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A71CH for secure connection to AWS

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Info	Content
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Abstract	This document describes how the A71CH security IC can be used to establish a secure connection with an AWS

Revision history

Rev	Date	Description
1.0	20180329	First release

Contact information

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1. Introduction

This document describes how the A71CH Security IC can be used to establish a secure connection between an IoT device and Amazon Web Services (AWS) IoT cloud. The connection between the IoT device and AWS IoT cloud will be established with the MQTT protocol [MQTT], running across Transport Layer Security (TLS) protocol.

To establish a Transport Layer Security (TLS) connection, the IoT device certificate has to be registered in AWS IoT. The AWS Just-in-time registration (JITR) mechanism allows the IoT device to automatically register its digital certificate, thus establishing a connection with AWS IoT. This document contains a brief introduction to TLS and key security concepts and then presents the workflow to prepare the JITR of an IoT device certificate in AWS IoT.

2. A71CH overview

The A71CH is a ready-to-use solution enabling ease-of-use security services for the IoT device makers. It is a tamper-resistant platform capable of securely storing and provisioning credentials, securely connecting IoT devices to cloud services and performing cryptographic node authentication.

The A71CH solution provides an outstanding level of security measures protecting the IC against physical and logical attacks. It can be used with various host platforms and host operating systems to secure a broad range of applications. In addition, it is complemented by a comprehensive product support package, offering easy design-in with plug & play host application code, easy-to-use development kits, reference designs, documentation and IC samples for product evaluation.

3. Public key infrastructure and ECC fundamentals

Security is an essential requirement for any IoT design. Thus, security should not be considered as differentiator option but rather a standard feature for the IoT designers. IoT devices must follow a secure-by-design approach, ensuring secure storage of credentials, device authentication, secure code execution and safe connections to remote servers among others. In this security context, the A71CH security IC is designed specifically to offer protected access to credentials, secure connection to private or public clouds and cryptographic device proof-of-origin verification.

Asymmetric cryptography, also known as public key cryptography, is any cryptographic algorithms based on a pair of keys: a public key and a private key. The private key must be kept secret, while the public key can be shared.

RSA (Rivest, Shamir and Adleman) and Elliptic-Curve Cryptography (ECC) are two of the most widely used asymmetric cryptography algorithms. In the case of ECC cryptography, it is based on the algebraic structure of elliptic curves over finite fields. Therefore, each key pair (public and private key) is generated from a certain elliptical curve.

The digital signature, digital certificates, Elliptic Curve Digital Signature Algorithm (ECDSA) and Elliptic Curve Diffie-Hellman (ECDH) key agreement algorithm are briefly explained in the next sections.

3.1 Digital signature

A digital signature is used to guarantee the authenticity, the integrity and non-repudiation of a message. A signing algorithm generates a signature given a message and a private key. A signature verifying algorithm accepts or rejects a message given the public key and the signature.

Fig 1 illustrates an example of digital signature. In this case, the message is signed with the sender private key. The receiver will validate the signature using both the message and the sender public.

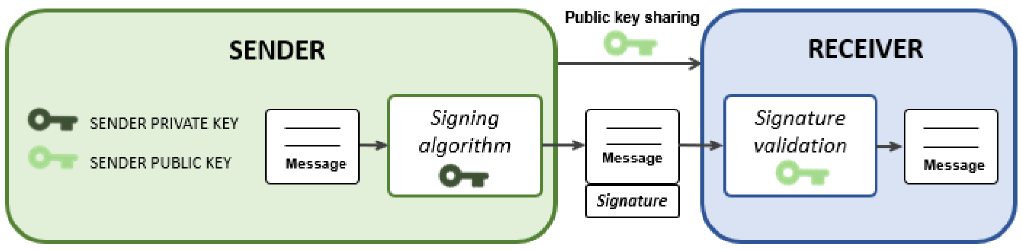


Fig 1. Digital signature diagram

3.2 Digital certificate, Certification Authority (CA) and Certificate Signing Request (CSR)

Digital certificates are used to prove the authenticity of shared public keys. Digital certificates are electronic documents that include information about the sender public key, identity of its owner and the signature of a trusted entity that has verified the contents of the certificate, normally called Certificate Authority (CA).

A Certificate Authority (CA) is an entity that issues digital certificates. The CA is trusted by both the certificate sender and the certificate receiver, and it is typically in charge of receiving a Certificate Signing Request (CSR) and generating a new certificate based upon information contained in the CSR and signed with the CA private key.

Therefore, a CSR is a request that contains all the necessary information, e.g., sender public key and relevant information to generate a new digital certificate.

Fig 2 shows digital certificates generation steps. First, the interested device (sender) creates a Certificate Signing Request. The CSR is then sent to the CA and a new digital certificate is created and signed with the CA private key. Also, the basic contents of this new digital certificate are illustrated in the figure.

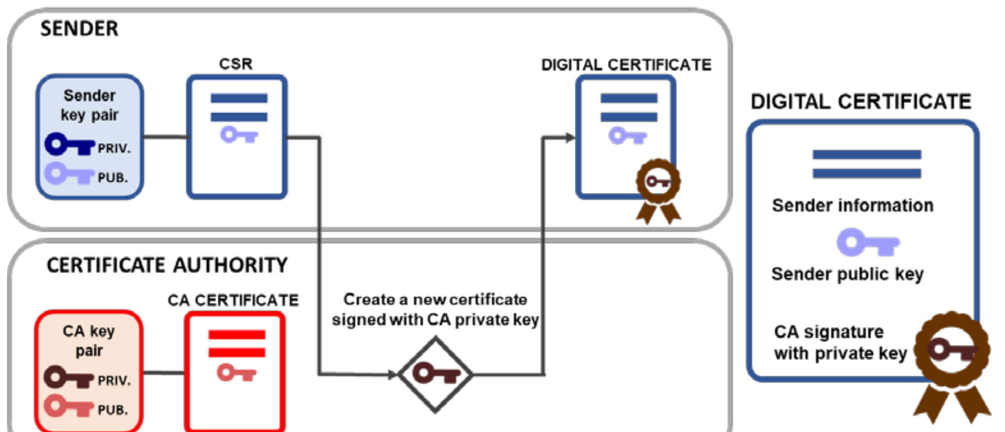


Fig 2. Digital certificate generation steps and contents

3.3 Elliptic Curve Digital Signature Algorithm (ECDSA)

The Elliptic Curve Digital Signature Algorithm (ECDSA) algorithm uses ECC to provide a variant of the Digital Signature Algorithm (DSA). A pair of keys (public and private) are generated from an elliptic curve, and these can be used both for signing or verifying a message's signature. Fig 3 illustrates an example of ECDSA application. In this example, the sender device generates a signature with its private key. The signed message is sent together with the sender digital certificate to the receiver. Finally, the receiver retrieves the sender public key from the digital certificate and uses it to validate the signature of the received message.

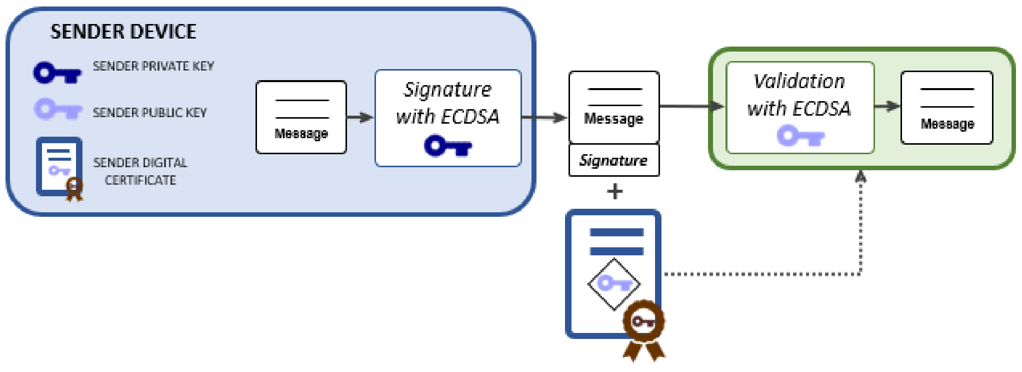


Fig 3. Elliptic Curve Digital Signature Algorithm (ECDSA) example

3.4 Elliptic Curve Diffie-Hellman (ECDH)

Elliptic Curve Diffie-Hellman algorithm (ECDH) is a key-agreement protocol. The goal of ECDH is to reach a key agreement between two parties, each having an elliptic-curve key pair generated from the same domain parameters. When the agreement has been reached, a shared secret key, usually referred to as the 'master key', is derived to obtain session keys. These session keys will be employed to establish a communication using symmetric-key encryption algorithms.

The sender and the receiver have its own elliptical key pair. Both the sender and receiver public keys are shared with each other. In this case, the exchange has been represented with digital certificates. Each party can compute the secret key using their own private key and the public key obtained from the received certificate. Due to the elliptical curve properties and the fact that both key pairs have been generated from the same domain parameters, the computed secret key is the same for both parties. This common secret key will be further used for establishing a communication and encrypt messages based on symmetrical cryptography. Fig 4 illustrates the usage of ECDH for a shared secret key agreement.

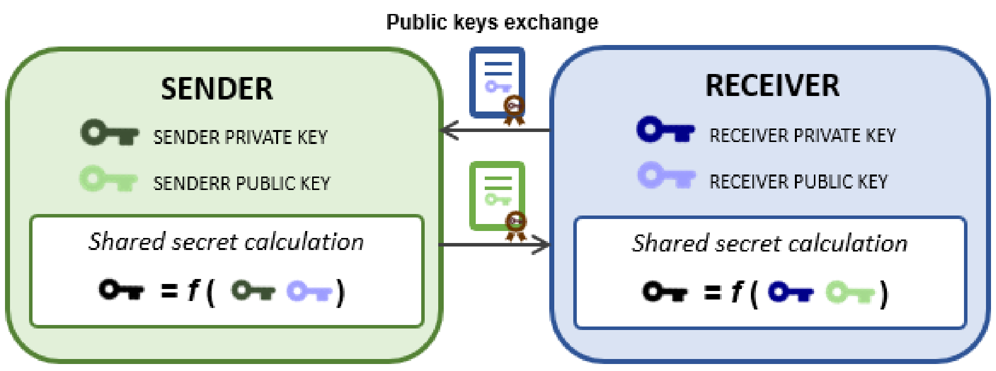


Fig 4. Elliptic Curve Diffie-Hellman Key Exchange (ECDH) example

In the Elliptic-curve Diffie-Hellman Ephemeral (ECDHE) algorithm case, a new elliptical key pair is generated for each key agreement instead of sharing the already existing public keys.

3.5 A71CH ECC supported functionality

The A71CH security IC supports the following ECC functionality:

- Signature generation and verification (ECDSA).
- Shared secret calculation using Key Agreement (ECDH or ECDH-E).
- Secure storage, generation, insertion or deletion of key pairs (NIST-P256 elliptical curve).

4. A71CH for secure connection to AWS IoT cloud

The scope of this document is to explain step by step how to connect an IoT device to an AWS IoT cloud by using the available AWS IoT services.

The IoT device will feature an A71CH Security IC to securely store credentials. Fig 5 illustrates the connection between several IoT devices with A71CH IC and the AWS IoT cloud.

The credentials of each one of the involved elements are explained in this chapter. Additionally, basic concepts on SSL/TLS and security are presented to provide the reader the necessary background for a better understanding of the presented contents such as TLS handshake protocol, OpenSSL and the A71CH OpenSSL engine.

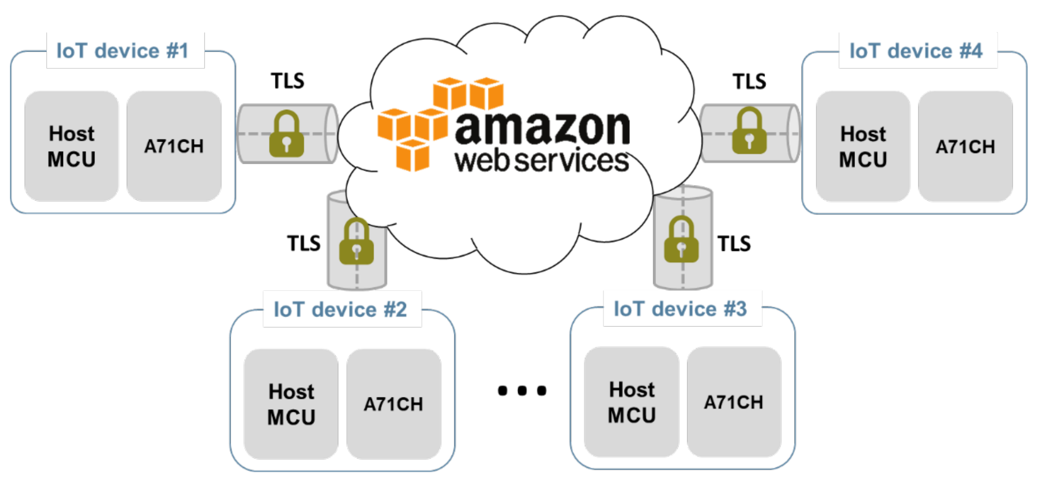


Fig 5. System overview. Connection between an IoT device(s) and AWS IoT cloud

4.1 OEM and AWS cloud credentials

The IoT device original equipment manufacturer (OEM) shall have an intermediate CA certificate, as well as their corresponding keys. This intermediate CA certificate will be issued by a root CA. Regarding the root CA there are two possibilities. The OEM can have its own public key infrastructure (PKI); thus, it will have the root CA certificate and the root CA key pair. Alternatively, the OEM can trust in a third-party CA.

Note that in Fig 6 only an intermediate CA and a root CA have been represented, though the OEM could have more than one intermediate CA issued by different root CAs.

