction

This Application Note covers the implementation of AZURE prov X.509 authentication and the generation of X.509 certificates on WIZnet's TOE Chip.

2 Github Link

<https://github.com/WIZnet-ioNIC/WIZnet-PICO-AZURE-C.git>

3 Applicable products

[Raspberry Pi Pico & WIZnet Ethernet HAT](#)

[W5100S-EVB-Pico](#)

[W5500-EVB-Pico](#)

[W55RP20-EVB-Pico](#)

[W5100S-EVB-Pico2](#)

[W5500-EVB-Pico2](#)

4 How to Test AZURE prov X.509 Example

4.1 Step 1: Prepare software

The following serial terminal program is required for AZURE prov X.509 example test, download and install from below links.

- [Tera Term](#)

4.2 Step 2: Prepare hardware

If you are using W5100S-EVB-Pico, W5500-EVB-Pico, W55RP20-EVB-Pico, W5100S-EVB-Pico2 or W5500-EVB-Pico2, you can skip '1. Combine...'

1. Combine WIZnet Ethernet HAT with Raspberry Pi Pico.
2. Connect ethernet cable to WIZnet Ethernet HAT, W5100S-EVB-Pico, W5500-EVB-Pico, W55RP20-EVB-Pico, W5100S-EVB-Pico2 or W5500-EVB-Pico2 ethernet port.
3. Connect Raspberry Pi Pico, W5100S-EVB-Pico or W5500-EVB-Pico to desktop or laptop using 5 pin micro USB cable. W55RP20-EVB-Pico, W5100S-EVB-Pico2 or W5500-EVB-Pico2 require a USB Type-C cable.

4.3 Step 3: Setup AZURE prov X.509 Example

To test the AZURE prov X.509 example, minor settings shall be done in code.

1. Setup SPI port and pin in 'w5x00_spi.h' in 'WIZnet-PICO-AZURE-C/port/ioLibrary_Driver/' directory.

Setup the SPI interface you use.

- If you use the W5100S-EVB-Pico, W5500-EVB-Pico, W5100S-EVB-Pico2 or W5500-EVB-Pico2,

```
/* SPI */
#define SPI_PORT spi0

#define PIN_SCK 18
#define PIN_MOSI 19
#define PIN_MISO 16
#define PIN_CS 17
#define PIN_RST 20
```

- If you want to test with the AZURE prov X.509 example using SPI DMA, uncomment USE_SPI_DMA.

```
/* Use SPI DMA */
//#define USE_SPI_DMA // if you want to use SPI DMA, uncomment.
```

- If you use the W55RP20-EVB-Pico,

```
/* SPI */
#define USE_SPI_PIO

#define PIN_SCK 21
#define PIN_MOSI 23
#define PIN_MISO 22
#define PIN_CS 20
#define PIN_RST 25
```

2. In 'WIZnet-PICO-AZURE-C/examples/main.c', uncomment APP_PROV_X509 to choose the sample application.

```
(...)
```

```
// The application you wish to use should be uncommented
//
//#define APP_TELEMETRY
//#define APP_C2D
//#define APP_CLI_X509
#define APP_PROV_X509
```

3. Setup network configuration such as IP in 'main.c', which is the AZURE prov X.509 example in 'WIZnet-PICO-AZURE-C/examples/' directory.
 - Setup IP, other network settings to suit your network environment.

```
// The application you wish to use DHCP mode should be uncommented
#define _DHCP
static wiz_NetInfo g_net_info =
{
    .mac = {0x00, 0x08, 0xDC, 0x12, 0x34, 0x56}, // MAC address
    .ip = {192, 168, 11, 2}, // IP address
    .sn = {255, 255, 255, 0}, // Subnet Mask
    .gw = {192, 168, 11, 1}, // Gateway
    .dns = {8, 8, 8, 8}, // DNS server
#ifdef _DHCP
    .dhcp = NETINFO_DHCP // DHCP enable/disable
#else
    // this example uses static IP
    .dhcp = NETINFO_STATIC
#endif
};
```

4.4 Step 4: Setup Device self-signed certificates

Please follow up [tutorial-x509-self-sign](#).

1. For your reference, prepare example log as below:

Notice! device ID = "W5100S_EVB_PICO_PROV_X509"

- At last stage, you need to run the following command for making .pem file.

```
MINGW64 ~/certi
$ openssl genpkey -out prov_device1.key -algorithm RSA -pkeyopt
rsa_keygen_bits:2048
.....+++++
.....+++++

MINGW64 ~/certi
$ openssl req -new -key prov_device1.key -out prov_device1.csr
You are about to be asked to enter information that will be incorporated
into your certificate request.
What you are about to enter is what is called a Distinguished Name or a
DN.
There are quite a few fields but you can leave some blank
For some fields there will be a default value,
If you enter '.', the field will be left blank.
-----
Country Name (2 letter code) [AU]:.
State or Province Name (full name) [Some-State]:.
Locality Name (eg, city) []:.
Organization Name (eg, company) [Internet Widgits Pty Ltd]:.
Organizational Unit Name (eg, section) []:.
Common Name (e.g. server FQDN or YOUR name) []:W5100S_EVB_PICO_PROV_X509
Email Address []:

Please enter the following 'extra' attributes
to be sent with your certificate request
A challenge password []:
An optional company name []:

MINGW64 ~/certi
$ openssl x509 -req -days 365 -in prov_device1.csr -signkey
prov_device1.key -out prov_device1.crt
Signature ok
subject=CN = W5100S_EVB_PICO_PROV_X509
Getting Private key

MINGW64 ~/certi
$ openssl x509 -in prov_device1.crt -out prov_device1.pem -outform PEM

MINGW64 ~/certi
$ ls
prov_device1.crt  prov_device1.key  prov_device1.csr  prov_device1.pem

MINGW64 ~/certi
$
```

2. Get the key value from files (prov_device1.crt, prov_device1.key) as below:
edit 'WIZnet-PICO-AZURE-C/exmaples/sample_certs.c' with generated certificates as upper.
 - For common name, Use "W5100S_EVB_PICO_PROV_X509" used in key generation.
 - pico_az_CERTIFICATE and pico_az_PRIVATE_KEY use key value from files (prov_device1.crt, prov_device1.key)
 - 'pico_az_id_scope' use "ID Scope" string from [Step 5](#).
 - pico_az_COMMON_NAME use "device ID" from [Step 4](#).

```
const char pico_az_id_scope[] = "0ne00xxxx5A";

const char pico_az_COMMON_NAME[] = "W5100S_EVB_PICO_PROV_X509";

const char pico_az_CERTIFICATE[] =
"-----BEGIN CERTIFICATE-----" "\n"
"MIIDrTCCApUCFG9+k0lk2I815L5XAGBX7DXNxGE+MA0GCSqGSIb3DQEBCwUAMIGS""\n"
"MQswCQYDVQQGEwJLUjEUMBIGA1UECAwLR3llb25nZ2ktZG8xFDASBgNVBACMC1Nl""\n"
"...
"AwyXH6BP1QhBylsB4J5psW9ptDNKDPwF5q9cC+UiER8nSoqo0nQkB/MFSqwpZ/t0""\n"
"F7Yi3Fh/3z0iiT3qJGbFq5hU6b+AWLFjEBf4STahh0m4""\n"
"-----END CERTIFICATE-----";

const char pico_az_PRIVATE_KEY[] =
"-----BEGIN PRIVATE KEY-----" "\n"
"MIIEvQIBADANBgkqhkiG9w0BAQEFAASCBAKcwggsSjAgEAAoIBAQC/+cTz9dwyx0oQ""\n"
"RZq4eefN3GV6CSAUjAEVabjw080a92rxAVtNhuPuFSOQMsixfW0EwPMrtBqWJx0k""\n"
"...
"DHuwsI6yH1KXJ8AhQ9N99JHM00oCxVb1whKQghatpe/+4daatxD6YEoGqypxUxGv""\n"
"NCv2+ABkemj5BI2RGP5cHHk="" "\n"
"-----END PRIVATE KEY-----";
```


4.5 Step 5: Setup Azure IoT Explorer

1. Create Azure Device Provisioning service.

[MUST] For Device Provisioning service creation, please follow up the [Quickstart: Set up the IoT Hub Device Provisioning Service with the Azure portal](#) document first.

- After creating DPS, get your "ID Scope" value.

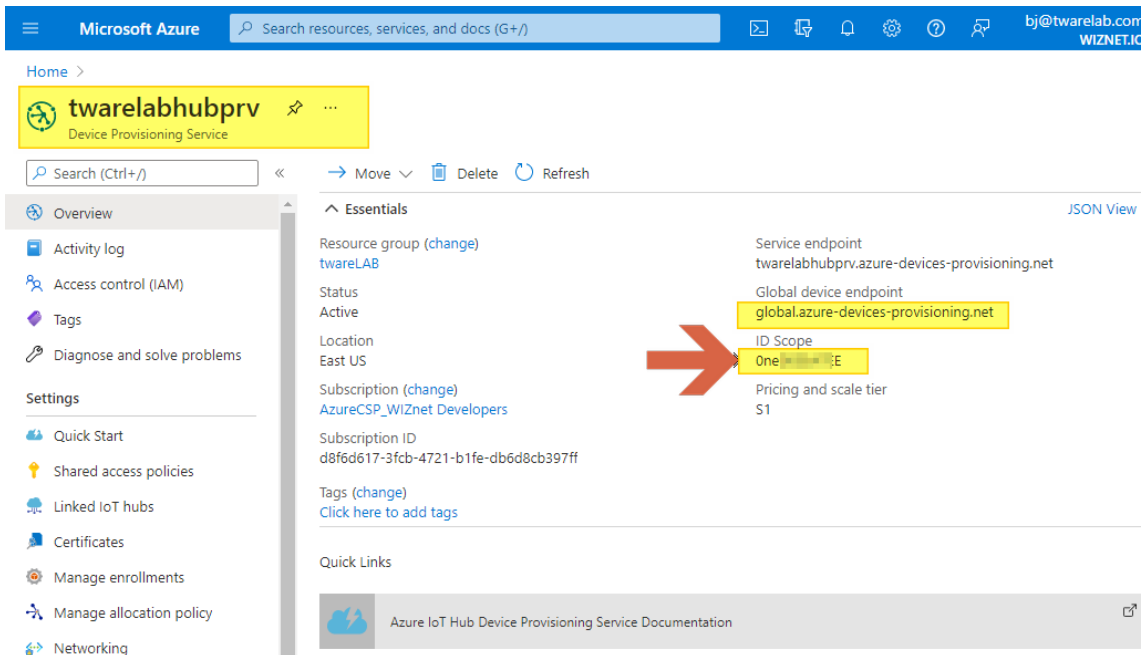


Figure 1. get "ID Scope"