The OEM will have to register the intermediate CA certificate in AWS cloud. The intermediate CA will be used to validate all the IoT devices certificates willing to connect to the cloud.

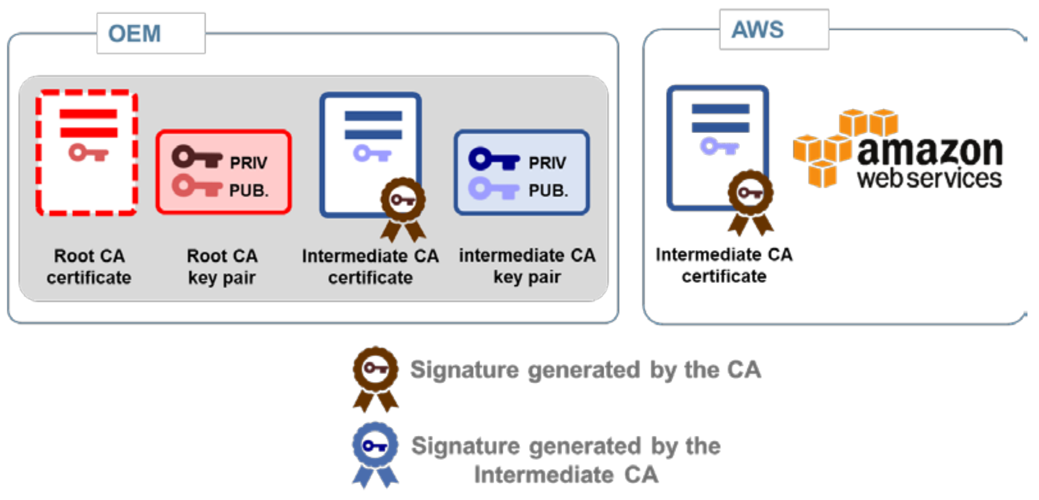

OEM
Root CA certificate
PRIV
PUB.
Root CA key pair
Intermediate CA certificate
PRIV
PUB.
intermediate CA key pair
AWS
amazon web services
Intermediate CA certificate
Signature generated by the CA
Signature generated by the Intermediate CA

Fig 6. OEM and AWS cloud credentials

4.2 IoT device credentials

Each IoT device will be provisioned with its corresponding key pair and its digital certificate issued by the intermediate CA. These credentials will be stored inside the A71CH and will be used to register the IoT device certificate and establish a secure connection with the AWS IoT cloud.

The IoT device must also contain the intermediate CA certificate to connect to AWS. Optionally, it could be stored inside the A71CH GP Storage for functionality purposes. Fig 7 illustrates the credentials of an IoT device.

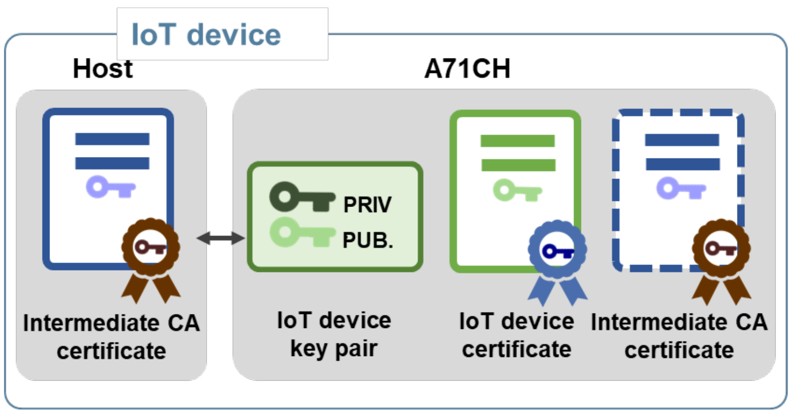


Fig 7. IoT device credentials

Fig 8 shows the complete connection between IoT devices and AWS cloud. The credentials described in 4.1 and 4.2 have also been represented.

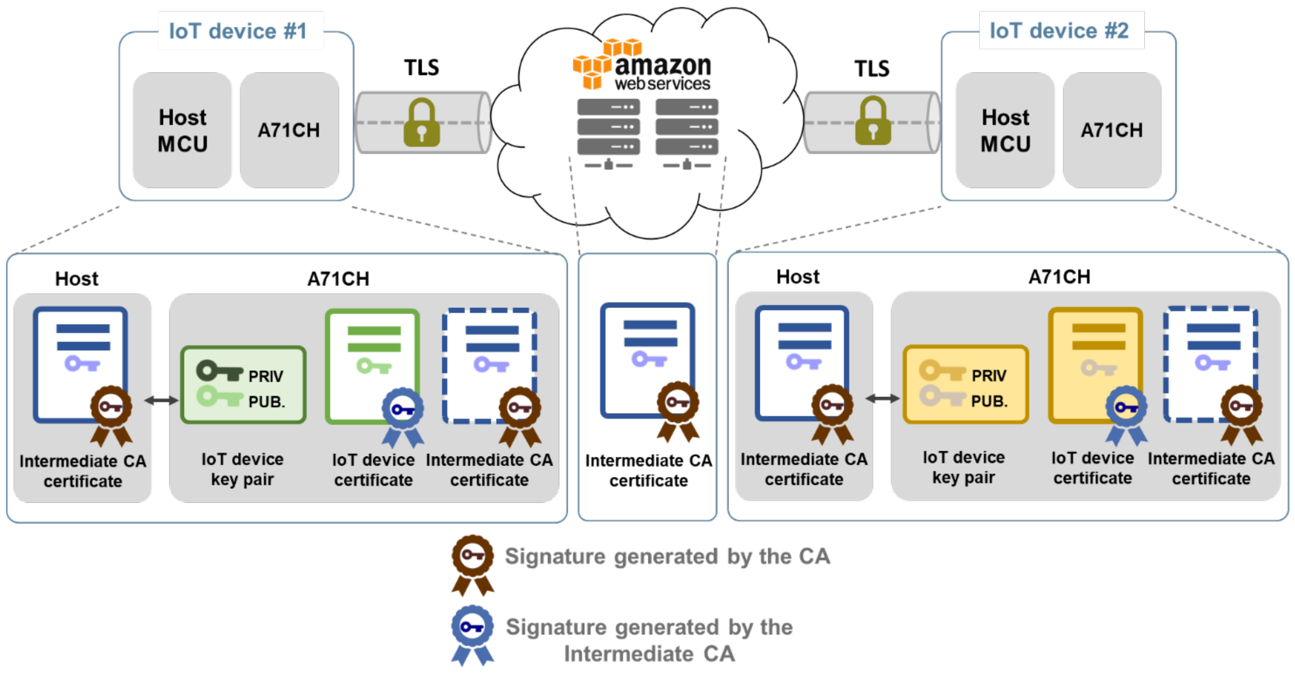

IoT device #1
Host MCU
A71CH
TLS
amazon web services
TLS
IoT device #2
Host MCU
A71CH
Host
A71CH
Intermediate CA certificate
PRIV
PUB.
IoT device key pair
IoT device certificate
Intermediate CA certificate
Intermediate CA certificate
Host
A71CH
Intermediate CA certificate
PRIV
PUB.
IoT device key pair
IoT device certificate
Intermediate CA certificate
Signature generated by the CA
Signature generated by the Intermediate CA

Fig 8. Connection between IoT devices and AWS IoT cloud

4.3 Transport Layer Security protocol (TLS)

IoT devices own several connectivity features that allow them to exchange data with the cloud. The network link between these IoT devices and the cloud or server should be secure. Transport Layer Security protocol (TLS), and its predecessor Secure Sockets Layer (SSL), are cryptographic protocols that provide communications security over unsecure networks. These protocols are created from the necessity of establishing a connection preserving confidentiality, integrity and authenticity.

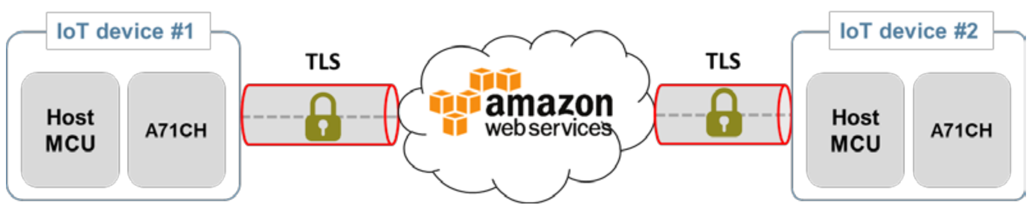


Fig 9. TLS connection between two IoT devices and AWS IoT cloud

Fig 10 illustrates the protocol stack of a TLS communication over a TCP/IP network. In the well-known ISO/OSI layer architecture, SSL/TLS would belong to the Presentation Layer in charge of encrypting and securing the entire communication. The transport and network protocol TCP/IP and the medium access control (MAC) would fall in layers from 4 to 2, respectively. Finally, data would be physically transferred according to ethernet (or wireless ethernet) protocols.

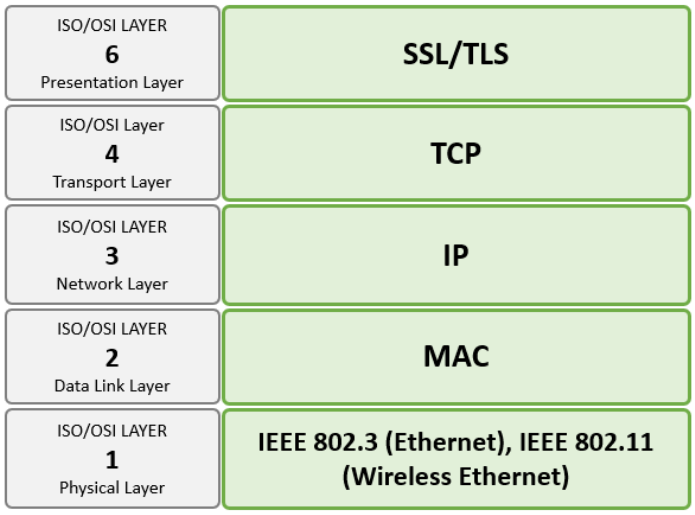


Fig 10. Communication stack. ISO/OSI Layers.

4.3.1 Transport Layer Security Handshake protocol

Before the IoT device and the server in the cloud begin exchanging data over TLS, the tunnel encryption must be negotiated. This negotiation is referred as TLS Handshake. The TLS Handshake Protocol is responsible for the authentication and key exchange necessary to establish or resume secure sessions. When establishing a secure session, the TLS Handshake Protocol manages the following:

- Agree on the TLS protocol version to be used.
- Select cipher suite.
- Authenticate each other by exchanging and validating digital certificates.
- Use asymmetric encryption techniques to generate a shared secret key, which avoids the key distribution problem. SSL or TLS then uses the shared key for the symmetric encryption of messages, which is faster than asymmetric encryption.

The TLS Handshake Protocol involves the following steps:

- Exchange Hello messages to agree on algorithms, exchange random values, and check for resumption.
- Exchange the necessary cryptographic parameters to allow the client and server to agree on a pre-master secret.
- Exchange certifications and cryptographic information to allow the client and server to authenticate themselves.
- Generate a master secret from the pre-master secret and exchanged random value.
- Provide security parameters to the record layer.
- Allow the client and server to verify that their peer has calculated the same security parameters and that the handshake occurred without tampering by an attacker.

The A71CH security IC supports the TLS Handshake Protocol version 1.2 with the following options:

- Pre-Shared Key Cipher suites for TLS as described in [RFC4279]: A set of cipher suites for supporting TLS using pre-shared symmetric keys (*TLS_PSK_WITH_xxx*)
- ECDHE_PSK Cipher suites for TLS as described in [RFC5489]: A set of cipher suites that use a pre-shared key to authenticate an Elliptic Curve Diffie-Hellman exchange with Ephemeral keys (*TLS_ECDHE_PSK_WITH_xxx*).

The Fig 11 represents an overview of the TLS 1.2 handshake with ECDSA-ECDHE. More information about the TLS 1.2 handshake protocol can be obtained from the standard specifications document [RFC5246] or from [AN_A71CH_HOST_SW].