2. Link to Azure IoT Hub & DPS.
 - Connect DPS and IoT Hub service

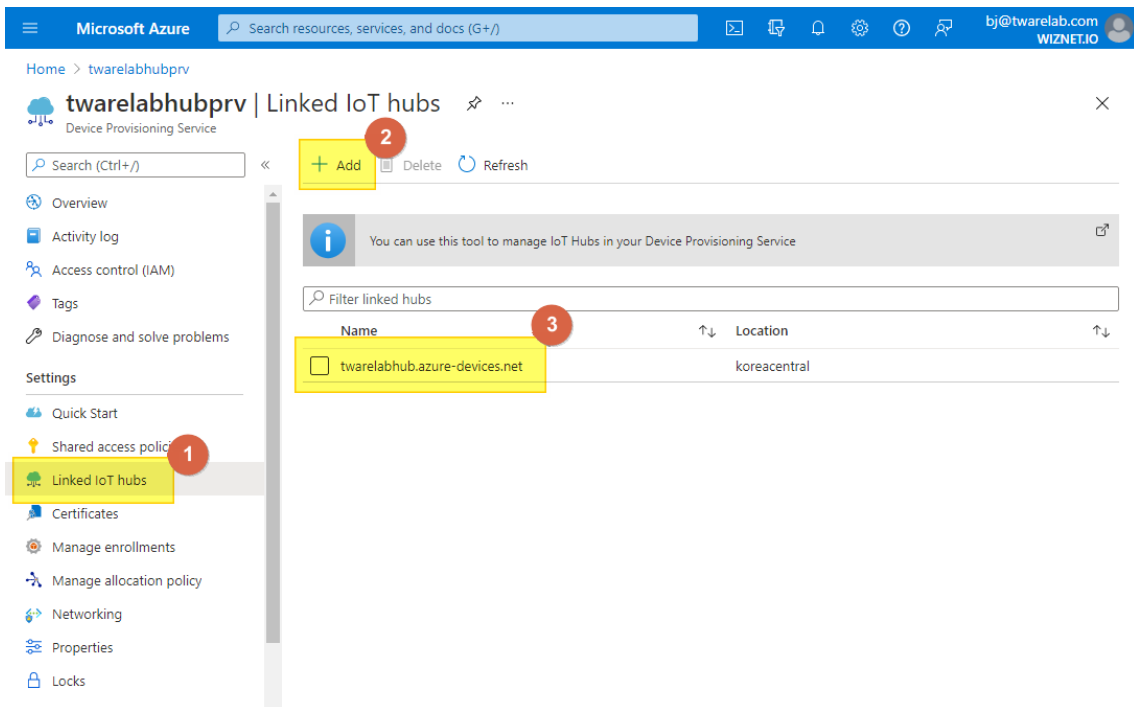


Figure 2. Linked IoT hubs

3. Create a device enrollment.
 - Add individual enrollment.

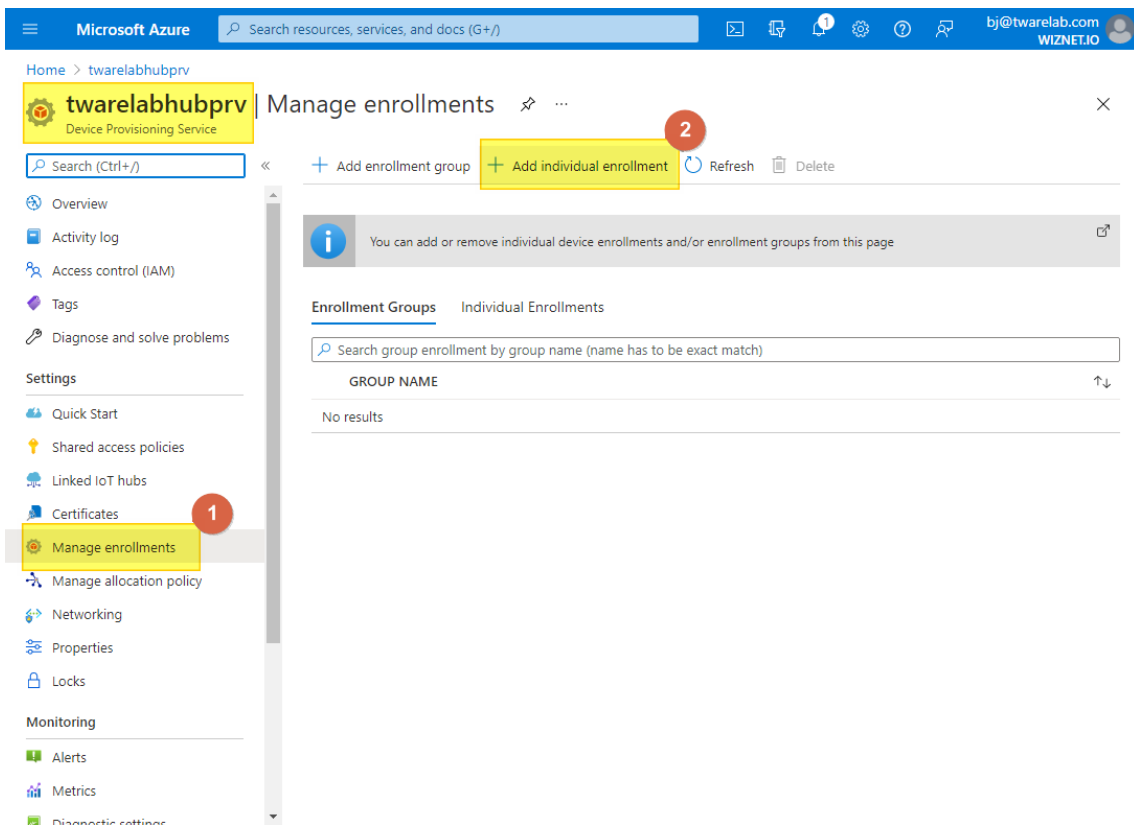


Figure 3. Manage enrollment

- Use "prov_device1.pem" file generated in previous section.

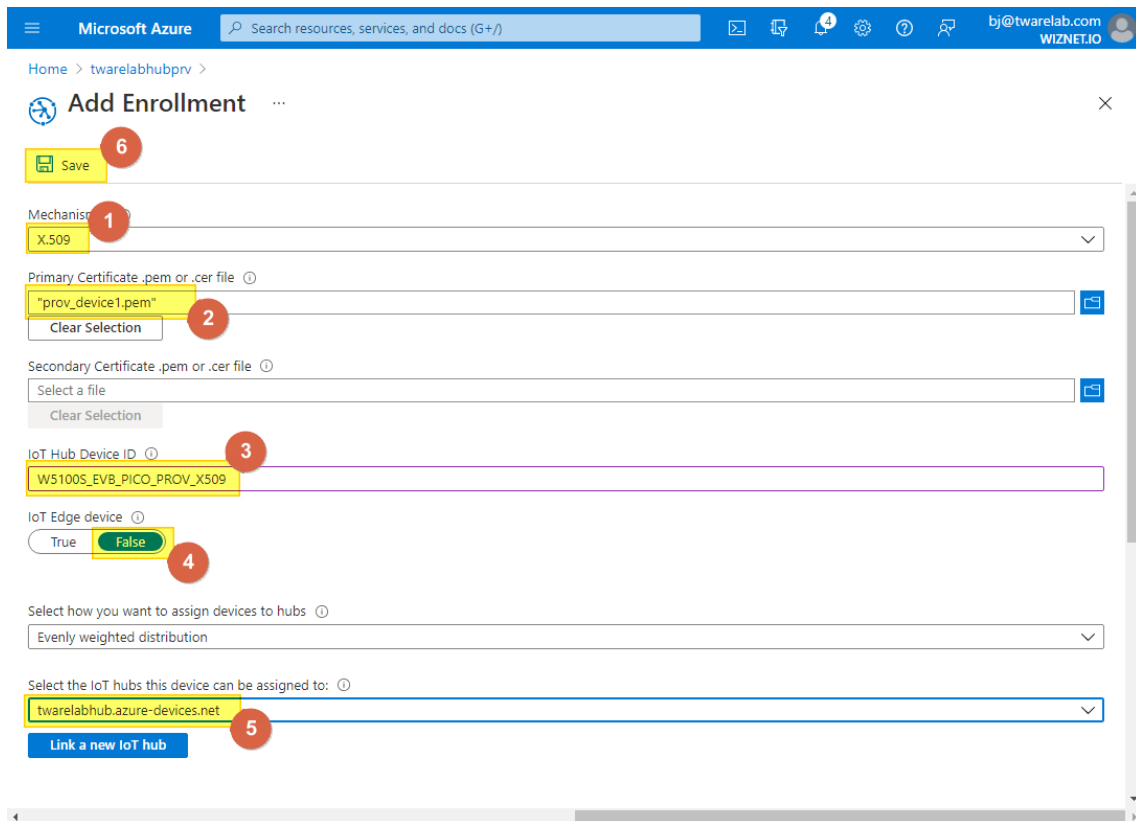


Figure 4. Enter the .pem file

- Check "Individual Enrollments" list.