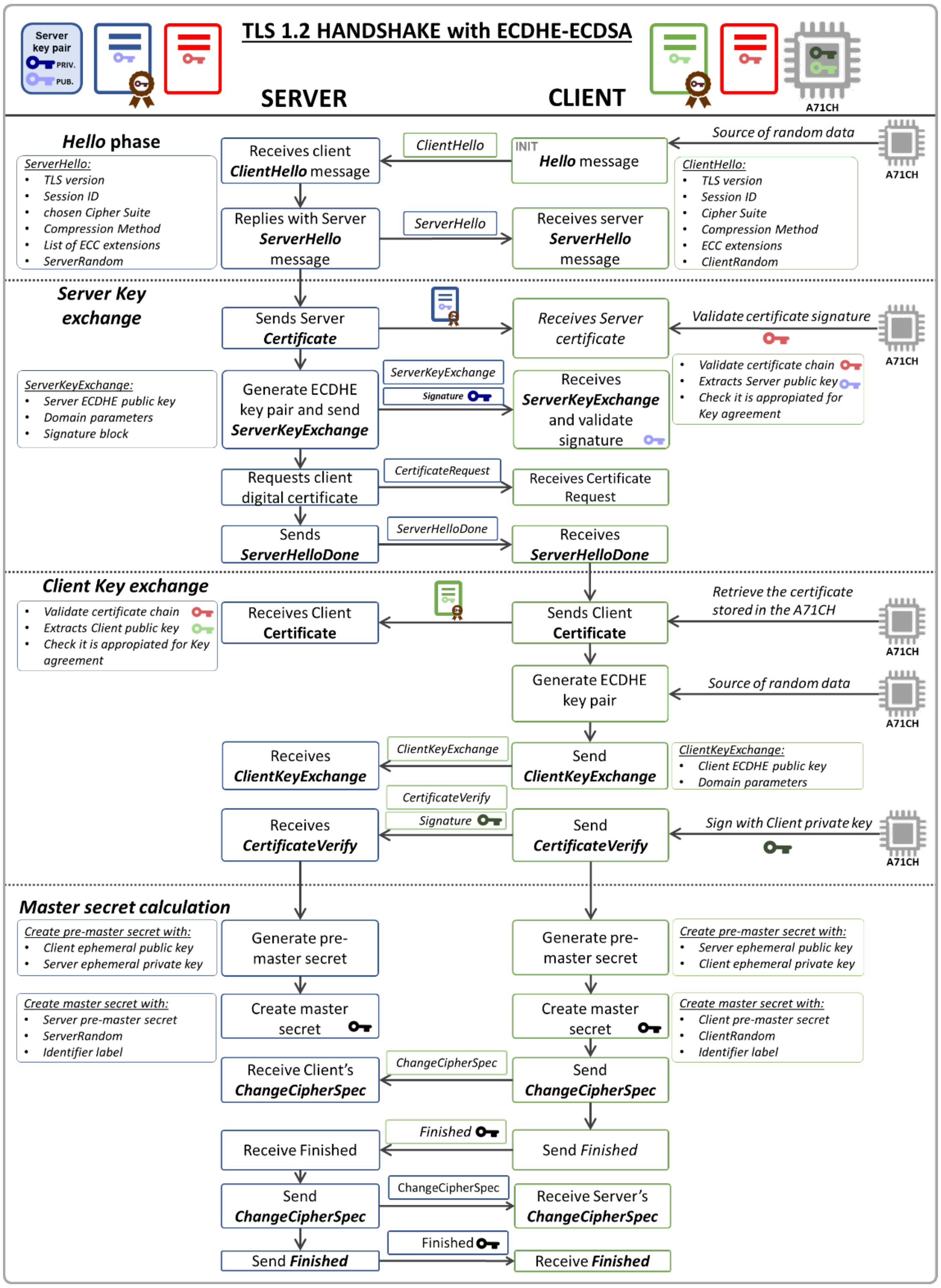

TLS 1.2 HANDSHAKE with ECDHE-ECDSA
Server key pair
PRIV.
PUB.
SERVER
CLIENT
A71CH
Hello phase
ServerHello:
TLS version
Session ID
chosen Cipher Suite
Compression Method
List of ECC extensions
ServerRandom
Receives client ClientHello message
ClientHello
INIT
Hello message
Source of random data
ClientHello:
TLS version
Session ID
Cipher Suite
Compression Method
ECC extensions
ClientRandom
Replies with Server ServerHello message
ServerHello
Receives server ServerHello message
Server Key exchange
Sends Server Certificate
Receives Server certificate
Validate certificate signature
Validate certificate chain
Extracts Server public key
Check it is appropiated for Key agreement
ServerKeyExchange:
Server ECDHE public key
Domain parameters
Signature block
Generate ECDHE key pair and send ServerKeyExchange
ServerKeyExchange
Signature
Receives ServerKeyExchange and validate signature
Requests client digital certificate
CertificateRequest
Receives Certificate Request
Sends ServerHelloDone
ServerHelloDone
Receives ServerHelloDone
Client Key exchange
Validate certificate chain
Extracts Client public key
Check it is appropiated for Key agreement
Receives Client Certificate
Sends Client Certificate
Retrieve the certificate stored in the A71CH
Generate ECDHE key pair
Source of random data
Receives ClientKeyExchange
ClientKeyExchange
Send ClientKeyExchange
ClientKeyExchange:
Client ECDHE public key
Domain parameters
Receives CertificateVerify
CertificateVerify
Signature
Send CertificateVerify
Sign with Client private key
Master secret calculation
Create pre-master secret with:
Client ephemeral public key
Server ephemeral private key
Generate pre-master secret
Generate pre-master secret
Create pre-master secret with:
Server ephemeral public key
Client ephemeral private key
Create master secret with:
Server pre-master secret
ServerRandom
Identifier label
Create master secret
Create master secret
Create master secret with:
Client pre-master secret
ClientRandom
Identifier label
Receive Client's ChangeCipherSpec
ChangeCipherSpec
Send ChangeCipherSpec
Receive Finished
Finished
Send Finished
Send ChangeCipherSpec
ChangeCipherSpec
Receive Server's ChangeCipherSpec
Send Finished
Finished
Receive Finished

Fig 11. TLS 1.2 Handshake diagram with ECC

4.3.2 Transport Layer Security software libraries

There are several full-featured TLS software libraries that can be used in both server cloud and IoT devices such OpenSSL, mbedTLS, WolfTLS, etc.

OpenSSL [OPEN_SSL] is an open-source implementation of SSL/TLS protocol. It is written in C language, although there are several wrappers to use this library in other languages. It implements all the cryptography functions needed and it is widely used. Starting with OpenSSL 0.9.6, an ‘Engine interface’ was added allowing support for alternative cryptographic implementations. This Engine interface can be used to interface with external crypto devices as e.g. HW accelerator cards or security ICs like the A71CH.

The OpenSSL toolkit including an A71CH OpenSSL Engine is available as part of the A71CH Host software package [A71CH_OPENSSL_ENGINE]. The A71CH OpenSSL Engine gives access to several A71CH features via the A71CH Host Library not natively supported by OpenSSL implementation. In other words, the Engine links the OpenSSL libraries to the A71CH Host API and overwrites some of the native OpenSSL functions in order to include the use of the A71CH crypto functionality such as sign, verify and key exchange operations or random messages generation, that can be used for instance during the TLS Handshake protocol.

The A7CH OpenSSL Engine is fully compatible with the i.MX6UltraLite embedded platform. Nevertheless, support will be added in future revisions.

Fig 12 illustrates the IoT Host MCU software architecture. As it can be observed, the software stack is formed by an application that calls OpenSSL functions. Some of these functions will be overwritten by the A71CH OpenSSL Engine, thus the A71CH crypto functionality will be used through the A71CH Host Library over I²C.

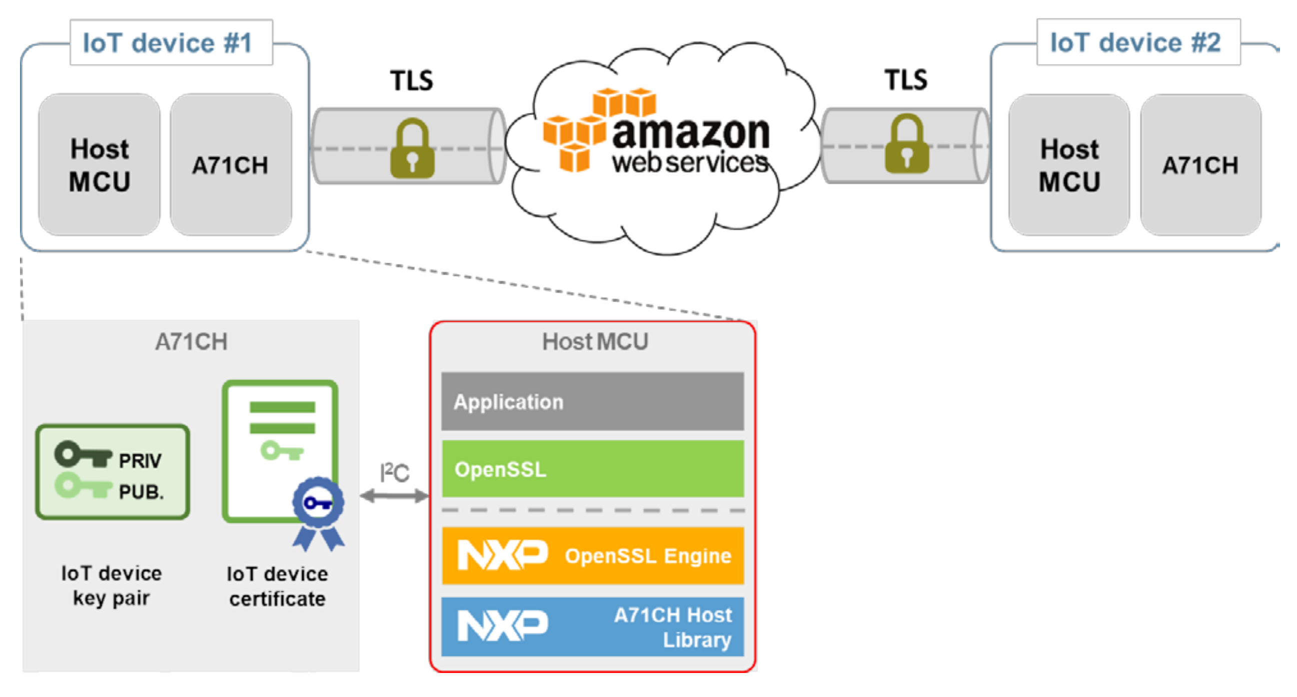


Fig 12. Host SW stack including OpenSSL, A71CH OpenSSL engine and A71CH Host Library

5. Introduction to AWS IoT and JITR

AWS has built IoT specific services. These services help IoT system developer collect and send IoT device data to the cloud, make it easy to load and analyze that information, and provide the ability to manage connected IoT devices.

AWS IoT Core service is a managed cloud platform that lets connected devices easily and securely interact with cloud applications and other devices. IoT Core can support billions of devices and trillions of messages and can process and route those messages

Fig 13 illustrates the end-to-end flow to establish a secure connection between an IoT devices with an A71CH to the AWS IoT services.

As a first step, the A71CH ICs provided by NXP need to be provisioned by a Programming facility in charge of injecting die-individual credentials (presented in Chapter 4). After that, the OEM manufacturer needs to register and activate his intermediate CA in the AWS platform. Then, in order to communicate in the AWS IoT network, each IoT device needs to be known via its device certificate. Thus, each IoT device certificate needs to be registered into the AWS IoT platform.

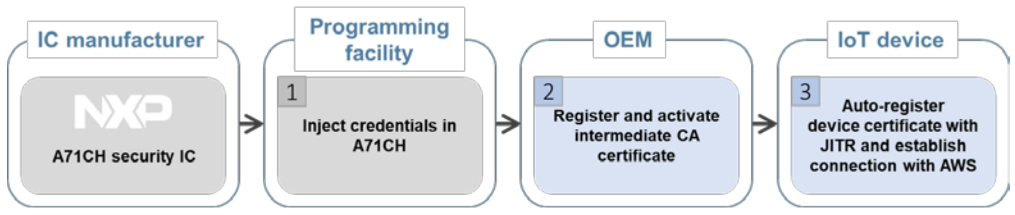

IC manufacturer
A71CH security IC
Programming facility
1
Inject credentials in A71CH
OEM
2
Register and activate intermediate CA certificate
IoT device
3
Auto-register device certificate with JITR and establish connection with AWS

Fig 13. End-to-end connection establishment flow

In order to ease this registration process, AWS introduced the Just-In-Time-Registration (JITR) mechanism. The AWS JITR is a mechanism to **automatically** register new device certificates during the initial communication between the IoT device and the AWS IoT cloud. Using AWS JITR mechanism, an IoT device can be connected to AWS IoT cloud if the OEM follows these two steps:

- Set up the AWS IoT account by registering and activating the intermediate CA certificate.
- Configure the AWS IoT account for the first-time device onboarding. Then, connect the IoT device to AWS IoT cloud to register its digital certificate automatically.

These two steps are further elaborated in Chapter 6 and Chapter 7. In addition, more information on AWS IoT services and the Just-In-Time registration mechanism can be found in [AWS_IOT] [JITR].

6. AWS setup by OEM: Register intermediate CA certificates

The OEM manufacturer should start setting up the AWS account by registering the intermediate CA digital certificate. This certificate must be uploaded to the AWS to enable auto-registration of certificate via JITR. Every time a new IoT device is connected to the AWS cloud, the chain of trust will be validated, i.e., the IoT device certificate signature is validated by the intermediate CA certificate, and at the same time, the intermediate CA certificate signature must have been validated by the root CA.

The workflow to register and activate a new intermediate CA certificate in AWS cloud is the following:

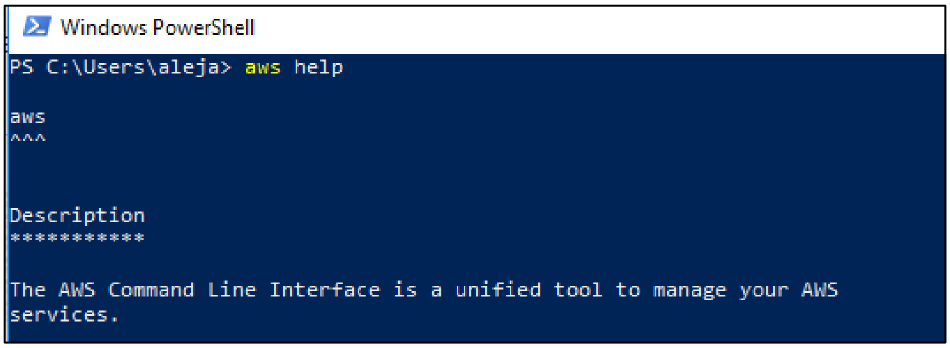
- Obtain a registration code from AWS.
- Use the registration code to create a Verification CSR. The registration code will be embedded in the ‘CN’ (Common Name) field of the Verification CSR.
- Use the CSR and the intermediate CA credentials to create a Verification Certificate.
- Upload both the Verification certificate and the intermediate CA certificate to AWS.
- Activate the registered intermediate CA certificate, after validation of the intermediate signature.
- Enable auto-registration status of the registered intermediate CA certificate.