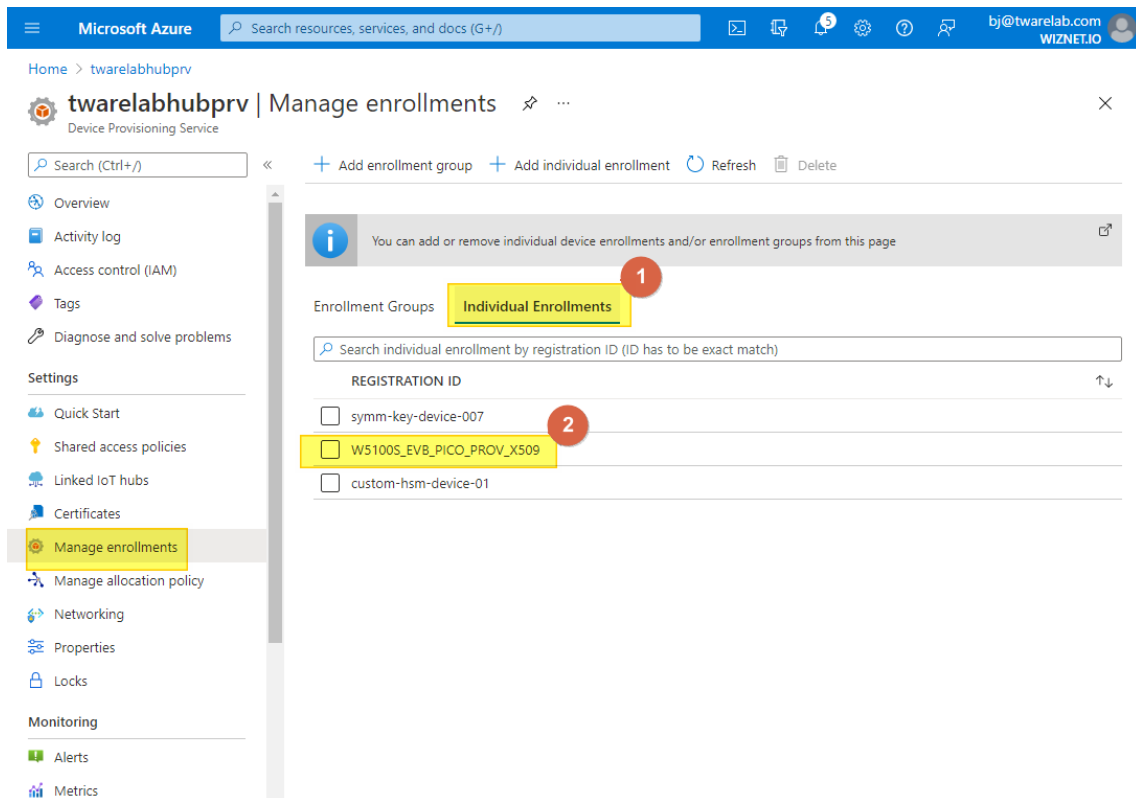


Figure 5. Individual Enrollments

- For more details,
 - Please refer [How to manage device enrollments with Azure portal.](#)
 - Or please read [Quickstart: Provision an X.509 certificate simulated device](#) document as well.
4. In the IoT Hub, go to the device menu and click "Refresh" until you see a provisioned device name.

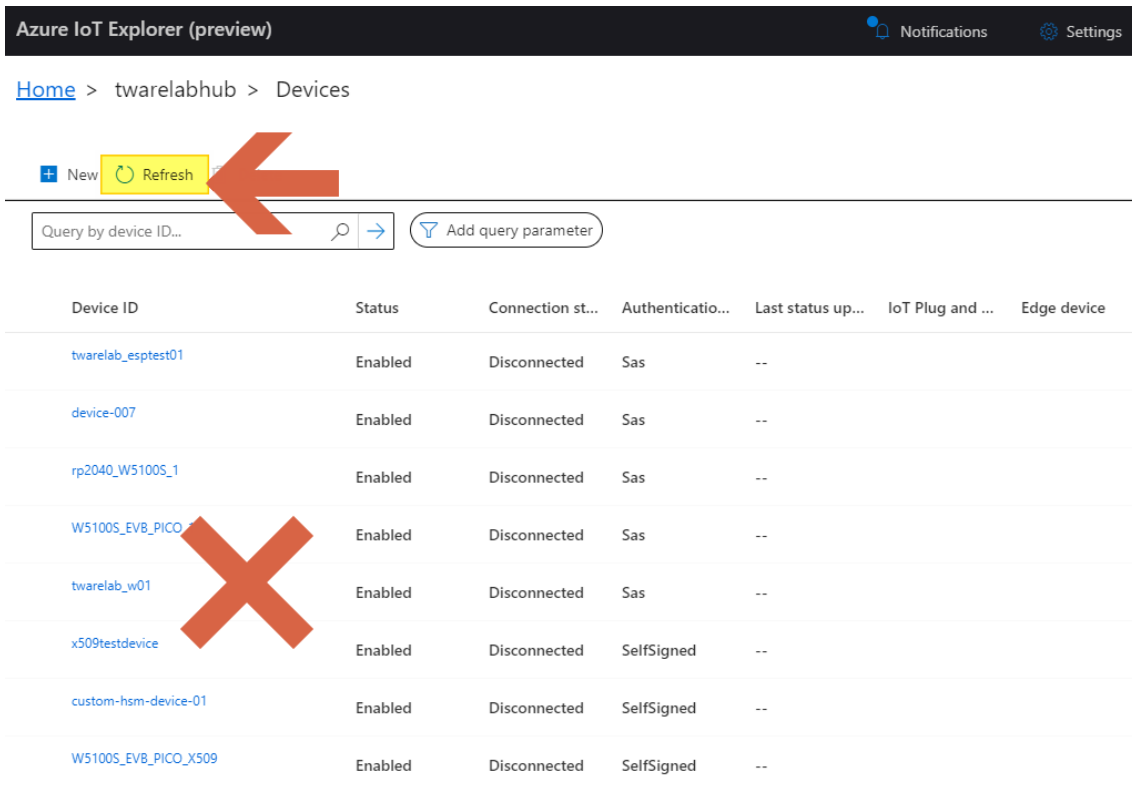


Figure 6. Click "Refresh"

- After few seconds, you can find provision device from device list as below:

Azure IoT Explorer (preview) Notifications Settings

Home > twarelabhub > Devices

New Refresh Delete

Query by device ID... Add query parameter

Device ID	Status	Connection st...	Authenticatio...	Last status up...	IoT Plug and ...	Edge device
twarelab_esptest01	Enabled	Disconnected	Sas	--		
device-007	Enabled	Disconnected	Sas	--		
rp2040_W5100S_1	Enabled	Disconnected	Sas	--		
W5100S_EVB_PICO_1	Enabled	Disconnected	Sas	--		
twarelab_w01	Enabled	Disconnected	Sas	--		
x509testdevice	Enabled	Disconnected	SelfSigned	--		
custom-hsm-device-01	Enabled	Disconnected	SelfSigned	--		
W5100S_EVB_PICO_X509	Enabled	Disconnected	SelfSigned	--		
W5100S_EVB_PICO_PROV_X509	Enabled	Disconnected	SelfSigned	--		