These required steps are described in this chapter. The entire workflow can be done using either the AWS CLI (command line interface) or the register certificate section of the AWS IoT website. In this document though, the AWS CLI has been used

6.1 AWS Command Line Interface (AWS CLI)

The AWS Command Line Interface (CLI) is an open source tool built on top of the AWS SDK for Python (Boto) that provides commands for interacting with AWS services and direct access to AWS service’s public APIs. It requires minimal configuration and once installed it can be used from a terminal application in Windows, Linux shells or even through a remote terminal such as PuTTY or SSH on Amazon EC2 instances. More information on AWS CLI can be found in [AWS_CLI].

The AWS CLI can be downloaded from [AWS_CLI] and installed on Windows, Mac and Linux platforms. Fig 14 shows a capture of the execution of AWS CLI with Windows PowerShell. The ‘help’ command has been executed to prompt all the AWS CLI functionality on the terminal.



```
PS C:\Users\aleja> aws help

aws
^^^


Description
***********

The AWS Command Line Interface is a unified tool to manage your AWS
services.
```

Fig 14. AWS CLI on Windows PowerShell

6.2 Obtain registration code from AWS

The process for validating ownership and registering an intermediate CA certificate in AWS IoT services is done through a challenge and response flow.

To register an intermediate CA certificate with AWS IoT, OEM have to verify that you have access to both the intermediate CA certificate and the intermediate CA private key. For this, a Verification certificate has to be generated using a registration code provided by AWS IoT and the CA private key.

The registration code can be obtained with the following AWS CLI command:

```
$ aws iot get-registration-code
```

The provided code is randomly generated and long-lived, i.e., it will not expire.

6.3 Create Verification certificate and upload it to AWS

Then, a certificate signing request (CSR) has to be prepared to generate the Verification certificate. This CSR will contain the registration code in its ‘CN’ field (highlighted in green). The following OpenSSL commands can be executed:

```
openssl ecparam -genkey -name prime256v1 -out VerificationKeys.pem

openssl req -new -key VerificationKeys.pem -subj "/CN=registration code" -out
VerificationCSR.pem

openssl x509 -req -in VerificationCSR.pem -CA intCACertificate.pem -CAkey
intCAkey.pem -CAcreateserial -out Verificationcertificate.pem -days 365 -sha256
```

Firstly, a new ECC key pair is generated. This key pair will belong to the Verification certificate. Then the CSR containing the registration code is created and the Verification certificate is created based upon the information contained in the CSR and signed with the intermediate CA private key. Finally, both the Verification certificate and the intermediate CA certificate are uploaded to AWS IoT using the AWS CLI:

```
$aws iot register-ca-certificate --ca-certificate file://intCAcertificate.pem -
-verification-certificate file://Verificationcertificate.pem
```

6.4 Activate intermediate CA certificate and enable auto-registration

By default, the registered intermediate CA certificate is in ‘inactive’ state, which means that it cannot be used for validating new IoT devices certificates. Hence, it is necessary to activate it.

The information of the registered certificate can be obtained with the following command:

```
$ aws iot describe-ca-certificate --certificate-id <certificateId>
```

Where <*certificateId*> is the ID returned in the response of the previous AWS CLI command (*iot register-ca-certificate*).

Then, the intermediate CA can be activated:

```
$ aws iot update-ca-certificate --certificate-id <certificateId> --new-status
ACTIVE
```

Also, the auto-registration-status property of the registered intermediate CA certificate has to be enabled. If auto-registration-status is enabled, AWS IoT services will automatically register any IoT device certificate issued by that intermediate CA.

```
$ aws iot update-ca-certificate --certificate-id <certificateId> --new-auto-
registration-status ENABLED
```

Fig 15 illustrates the explained CA certificate registration workflow.

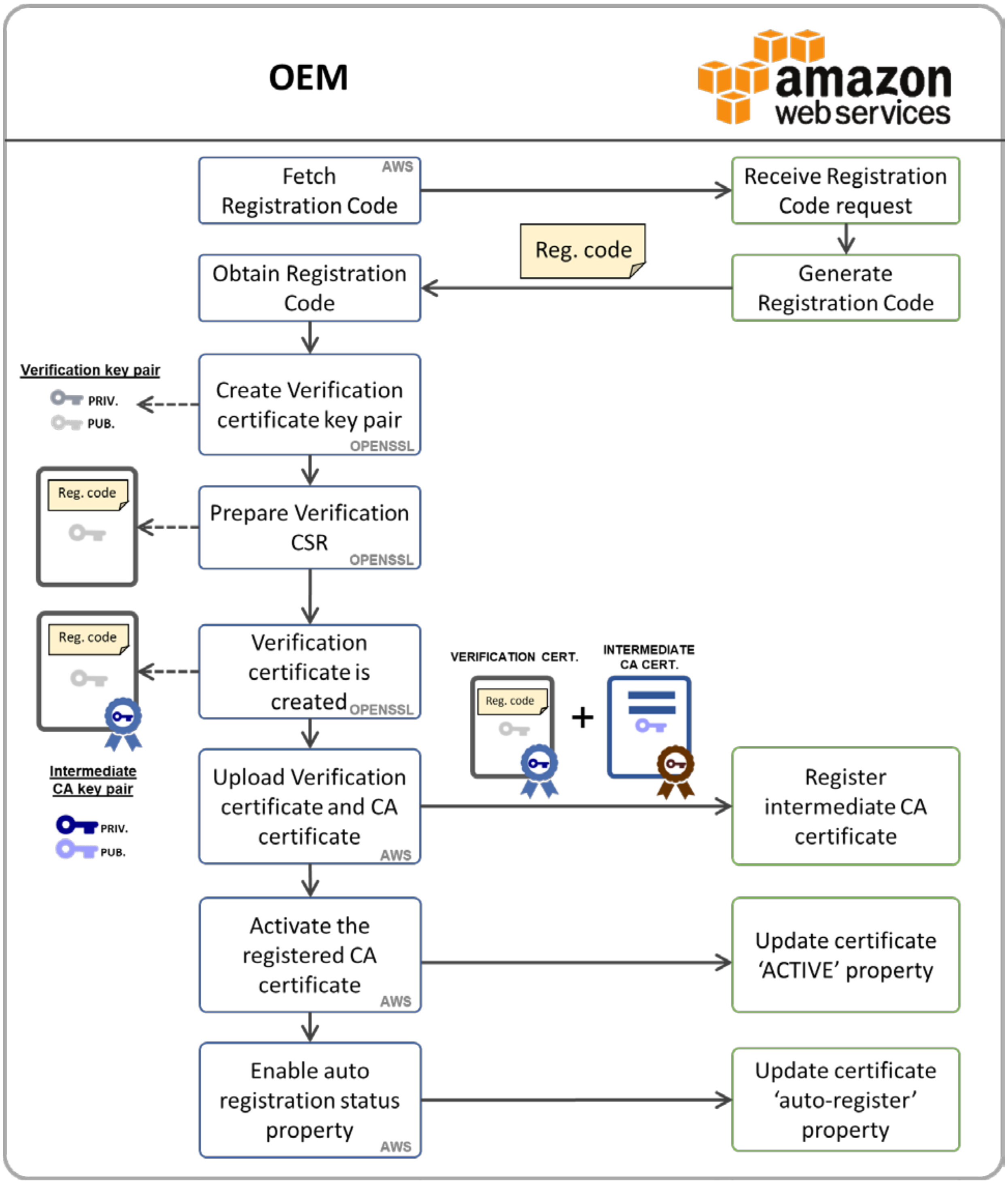
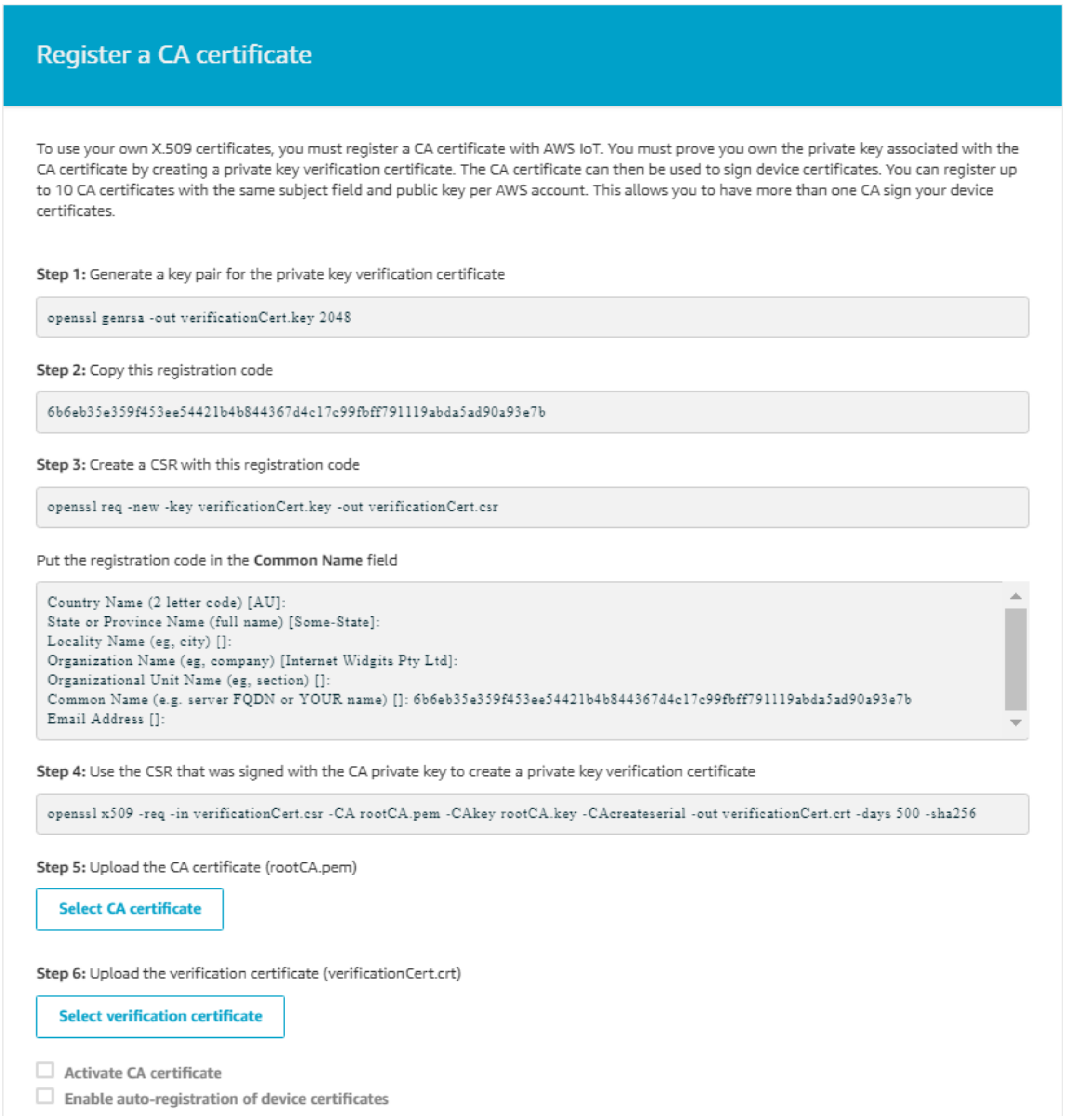

OEM
amazon web services
Fetch Registration Code AWS
Receive Registration Code request
Reg. code
Obtain Registration Code
Generate Registration Code
Verification key pair
PRIV.
PUB.
Create Verification certificate key pair OPENSSL
Reg. code
Prepare Verification CSR OPENSSL
Reg. code
Verification certificate is created OPENSSL
VERIFICATION CERT.
INTERMEDIATE CA CERT.
Reg. code
+
Intermediate CA key pair
PRIV.
PUB.
Upload Verification certificate and CA certificate AWS
Register intermediate CA certificate
Activate the registered CA certificate AWS
Update certificate 'ACTIVE' property
Enable auto registration status property AWS
Update certificate 'auto-register' property

Fig 15. CA certificate registration workflow

6.5 Register CA certificates with AWS IoT website interface

The intermediate CA registration process can also be carried out through the user interface available in the AWS IoT website. Fig 16 shows a screen capture of the CA certificate registry section. As can be observed, the same steps have to be followed, i.e., obtain a registration code, prepare the Verification CSR with the registration code in the “Common Name” field, sign the Verification CSR with the intermediate CA and upload it together with the intermediate CA.



Register a CA certificate

To use your own X.509 certificates, you must register a CA certificate with AWS IoT. You must prove you own the private key associated with the CA certificate by creating a private key verification certificate. The CA certificate can then be used to sign device certificates. You can register up to 10 CA certificates with the same subject field and public key per AWS account. This allows you to have more than one CA sign your device certificates.

Step 1: Generate a key pair for the private key verification certificate

```
openssl genrsa -out verificationCert.key 2048
```

Step 2: Copy this registration code

```
6b6eb35e359f453ee54421b4b844367d4c17c99fbff791119abda5ad90a93e7b
```

Step 3: Create a CSR with this registration code

```
openssl req -new -key verificationCert.key -out verificationCert.csr
```

Put the registration code in the **Common Name** field

```
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) []: 6b6eb35e359f453ee54421b4b844367d4c17c99fbff791119abda5ad90a93e7b
Email Address []:
```

Step 4: Use the CSR that was signed with the CA private key to create a private key verification certificate

```
openssl x509 -req -in verificationCert.csr -CA rootCA.pem -CAkey rootCA.key -CAcreateserial -out verificationCert.crt -days 500 -sha256
```

Step 5: Upload the CA certificate (rootCA.pem)

Step 6: Upload the verification certificate (verificationCert.crt)

☐ Activate CA certificate

☐ Enable auto-registration of device certificates

Fig 16. Register CA certificate AWS IoT website interface

7. First time device onboarding: IoT device certificate registration

The intermediate CA certificate is already registered, activated and its ‘auto-registration-status’ has been enabled. Every time a new IoT device is connected to the AWS IoT cloud, the service will detect an unidentified IoT device certificate issued by that intermediate CA and will proceed to auto-register it. The first-time device onboarding workflow can be divided into the following two steps:

- Combine the IoT device certificate with the intermediate CA certificate.
- Initiate a TLS communication with AWS IoT cloud using an MQTT client.

First of all, the IoT device will have to prepare a file composed of the IoT device certificate and the intermediate CA certificate. Then, the IoT device will attempt to establish a TLS connection with AWS IoT using an MQTT client. The AWS IoT service supports the publish-subscribe MQTT.

During the TLS handshake, AWS IoT will detect that the IoT device has not been registered before and therefore will proceed to register it on AWS IoT automatically.

The registered IoT device certificate will be ‘de-activated’ by default. To automatically activate a new IoT device, an AWS Lambda function has to be previously created and properly configured.

Finally, the IoT device will be able to establish a TLS connection with AWS IoT.

All these steps are explained in detail in this chapter, as well as the MQTT protocol and the AWS Lambda functions

7.1 Combine IoT device certificate with intermediate CA certificate

The IoT device certificate has to be combined with the issuer intermediate CA certificate. In Linux based platforms, it can be done with ‘cat’ terminal command:

```
$ cat IoTdeviceCertificate.pem intCAcertificate.pem > CAandIoTcertificate.pem
```

While in Windows-based environments, it can be done by running the following command on the shell:

```
type IoTdeviceCertificate.pem intCAcertificate.pem > CAandIoTcertificate.pem
```

An MQTT client running across TLS will be used to establish a TLS link between the IoT device and AWS IoT. During the TLS handshake, the “CAandIoTcertificate” file will be sent to AWS IoT.

7.2 MQTT

Message Queue Telemetry Transport (MQTT) is an ISO standard (ISO/IEC PRF 20922) Machine-to-Machine (M2M) publish-subscribe based communication protocol used in the Internet of Things. The MQTT is a low-power and low-bandwidth protocol oriented to embedded devices with small computational resources such as sensors. For this reason, it is commonly employed in sensor networks, i.e., IoT devices networks.

MQTT takes layers 5-7 of the ISO/OSI layers model and relies on TCP/IP as transport and network protocols. Additionally, it supports the use of SSL/TLS for encrypting and securing the communication. Fig 17 illustrates the communication stack presented in 4.3, including MQTT.

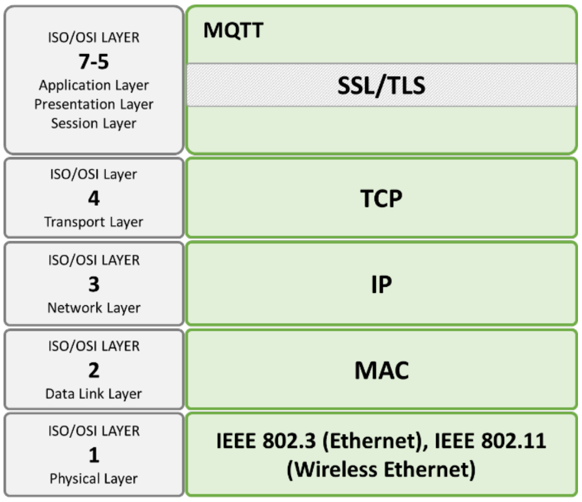


Fig 17. Communication stack with MQTT and TLS. ISO/OSI Layers

Regarding the network architecture, MQTT protocol follows a star topology in which there is a central node, also called broker, and a series of clients. The broker device is in charge of managing the network message exchange, while the clients are periodically transmitting messages and waiting for the broker response. Fig 18 illustrates an example of an MQTT star architecture. In this case, an AWS IoT cloud acts as the broker device and a series of IoT devices are the clients.

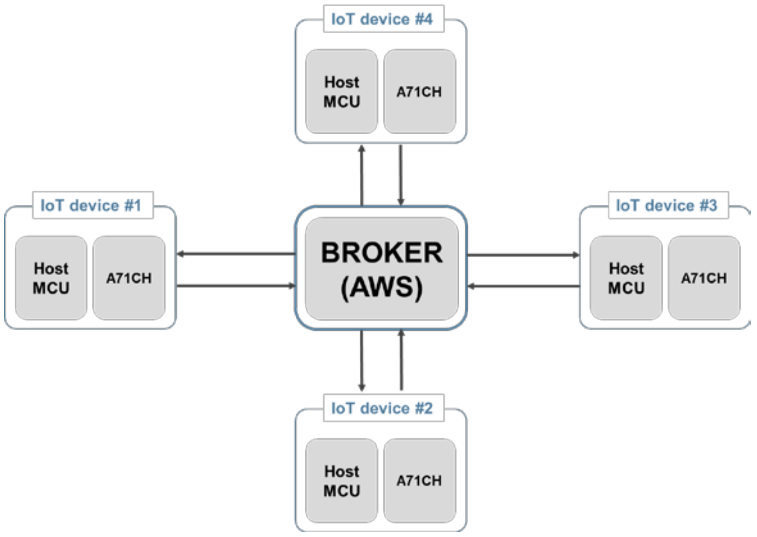


Fig 18. Example of MQTT star architecture

Communication between client devices and the broker is based on ‘topics’. A topic is a UTF-8 string which is used by the broker to filter messages for each connected client. A topic can consist of one or more levels, each one separated by a forward slash. Clients can publish messages in a given topic, or they can subscribe to a topic to receive messages published by the rest of the client devices.

For instance, in the AWS IoT scenario, the following MQTT topic is used by the broker (AWS IoT) for managing the registered IoT device certificates (clients):

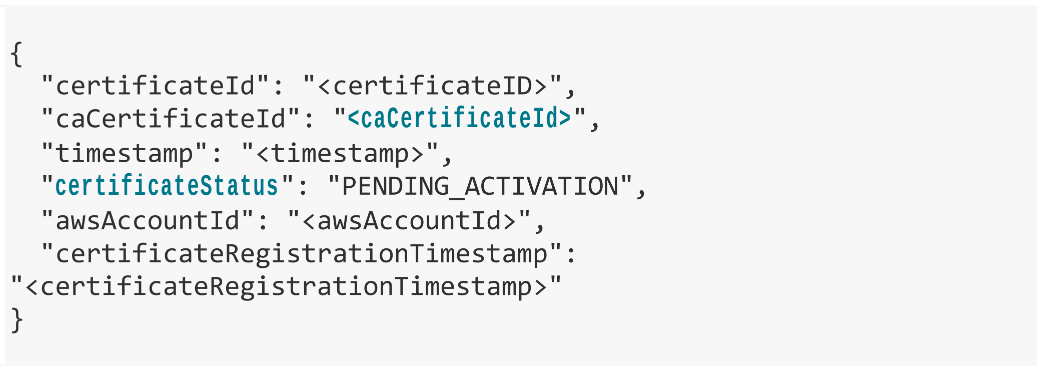
```
$aws/events/certificates/registered/<caCertificateID>
```

Whenever an IoT device wants to establish a TLS connection with AWS IoT, the IoT device certificate will be first checked. First, the signature of the IoT device certificate will be validated with the public key contained in the registered intermediate CA certificate.

In case the IoT device certificate signature is validated, but the certificate is not registered in AWS IoT (or it is in 'PENDING_ACTIVATION' state), the TLS handshake will fail.

Then, the IoT device certificate will be auto-registered in the AWS IoT server and an MQTT message will be automatically published by AWS IoT in that 'registration' topic. Remember that, the 'auto-registration' property of the registered intermediate CA should be enabled as it is explained in 6.4.

The published MQTT message has the following structure:



```
{
  "certificateId": "<certificateID>",
  "caCertificateId": "<caCertificateId>",
  "timestamp": "<timestamp>",
  "certificateStatus": "PENDING_ACTIVATION",
  "awsAccountId": "<awsAccountId>",
  "certificateRegistrationTimestamp":
"<certificateRegistrationTimestamp>"
}
```

Fig 19. Example of MQTT certificate registration publication

where <*caCertificateID*> belongs to the identifier of the intermediate CA certificate. Furthermore, as it can be observed, the *certificateStatus* field is in 'PENDING_ACTIVATION'.

More information on MQTT and MQTT with AWS can be found in [MQTT] [JITR].

7.3 IoT device certificate registration event with AWS Lambda function

As has been mentioned in 7.2, when AWS IoT publishes an MQTT 'certificate registration' message, the registered IoT device certificate *certificateStatus* field is in 'PENDING_ACTIVATION' state.

Further TLS connection attempts will continue failing because only 'ACTIVE' certificates are authenticated with AWS IoT. Therefore, the *certificateStatus* field of the registered IoT device should be changed to 'ACTIVE' in order to be successfully authenticated during the TLS handshake. It is possible to automatically move certificate status from 'PENDING_ACTIVATION' to 'ACTIVE' by using AWS Lambda functions.

AWS Lambda is a compute service that lets you run code without provisioning or managing servers. AWS Lambda executes your code only when needed and scales automatically, from a few requests per day to thousands per second. For instance, it is possible to attach a rule to an AWS IoT MQTT topic that can take some action based on the messages received.

Therefore, regarding the IoT device certificates registration, it is possible to create a rule for the 'registration' topic that automatically activates the registered IoT device certificates. A step-by-step guide explaining how to create a new AWS Lambda function and attach a new rule to a MQTT topic is presented in detail in [JITR].

Also, more information on AWS Lambda functionality can be found in [AWS_LAMBDA].

7.4 Connection to AWS IoT with an MQTT client

Finally, the IoT device will attempt to establish a TLS connection with AWS IoT. In this example, the MQTT Mosquitto client is used [MQTT_MOSQUITTO], and the following command is executed:

```
$ mosquitto_pub --cafile root.cert --cert CAandIoTcertificate.pem --key
IoTdeviceKey.pem -h <prefix>.iot.us-east-1.amazonaws.com -p 8883 -q 1 -t
foo/bar -i  anyclientID --tls-version tlsv1.2 -m "Hello" -d
```

where:

- "root.cert" (--ca file) is the AWS IoT root certificate used by an IoT device to verify the identity of the AWS IoT servers during the TLS Handshake (4.3.1). This AWS root certificate can be downloaded from [AWS_ROOT].
- "CAandIoTcertificate.pem" (--cert) is the file containing the IoT device certificate and the intermediate CA certificate.
- "IoTdeviceKey.pem" (--key) is the IoT device key pair.
- "<prefix>. iot.us-east-1.amazonwas.com" (-h) is the AWS IoT service instance.
- "8883" (-p) is the port number.
- "1" (-q) specifies the quality of service to use for the message.
- "foo/bar" (-t) specifies the topic on which to publish the message.
- "anyclientID" (-i) specifies the id to use for this client.
- "tlsv1.2" (--tls-version) specifies which TLS protocol version to use when communicating with AWS.
- "Hello" (-m) is the message to be sent.
- Finally (-d) enables debug messages.

This command will lead to the auto-registration of the IoT device certificate during the TLS handshake:

- The TLS Handshake protocol will start.
- A registration message (Fig 19) will be published by AWS in the MQTT 'registration' topic in order to register the IoT device certificate.

- The TLS Handshake will fail since AWS IoT disconnects the connection after the registration of the IoT device certificate.
- The attached AWS Lambda rule will be triggered and the ‘certificateStatus’ field of the publication will be automatically changed from ‘PENDING_ACTIVATION’ to ‘ACTIVE’.
- The IoT device could implement an automatic reconnect strategy to correctly establish a TLS connection with AWS IoT cloud.

Fig 20 illustrates the explained IoT device certificate registration workflow.

Note: This example is just a conceptual illustration on how the MQTT client works. In this example the A71CH is not involved in the TLS handshake protocol. The next chapter takes the reader step-by-step on how to achieve the same using an A71CH.