Figure 7. Click the provisioned device

5. Go to "Telemetry" menu, click "Start", and wait for incoming messages.

Azure IoT Explorer (preview) Notifications Settings

Home > twarelabhub > Devices > W5100S_EVB_PICO_PROV_X509 > Telemetry

File Edit View Window Help

Start Show system properties Clear events Simulate a device

Telemetry

Consumer group \$Default

Specify enqueue time

No

Use built-in event hub

Yes

Figure 8. Click Start

4.6 Step 6: Build

1. After completing the AZURE prov X.509 example configuration, click 'build' in the status bar at the bottom of Visual Studio Code or press the 'F7' button on the keyboard to build.
2. When the build is completed, 'main.uf2' is generated in 'WIZnet-PICO-AZURE-C/build/examples/' directory.

4.7 Step 7: Upload and Run

1. While pressing the BOOTSEL button of Raspberry Pi Pico, W5100S-EVB-Pico, W5500-EVB-Pico, W55RP20-EVB-Pico, W5100S-EVB-Pico2 or W5500-EVB-Pico2 power on the board, the USB mass storage 'RPI-RP2' is automatically mounted.

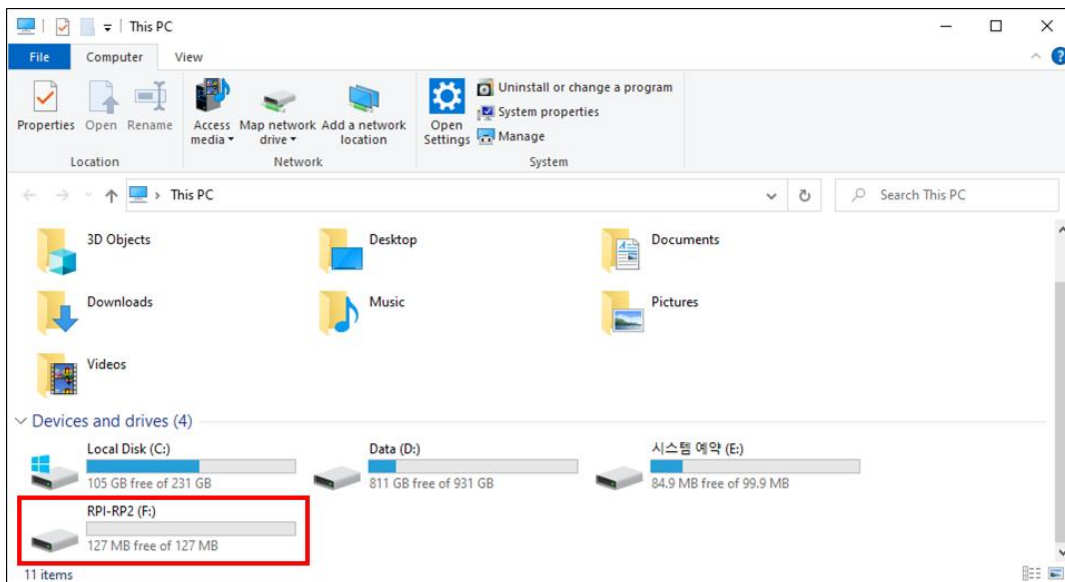


Figure 9. USB mass storage

2. Drag and drop 'main.uf2' onto the USB mass storage device 'RPI-RP2'.

3. Connect to the serial COM port of Raspberry Pi Pico, W5100S-EVB-Pico, W5500-EVB-Pico, W55RP20-EVB-Pico, W5100S-EVB-Pico2 or W5500-EVB-Pico2 with Tera Term.