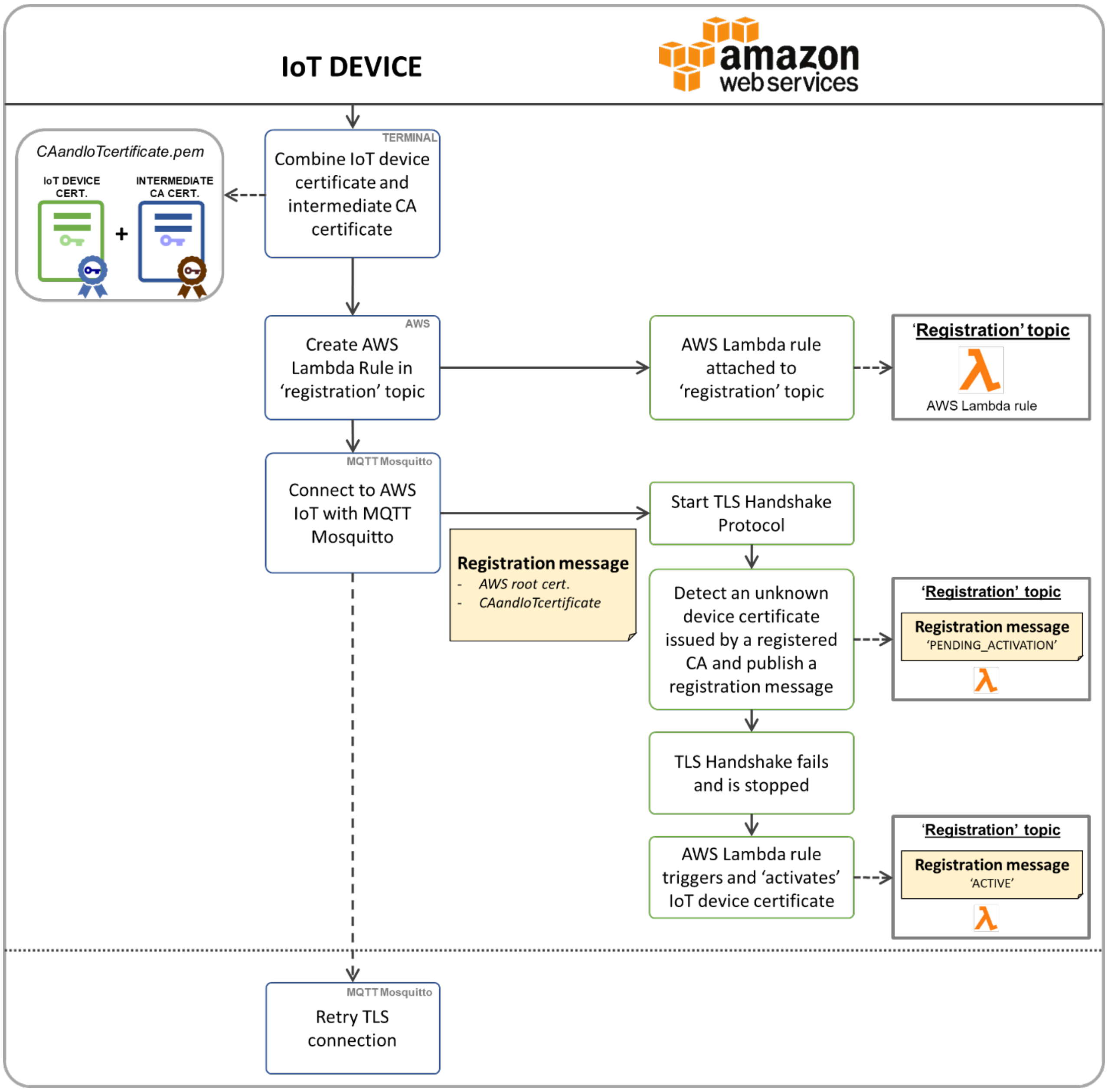

IoT DEVICE
amazon web services
CAandIoTcertificate.pem
IoT DEVICE CERT.
INTERMEDIATE CA CERT.
+
TERMINAL
Combine IoT device certificate and intermediate CA certificate
AWS
Create AWS Lambda Rule in 'registration' topic
AWS Lambda rule attached to 'registration' topic
'Registration' topic
AWS Lambda rule
MQTT Mosquitto
Connect to AWS IoT with MQTT Mosquitto
Start TLS Handshake Protocol
Registration message
- AWS root cert.
- CAandIoTcertificate
Detect an unknown device certificate issued by a registered CA and publish a registration message
'Registration' topic
Registration message
'PENDING_ACTIVATION'
TLS Handshake fails and is stopped
AWS Lambda rule triggers and 'activates' IoT device certificate
'Registration' topic
Registration message
'ACTIVE'
MQTT Mosquitto
Retry TLS connection

Fig 20. IoT device certificate registration workflow

8. Evaluating A71CH for secure connection to AWS IoT

This section concerns how to establish a secure connection between an IoT device featuring the A71CH and AWS IoT cloud. In this example, the following elements are involved:

- MCIMX6UL-EVK: i.MX6UltraLite MCU evaluation board with Internet connectivity via Ethernet. This board will act as the IoT device and will connect to the A71CH through OM3710/A71CHARD Arduino shield.
- OM3710/A71CHARD: Arduino development kit containing a mini PCB board with the A71CH security IC and an Arduino shield compatible with the MCIMX6UL-EVK.
- Development PC: a Windows platform will be used to configure and prepare the AWS IoT account and register a demo CA certificate. Additionally, the i.MX6UltraLite will be controlled from the development PC using Tera Term.

A quick-start guide on how to get started with the OM3710/A71CHARD development kit and the MCIMX6UL-EVK i.MX6UltraLite evaluation board can be found in [QUICK_START_IMX6]. Regarding the i.MX6UltraLite Internet connection, it might be necessary to manually set the IP address of the DNS server.

Note: This section describes how to establish a secure connection with AWS using a development PC and an i.MX6UltraLite with an A71CH security IC. The following description will re-uses several of the commands already presented in this document and it is provided only for demonstration. Therefore, the subsequent procedure must be adapted and adjusted accordingly for commercial deployment.

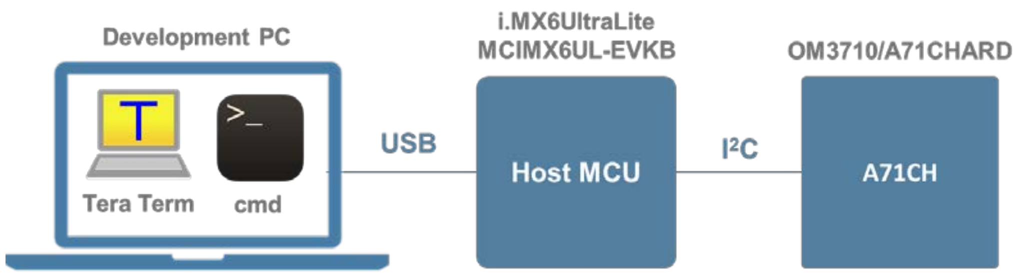


Fig 21. Demo system setup

Fig 21 depicts the setup that will be used for this demonstration. The connection with AWS IoT cloud will be established from the i.MX6UltraLite MCU. The A71CH security IC will be connected to the i.MX6UltraLite through the OM3710/A71CHARD Arduino shield.

First, the user acting as the OEM will use a development PC to register and activate an intermediate CA certificate as it is explained in chapter 6. In this example, it is assumed that there is no existing intermediate CA; thus, a self-signed demo CA certificate will be created only for demo purposes.

Windows OpenSSL libraries (included in the A71CH Host software package) will be used to create the demo CA credentials, while AWS CLI will be used to configure OEM's AWS account and to register the demo CA certificate. Both OpenSSL and AWS CLI commands will be called from a Windows command prompt 'cmd'. Once the demo CA certificate is registered and activated, the demo CA credentials will be transferred to the i.MX6UltraLite.

In the i.MX6UltraLite, the demo CA certificate will be combined with the IoT device certificate and the connection with AWS will be established as explained in chapter 7. For this purpose, the IoT device credentials will be created in the i.MX6UltraLite using OpenSSL libraries, and the IoT device key pair will be securely stored into the A71CH using the Configure tool. Finally, the TLS connection with AWS IoT will be established using an MQTT client compatible with the A71CH OpenSSL engine.

To summarize, the steps are the following:

1. Configure the AWS IoT account and obtain a registration code using AWS CLI.
2. Using OpenSSL, create demo CA credentials and the Verification certificate with the registration code.
3. Upload both the Verification certificate and the demo CA certificate to AWS IoT using the AWS CLI.
4. Activate the registered demo CA and enable 'auto-registration' status using AWS CLI.
5. Transfer the demo CA credentials from the development PC to the i.MX6.
6. Using OpenSSL on the i.MX6UltraLite, prepare the IoT device credentials and combine the IoT device certificate with the demo CA certificate.
7. Connect to AWS IoT using an MQTT client.

In this chapter, each one of the listed steps will be explained.

8.1 Obtain registration code from AWS

The first step is to obtain a registration code from AWS IoT. For this, the AWS CLI will be used as stated in section 6.2. The AWS CLI will be launched from a Windows command line terminal, and the following command will be called to first configure the AWS IoT account:

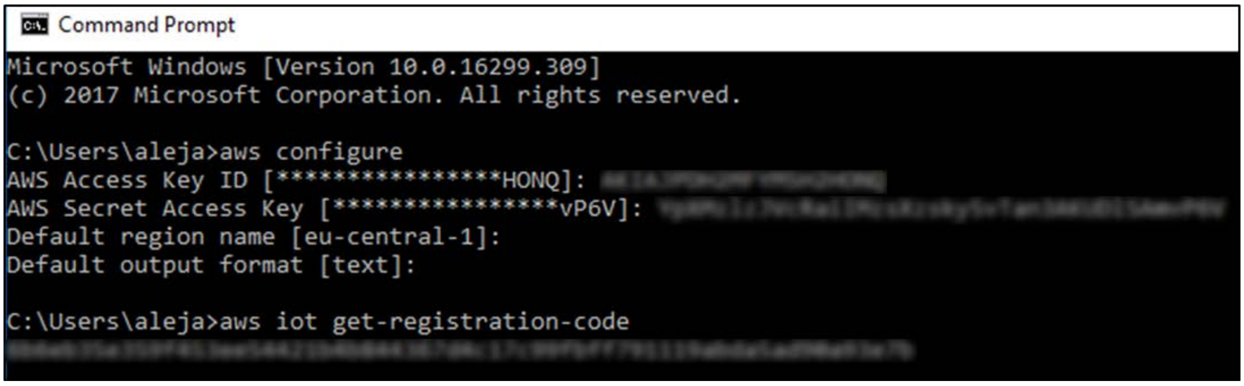
```
aws configure
```

AWS Access credentials (Access Key ID and Secret Access Key), region name and output format will be asked. The AWS Access Key ID and Secret Access Key can be obtained from the AWS IoT control panel console [AWS_CLI_ACCESS], while the region name can be obtained from [AWS_CLI_REGIONS]. Finally, the default output format will be set as 'text' (by default, it is configured as 'json').

Once the AWS CLI account has been configured, a registration code can be requested:

```
aws iot get-registration-code
```

Fig 22 shows the command line terminal and the output of both 'configure' and 'iot get-registration-code' commands. The AWS Access Key ID, AWS Secret Access Key and registration code have been blurred.



```
Microsoft Windows [Version 10.0.16299.309]
(c) 2017 Microsoft Corporation. All rights reserved.

C:\Users\aleja>aws configure
AWS Access Key ID [****************HONQ]: [redacted]
AWS Secret Access Key [****************vP6V]: [redacted]
Default region name [eu-central-1]:
Default output format [text]:

C:\Users\aleja>aws iot get-registration-code
[redacted]
```

Fig 22. AWS CLI configure command

8.2 Create Verification certificate and upload it to AWS

The demo CA credentials and the Verification certificate will be created in the Windows platform using OpenSSL commands (section 6.3) in a command line terminal. The following steps have to be taken:

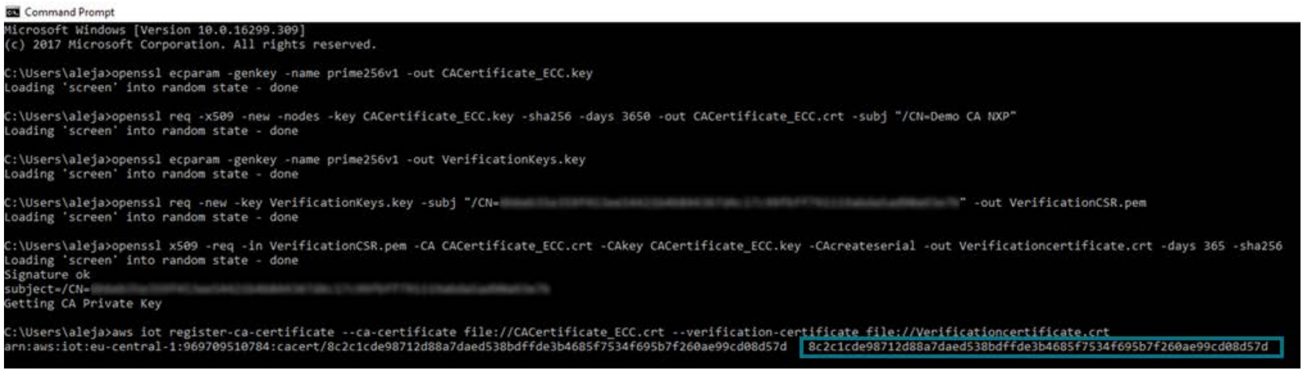
- First, a new pair of ECC keys *CACertificate_ECC.key* will be created for the demo CA credentials.
- Then, a self-signed *CACertificate_ECC.crt* certificate will be created.
- The Verification ECC key pair *VerificationKeys.key* will be generated.
- The Verification public key and the registration code obtained in 0 will be included in the *VerificationCSR.pem*.
- The Verification certificate *Verificationcertificate.crt* will be issued by the demo CA certificate *CACertificate_ECC.crt*. It will contain the information retrieved from the *VerificationCSR.pem*.

Each one of the listed steps corresponds to the following OpenSSL commands:

```
openssl ecparam -genkey -name prime256v1 -out CACertificate_ECC.key

openssl req -x509 -new -nodes -key CACertificate_ECC.key -sha256 -days 3650 -
out CACertificate_ECC.crt -subj "/CN="Demo CA NXP"

openssl ecparam -genkey -name prime256v1 -out VerificationKeys.key

openssl req -new -key VerificationKeys.key -subj "/CN=REGISTRATION CODE" -out
VerificationCSR.pem

openssl x509 -req -in VerificationCSR.pem -CA CACertificate_ECC.crt -CAkey
CACertificate_ECC.key -CAcreateserial -out Verificationcertificate.crt -days
3650 -sha256
```

Once the Verification certificate has been created, it will be registered to AWS IoT using AWS CLI with the '*iot register-ca-certificate*' command:

```
aws iot register-ca-certificate -ca-certificate file://CACertificate_ECC.crt --
verification-certificate file://Verificationcertificate.crt
```



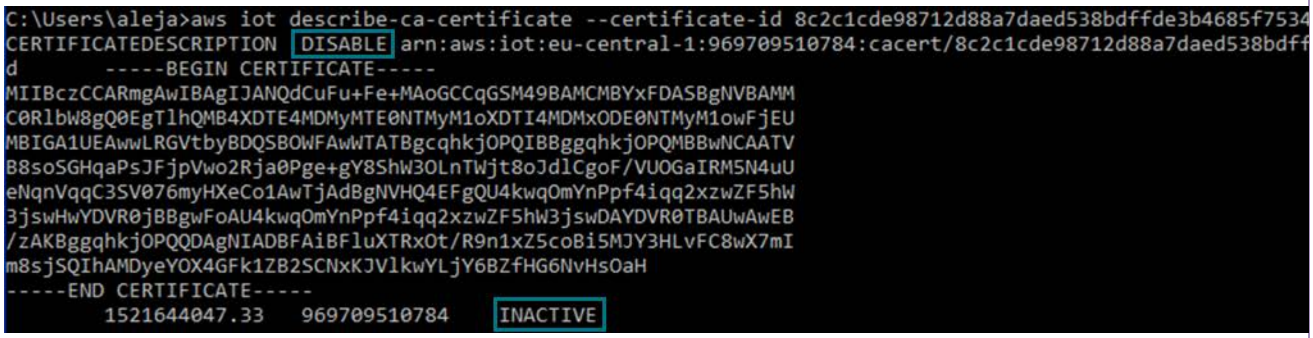
```
Command Prompt
Microsoft Windows [Version 10.0.16299.309]
(c) 2017 Microsoft Corporation. All rights reserved.

C:\Users\aleja>openssl ecparam -genkey -name prime256v1 -out CACertificate_ECC.key
Loading 'screen' into random state - done

C:\Users\aleja>openssl req -x509 -new -nodes -key CACertificate_ECC.key -sha256 -days 3650 -out CACertificate_ECC.crt -subj "/CN=Demo CA NXP"
Loading 'screen' into random state - done

C:\Users\aleja>openssl ecparam -genkey -name prime256v1 -out VerificationKeys.key
Loading 'screen' into random state - done

C:\Users\aleja>openssl req -new -key VerificationKeys.key -subj "/CN=[redacted]" -out VerificationCSR.pem
Loading 'screen' into random state - done

C:\Users\aleja>openssl x509 -req -in VerificationCSR.pem -CA CACertificate_ECC.crt -CAkey CACertificate_ECC.key -CAcreateserial -out Verificationcertificate.crt -days 365 -sha256
Loading 'screen' into random state - done
Signature ok
subject=/CN=[redacted]
Getting CA Private Key

C:\Users\aleja>aws iot register-ca-certificate --ca-certificate file://CACertificate_ECC.crt --verification-certificate file://Verificationcertificate.crt
arn:aws:iot:eu-central-1:969709510784:cacert/8c2c1cde98712d88a7daed538bdffde3b4685f7534f695b7f260ae99cd08d57d  8c2c1cde98712d88a7daed538bdffde3b4685f7534f695b7f260ae99cd08d57d
```

Fig 23. **OpenSSL commands executed in the development PC**

Fig 23 shows the Windows terminal with the execution of the above-mentioned commands. The registered demo CA certificate information can be prompted with the following AWS command (section 6.4):

```
aws iot describe-ca-certificate --certificate-id
8c2c1cde98712d88a7daed538bdffde3b4685f7534f695b7f260ae99cd08d57d
```

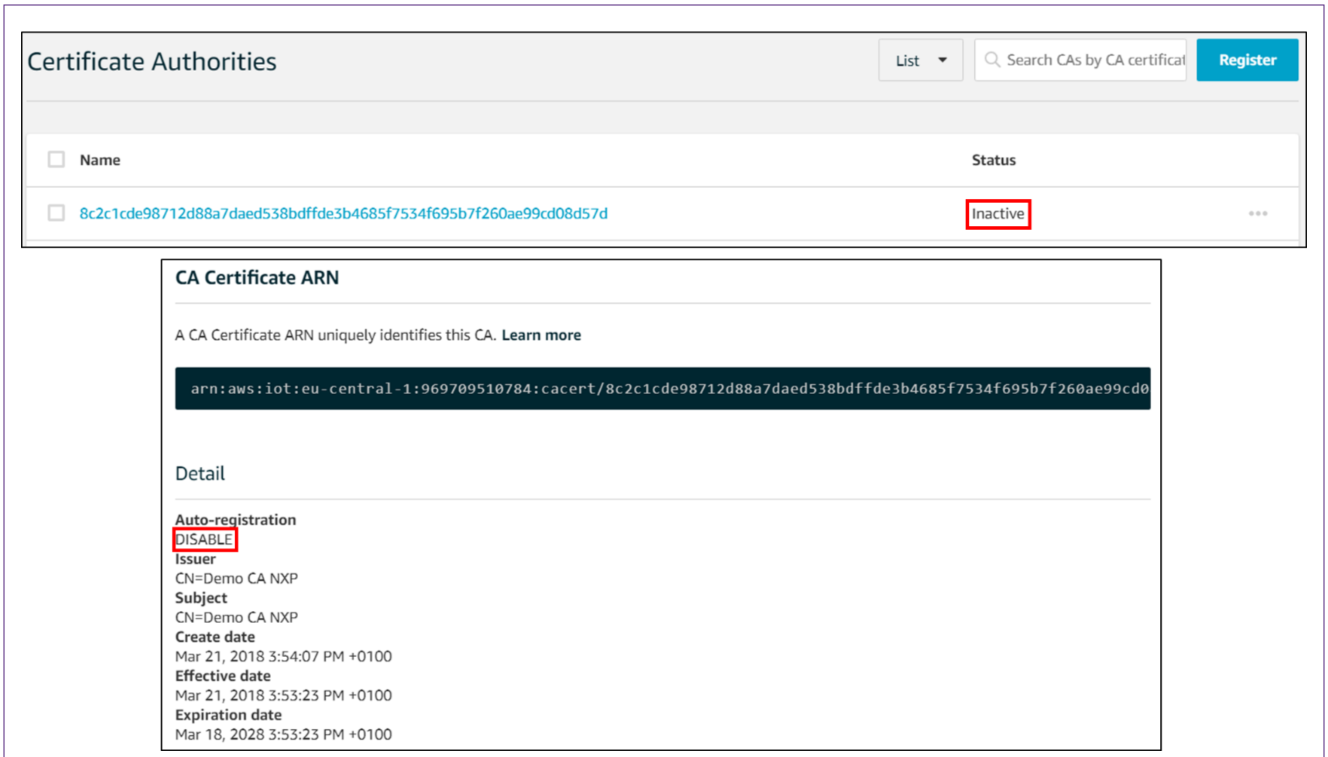
Where the certificate ID ‘*8c2c1cde…*’ is the string returned in the response of the ‘*iot register-ca-certificate*’ command. As is highlighted in Fig 24, the registered CA certificate is set as inactive, and its auto-registration property is disabled by default.



```
C:\Users\aleja>aws iot describe-ca-certificate --certificate-id 8c2c1cde98712d88a7daed538bdffde3b4685f7534
CERTIFICATEDESCRIPTION  DISABLE  arn:aws:iot:eu-central-1:969709510784:cacert/8c2c1cde98712d88a7daed538bdff
d       -----BEGIN CERTIFICATE-----
MIIBczCCARmgAwIBAgIJANQdCuFu+Fe+MAoGCCqGSM49BAMCMBYxFDASBgNVBAMM
C0RlbW8gQ0EgTlhQMB4XDTE4MDMyMTE0NTMyM1oXDTI4MDMxODE0NTMyM1owFjEU
MBIGA1UEAwwLRGVtbyBDQSBOWFAwWTATBgcqhkjOPQIBBggqhkjOPQMBBwNCAATV
B8soSGHqaPsJFjpVwo2Rja0Pge+gY8ShW3OLnTWjt8oJdlCgoF/VUOGaIRM5N4uU
eNqnVqqC3SV076myHXeCo1AwTjAdBgNVHQ4EFgQU4kwqOmYnPpf4iqq2xzwZF5hW
3jswHwYDVR0jBBgwFoAU4kwqOmYnPpf4iqq2xzwZF5hW3jswDAYDVR0TBAUwAwEB
/zAKBggqhkjOPQQDAgNIADBFAiBFluXTRxOt/R9n1xZ5coBi5MJY3HLvFC8wX7mI
m8sjSQIhAMDyeYOX4GFk1ZB2SCNxKJVlkwYLjY6BZfHG6NvHsOaH
-----END CERTIFICATE-----
        1521644047.33    969709510784    INACTIVE
```

Fig 24. **Registered demo CA**

It is also possible to observe the status of the registered CA certificate directly on the AWS IoT website interface (Fig 25).



Name	Status
8c2c1cde98712d88a7daed538bdffde3b4685f7534f695b7f260ae99cd08d57d	Inactive

CA Certificate ARN

A CA Certificate ARN uniquely identifies this CA. **Learn more**

```
arn:aws:iot:eu-central-1:969709510784:cacert/8c2c1cde98712d88a7daed538bdffde3b4685f7534f695b7f260ae99cd0
```

Detail

Auto-registration
DISABLE
Issuer
CN=Demo CA NXP
Subject
CN=Demo CA NXP
Create date
Mar 21, 2018 3:54:07 PM +0100
Effective date
Mar 21, 2018 3:53:23 PM +0100
Expiration date
Mar 18, 2028 3:53:23 PM +0100

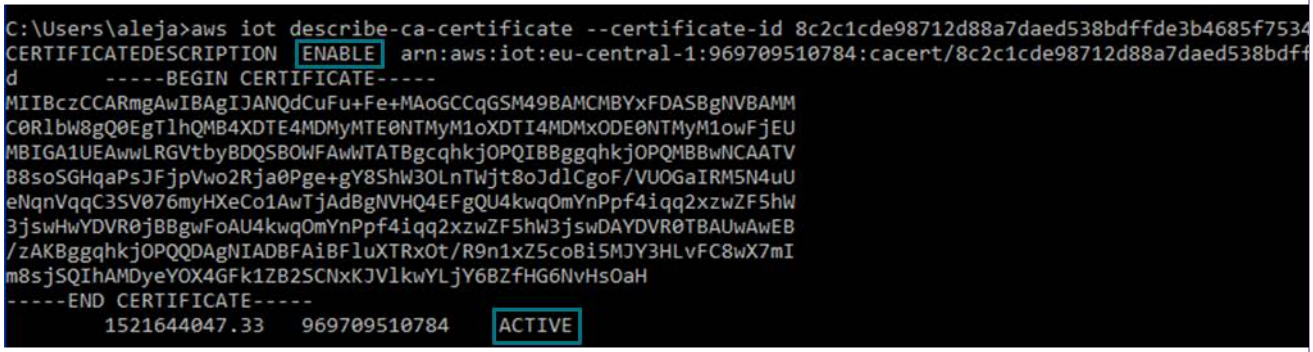
Fig 25. AWS IoT website interface

8.3 Activate demo CA certificate and enable auto-registration

The registered CA certificate can be activated, and its ‘auto-registration’ property can be enabled with the following AWS CLI commands:

```
aws iot update-ca-certificate --certificate-id
8c2c1cde98712d88a7daed538bdffde3b4685f7534f695b7f260ae99cd08d57d --new-status
ACTIVE

aws iot update-ca-certificate --certificate-id
8c2c1cde98712d88a7daed538bdffde3b4685f7534f695b7f260ae99cd08d57d --new-auto-
registration-status ENABLE

aws iot describe-ca-certificate --certificate-id
8c2c1cde98712d88a7daed538bdffde3b4685f7534f695b7f260ae99cd08d57d
```

Fig 26 shows the final state of the registered CA. The ‘auto-registration’ property has been enabled, and the certificate has been activated.



```
C:\Users\aleja>aws iot describe-ca-certificate --certificate-id 8c2c1cde98712d88a7daed538bdffde3b4685f7534
CERTIFICATEDESCRIPTION  ENABLE  arn:aws:iot:eu-central-1:969709510784:cacert/8c2c1cde98712d88a7daed538bdff
d        -----BEGIN CERTIFICATE-----
MIIBczCCARmgAwIBAgIJANQdCuFu+Fe+MAoGCCqGSM49BAMCMBYxFDASBgNVBAMM
C0RlbW8gQ0EgTlhQMB4XDTE4MDMyMTE0NTMyM1oXDTI4MDMxODE0NTMyM1owFjEU
MBIGA1UEAwwLRGVtbyBDQSBOWFAwWTATBgcqhkjOPQIBBggqhkjOPQMBBwNCAATV
B8soSGHqaPsJFjpVwo2Rja0Pge+gY8ShW3OLnTWjt8oJdlCgoF/VUOGaIRM5N4uU
eNqnVqqC3SV076myHXeCo1AwTjAdBgNVHQ4EFgQU4kwqOmYnPpf4iqq2xzwZF5hW
3jswHwYDVR0jBBgwFoAU4kwqOmYnPpf4iqq2xzwZF5hW3jswDAYDVR0TBAUwAwEB
/zAKBggqhkjOPQQDAgNIADBFAiBFluXTRxOt/R9n1xZ5coBi5MJY3HLvFC8wX7mI
m8sjSQIhAMDyeYOX4GFk1ZB2SCNxKJVlkwYLjY6BZfHG6NvHsOaH
-----END CERTIFICATE-----
        1521644047.33    969709510784     ACTIVE
```

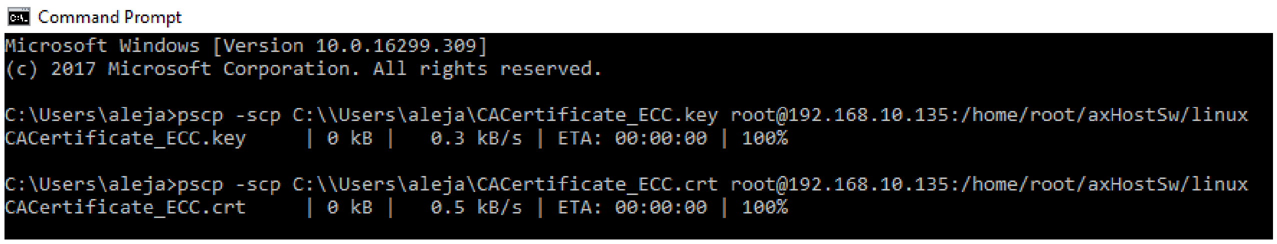
Fig 26. Registered demo CA

8.4 Transfer demo CA credentials to the i.MX6 MCU

The demo CA credentials have to be transferred to the i.MX6UltraLite, for instance using SCP (Secure Copy Protocol). Using SCP permits the OEM to distribute the CA certificates remotely to all their IoT devices connected to the same network in a secure way.