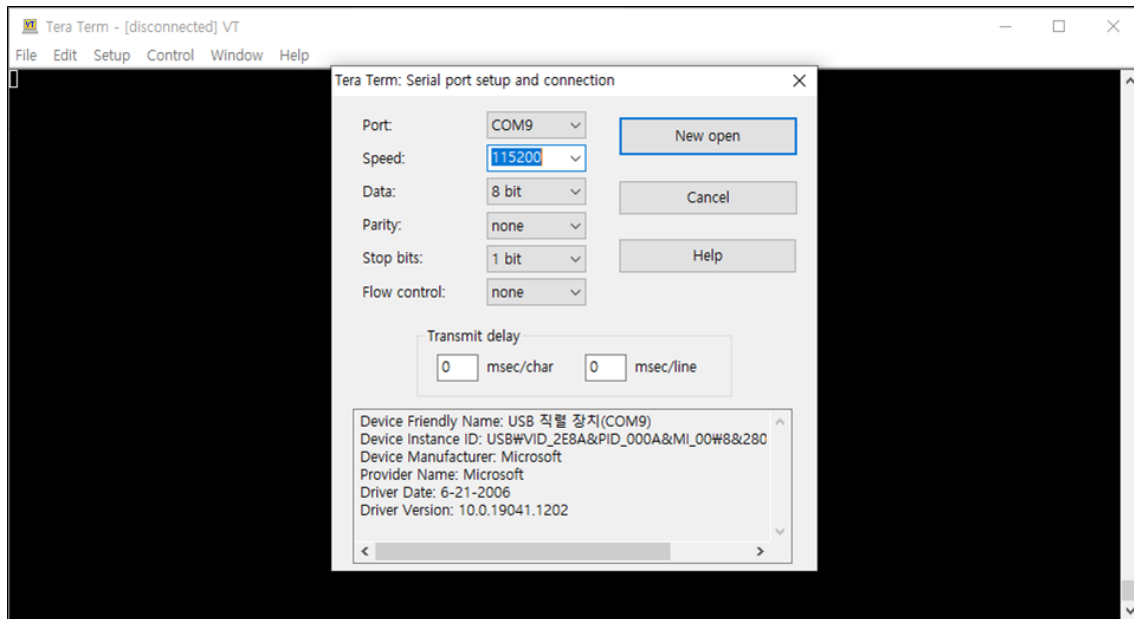


Figure 10. Tera Term

4. Reset your board.

- If the Azure prov X.509 example works normally on Raspberry Pi Pico, W5100S-EVB-Pico, W5500-EVB-Pico, W55RP20-EVB-Pico, W5100S-EVB-Pico2 or W5500-EVB-Pico2, you can see the network information of Raspberry Pi Pico, W5100S-EVB-Pico, W5500-EVB-Pico, W55RP20-EVB-Pico, W5100S-EVB-Pico2 or W5500-EVB-Pico2, Connect to Azure DPS (Device Provisioning Server) and perform the provisioning work.

```

COM10 - Tera Term VT
File Edit Setup Control Window Help
D:/twarelab/pico-examples/pico-azure-iot-sdk-c/nbedtls-3.0.0/library/ssl_msg.c:3774: <= read record
D:/twarelab/pico-examples/pico-azure-iot-sdk-c/nbedtls-3.0.0/library/ssl_cli.c:2024: dumping 'server hello, version' (2 bytes)
D:/twarelab/pico-examples/pico-azure-iot-sdk-c/nbedtls-3.0.0/library/ssl_cli.c:2024: 0000: 03 03
D:/twarelab/pico-examples/pico-azure-iot-sdk-c/nbedtls-3.0.0/library/ssl_cli.c:2047: server hello, current time: 1634285980
D:/twarelab/pico-examples/pico-azure-iot-sdk-c/nbedtls-3.0.0/library/ssl_cli.c:2057: dumping 'server hello, random bytes' (32 bytes)
D:/twarelab/pico-examples/pico-azure-iot-sdk-c/nbedtls-3.0.0/library/ssl_cli.c:2057: 0000: 61 69 39 9c 7d 3b 2a b9 6f a0 a1 59 95 fa 60 4d a19.*;*.o..Y..M
D:/twarelab/pico-examples/pico-azure-iot-sdk-c/nbedtls-3.0.0/library/ssl_cli.c:2057: 0010: f1 22 af 38 63 3c 6e f8 42 f2 7f d0 18 0f 90 a5 ..8c<n.B.....
D:/twarelab/pico-examples/pico-azure-iot-sdk-c/nbedtls-3.0.0/library/ssl_cli.c:2129: server hello, session id len.: 32
D:/twarelab/pico-examples/pico-azure-iot-sdk-c/nbedtls-3.0.0/library/ssl_cli.c:2130: dumping 'server hello, session id' (32 bytes)
D:/twarelab/pico-examples/pico-azure-iot-sdk-c/nbedtls-3.0.0/library/ssl_cli.c:2130: 0000: d9 4d 00 00 4f 03 67 80 3e 5f c0 04 b1 7a b1 fc .M..0.g>...z..
D:/twarelab/pico-examples/pico-azure-iot-sdk-c/nbedtls-3.0.0/library/ssl_cli.c:2130: 0010: c2 77 5f b1 5a f3 e2 35 25 46 56 99 3e d2 f2 23 ..w..Z..5%FV.>..#
D:/twarelab/pico-examples/pico-azure-iot-sdk-c/nbedtls-3.0.0/library/ssl_cli.c:2169: no session has been resumed
D:/twarelab/pico-examples/pico-azure-iot-sdk-c/nbedtls-3.0.0/library/ssl_cli.c:2172: server hello, chosen ciphersuite: 009c
D:/twarelab/pico-examples/pico-azure-iot-sdk-c/nbedtls-3.0.0/library/ssl_cli.c:2173: server hello, compress alg.: 0
D:/twarelab/pico-examples/pico-azure-iot-sdk-c/nbedtls-3.0.0/library/ssl_cli.c:2212: server hello, chosen ciphersuite: TLS-RSA-WITH-AES-128-GCM-SHA256
D:/twarelab/pico-examples/pico-azure-iot-sdk-c/nbedtls-3.0.0/library/ssl_cli.c:2237: server hello, total extension length: 5
D:/twarelab/pico-examples/pico-azure-iot-sdk-c/nbedtls-3.0.0/library/ssl_cli.c:2259: found renegotiation extension
D:/twarelab/pico-examples/pico-azure-iot-sdk-c/nbedtls-3.0.0/library/ssl_cli.c:2449: <= parse server hello
D:/twarelab/pico-examples/pico-azure-iot-sdk-c/nbedtls-3.0.0/library/ssl_cli.c:4215: client state: 3
D:/twarelab/pico-examples/pico-azure-iot-sdk-c/nbedtls-3.0.0/library/ssl_msg.c:1965: => Flush output
D:/twarelab/pico-examples/pico-azure-iot-sdk-c/nbedtls-3.0.0/library/ssl_msg.c:1977: <= Flush output
D:/twarelab/pico-examples/pico-azure-iot-sdk-c/nbedtls-3.0.0/library/ssl_tls.c:2305: => parse certificate
D:/twarelab/pico-examples/pico-azure-iot-sdk-c/nbedtls-3.0.0/library/ssl_msg.c:3700: => read record
D:/twarelab/pico-examples/pico-azure-iot-sdk-c/nbedtls-3.0.0/library/ssl_msg.c:2832: handshake message: msglen = 3440, type = 11, hslen = 3466
D:/twarelab/pico-examples/pico-azure-iot-sdk-c/nbedtls-3.0.0/library/ssl_msg.c:3774: <= read record
D:/twarelab/pico-examples/pico-azure-iot-sdk-c/nbedtls-3.0.0/library/ssl_tls.c:1990: peer certificate #1:
D:/twarelab/pico-examples/pico-azure-iot-sdk-c/nbedtls-3.0.0/library/ssl_tls.c:1990: cert. version : 3
D:/twarelab/pico-examples/pico-azure-iot-sdk-c/nbedtls-3.0.0/library/ssl_tls.c:1990: serial number : 7F-00-10-60-00-7A-04-52-E7-00-00-94-14-00-00-10-6B-CB
D:/twarelab/pico-examples/pico-azure-iot-sdk-c/nbedtls-3.0.0/library/ssl_tls.c:1990: issuer name : C=US, O=Microsoft Corporation, CN=Microsoft RSA TLS CA 02
D:/twarelab/pico-examples/pico-azure-iot-sdk-c/nbedtls-3.0.0/library/ssl_tls.c:1990: subject name : CN=*.azure-devices-provisioning.net
D:/twarelab/pico-examples/pico-azure-iot-sdk-c/nbedtls-3.0.0/library/ssl_tls.c:1990: issued on : 2021-09-17 21:30:33
D:/twarelab/pico-examples/pico-azure-iot-sdk-c/nbedtls-3.0.0/library/ssl_tls.c:1990: expires on : 2022-02-17 21:30:33
D:/twarelab/pico-examples/pico-azure-iot-sdk-c/nbedtls-3.0.0/library/ssl_tls.c:1990: signed using : RSA with SHA-256
D:/twarelab/pico-examples/pico-azure-iot-sdk-c/nbedtls-3.0.0/library/ssl_tls.c:1990: RSA key size : 2048 bits
D:/twarelab/pico-examples/pico-azure-iot-sdk-c/nbedtls-3.0.0/library/ssl_tls.c:1990: subject alt name :
D:/twarelab/pico-examples/pico-azure-iot-sdk-c/nbedtls-3.0.0/library/ssl_tls.c:1990: dNSName : *.azure-devices-provisioning.net
D:/twarelab/pico-examples/pico-azure-iot-sdk-c/nbedtls-3.0.0/library/ssl_tls.c:1990: dNSName : *.su.management-azure-devices-provisioning.net
D:/twarelab/pico-examples/pico-azure-iot-sdk-c/nbedtls-3.0.0/library/ssl_tls.c:1990: key usage : Digital Signature, Key Encipherment, Data Encipherment
D:/twarelab/pico-examples/pico-azure-iot-sdk-c/nbedtls-3.0.0/library/ssl_tls.c:1990: ext key usage : TLS Web Server Authentication, TLS Web Client Authentication
D:/twarelab/pico-examples/pico-azure-iot-sdk-c/nbedtls-3.0.0/library/ssl_tls.c:1990: certificate policies : ???, ???
D:/twarelab/pico-examples/pico-azure-iot-sdk-c/nbedtls-3.0.0/library/ssl_tls.c:1990: value of 'crt->rsa.N' (2048 bits) is:
D:/twarelab/pico-examples/pico-azure-iot-sdk-c/nbedtls-3.0.0/library/ssl_tls.c:1990: ac f3 c4 59 45 e7 ea 79 f2 62 c0 9f d1 58 6f ff
D:/twarelab/pico-examples/pico-azure-iot-sdk-c/nbedtls-3.0.0/library/ssl_tls.c:1990: d0 77 3b bd 84 24 81 c4 53 d0 b9 70 32 cf 3f cb
D:/twarelab/pico-examples/pico-azure-iot-sdk-c/nbedtls-3.0.0/library/ssl_tls.c:1990: 82 00 f2 c4 15 00 59 46 90 d6 d4 47 ac 84 7c 2e

```

Figure 11. Connect to Azure DPS

7. You can see the 2 messages from the device in Azure IoT Explorer.

Azure IoT Explorer (preview) Notifications Settings

Home > twarelabhub > Devices > W5100S_EVB_PICO_PROV_X509 > Telemetry

Stop Show system properties Clear events Simulate a device

Telemetry

Consumer group \$Default

Specify enqueue time No

Use built-in event hub Yes

Receiving events...

Fri Oct 15 2021 17:20:37 GMT+0900 (대한민국 표준시):

```
{
  "body": {
    "message_index": "1"
  },
  "enqueuedTime": "Fri Oct 15 2021 17:20:37 GMT+0900 (대한민국 표준시)",
  "properties": {}
}
```

Fri Oct 15 2021 17:20:31 GMT+0900 (대한민국 표준시):

```
{
  "body": {
    "message_index": "0"
  },
  "enqueuedTime": "Fri Oct 15 2021 17:20:31 GMT+0900 (대한민국 표준시)",
  "properties": {}
}
```

Figure 14. Receiving events in Azure IoT Explorer

Revision history

Version	Date	Descriptions
Ver. 1.0.0	Dec, 2024	Initial release.

Table 1. Revision history

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