Fig 27 shows the '*pscp -scp*' command executed from the Windows command prompt. It shows the transfer of both demo CA credentials from the development PC to the i.MX6UltraLite platform. This '*pscp -scp*' command is provided by installing the PuTTY client [PUTTY].

SCP and OpenSSL tools can also be easily obtained by installing Cygwin on a Windows PC [CYGWIN].



```
Microsoft Windows [Version 10.0.16299.309]
(c) 2017 Microsoft Corporation. All rights reserved.

C:\Users\aleja>pscp -scp C:\\Users\aleja\CACertificate_ECC.key root@192.168.10.135:/home/root/axHostSw/linux
CACertificate_ECC.key     | 0 kB |   0.3 kB/s | ETA: 00:00:00 | 100%

C:\Users\aleja>pscp -scp C:\\Users\aleja\CACertificate_ECC.crt root@192.168.10.135:/home/root/axHostSw/linux
CACertificate_ECC.crt     | 0 kB |   0.5 kB/s | ETA: 00:00:00 | 100%
```

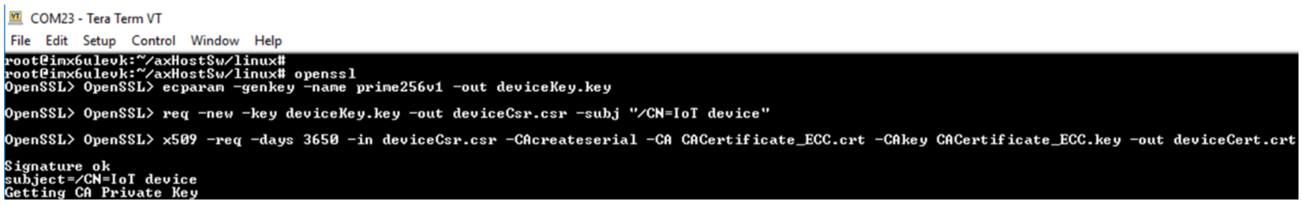
Fig 27. Transfer the demo CA credentials using SCP

8.5 Create IoT device credentials and combine IoT device certificate with the demo CA certificate

The i.MX6UltraLite will be controlled from the development PC using the Tera Term terminal as is explained in [QUICK_START_IMX6]. For the sake of simplicity, the IoT device credentials will be created in the same folder where the A71CH Configure tool executable and the demo CA credentials are located. The following OpenSSL commands can be used:

```
openssl ecparam -genkey -name prime256v1 -out deviceKey.key
openssl req -new -key deviceKey.key -out deviceCsr.csr -subj "/CN=IoT device"

openssl x509 -req -days 3650 -in deviceCsr.csr -CAcreateserial -CA
CACertificate_ECC.crt -CAkey CACertificate_ECC.key -out deviceCert.crt
```

Fig 28 shows the Tera Term window with the OpenSSL commands executed from the i.MX6UltraLite.



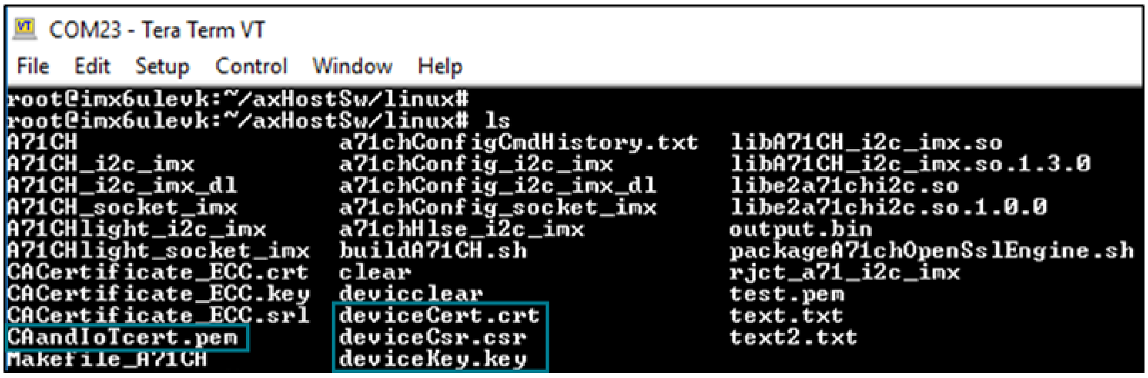
```
root@imx6ulevk:~/axHostSw/linux#
root@imx6ulevk:~/axHostSw/linux# openssl
OpenSSL> OpenSSL> ecparam -genkey -name prime256v1 -out deviceKey.key

OpenSSL> OpenSSL> req -new -key deviceKey.key -out deviceCsr.csr -subj "/CN=IoT device"

OpenSSL> OpenSSL> x509 -req -days 3650 -in deviceCsr.csr -CAcreateserial -CA CACertificate_ECC.crt -CAkey CACertificate_ECC.key -out deviceCert.crt

Signature ok
subject=/CN=IoT device
Getting CA Private Key
```

Fig 28. OpenSSL commands executed in the i.MX6 MCU

Finally, the IoT device certificate *deviceCert.crt* is combined with the demo CA credentials using the '*cat*' command as explained in 7.1:

```
cat deviceCert.crt CACertificate_ECC.crt > CAandIoTcert.pem
```

Fig 29 shows the created IoT device credentials and the file composed of the IoT device certificate and the demo CA certificate in the i.MX6UltraLite file system.



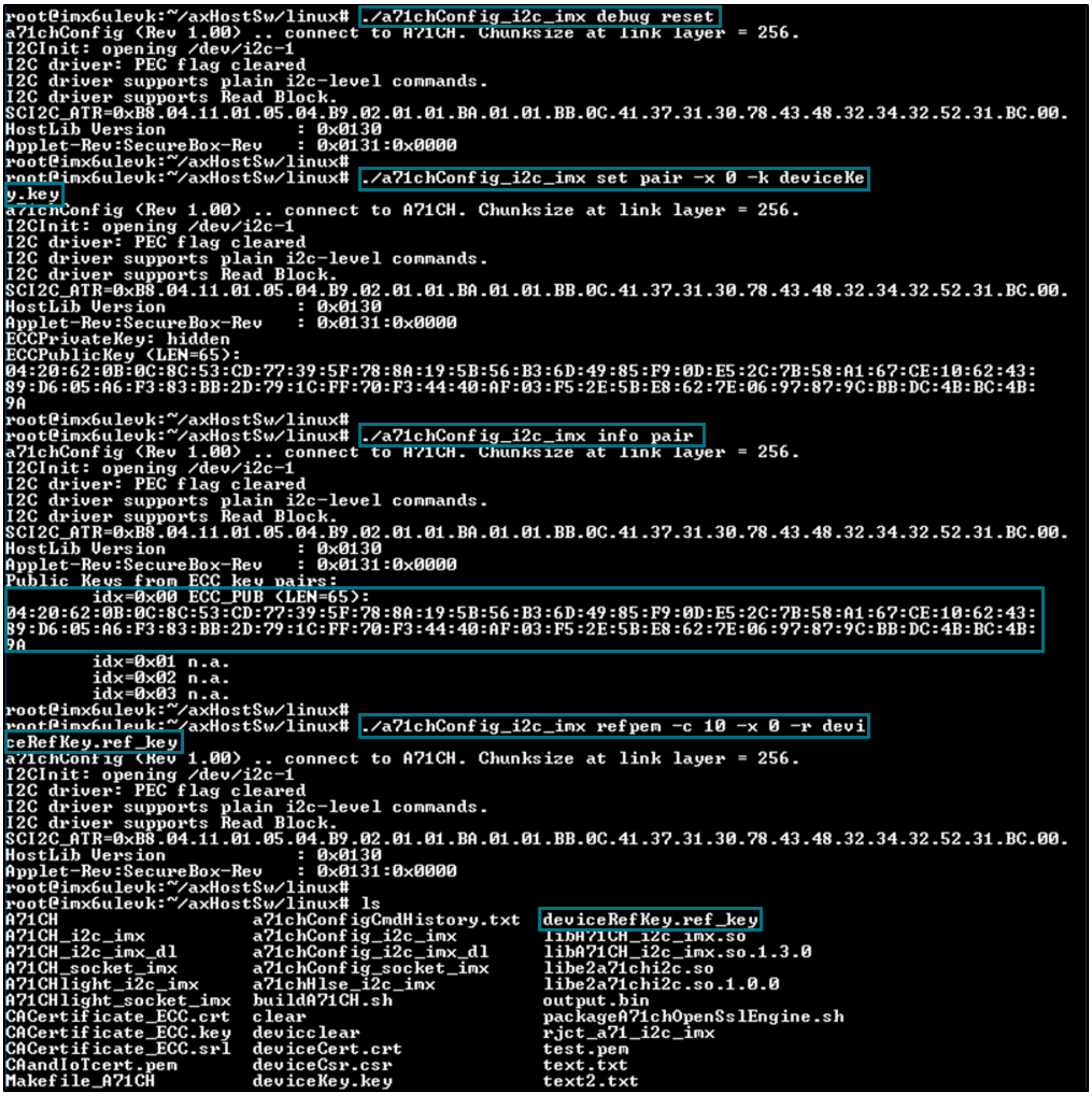
```
root@imx6ulevk:~/axHostSw/linux#
root@imx6ulevk:~/axHostSw/linux# ls
A71CH                  a71chConfigCmdHistory.txt  libA71CH_i2c_imx.so
A71CH_i2c_imx          a71chConfig_i2c_imx        libA71CH_i2c_imx.so.1.3.0
A71CH_i2c_imx_dl       a71chConfig_i2c_imx_dl     libe2a71chi2c.so
A71CH_socket_imx       a71chConfig_socket_imx     libe2a71chi2c.so.1.0.0
A71CHlight_i2c_imx     a71chHlse_i2c_imx          output.bin
A71CHlight_socket_imx  buildA71CH.sh              packageA71chOpenSslEngine.sh
CACertificate_ECC.crt  clear                      rjct_a71_i2c_imx
CACertificate_ECC.key  devicclear                 test.pem
CACertificate_ECC.srl  deviceCert.crt             text.txt
CAandIoTcert.pem       deviceCsr.csr              text2.txt
Makefile_A71CH         deviceKey.key
```

Fig 29. Created IoT device credentials

The IoT device keys can be stored in the A71CH using the A71CH Configure tool and the following commands:

```
./a71chConfig_i2c_imx debug reset

./a71chConfig_i2c_imx set pair -x 0 -k deviceKey.key

./a71chConfig_i2c_imx info pair

./a71chConfig_i2c_imx refpem -c 10 -x 0 -r deviceRefKey.ref_key
```

Where *deviceRefKey.ref_key* is the reference to the stored key. This reference file will be further employed by the i.MX6 to use the IoT device key stored inside the A71CH IC.



```
root@imx6ulevk:~/axHostSw/linux# ./a71chConfig_i2c_imx debug reset
a71chConfig (Rev 1.00) .. connect to A71CH. Chunksize at link layer = 256.
I2CInit: opening /dev/i2c-1
I2C driver: PEC flag cleared
I2C driver supports plain i2c-level commands.
I2C driver supports Read Block.
SCI2C_ATR=0xB8.04.11.01.05.04.B9.02.01.01.BA.01.01.BB.0C.41.37.31.30.78.43.48.32.34.32.52.31.BC.00.
HostLib Version              : 0x0130
Applet-Rev:SecureBox-Rev     : 0x0131:0x0000
root@imx6ulevk:~/axHostSw/linux#
root@imx6ulevk:~/axHostSw/linux# ./a71chConfig_i2c_imx set pair -x 0 -k deviceKe
y.key
a71chConfig (Rev 1.00) .. connect to A71CH. Chunksize at link layer = 256.
I2CInit: opening /dev/i2c-1
I2C driver: PEC flag cleared
I2C driver supports plain i2c-level commands.
I2C driver supports Read Block.
SCI2C_ATR=0xB8.04.11.01.05.04.B9.02.01.01.BA.01.01.BB.0C.41.37.31.30.78.43.48.32.34.32.52.31.BC.00.
HostLib Version              : 0x0130
Applet-Rev:SecureBox-Rev     : 0x0131:0x0000
ECCPrivateKey: hidden
ECCPublicKey (LEN=65):
04:20:62:0B:0C:8C:53:CD:77:39:5F:78:8A:19:5B:56:B3:6D:49:85:F9:0D:E5:2C:7B:58:A1:67:CE:10:62:43:
89:D6:05:A6:F3:83:BB:2D:79:1C:FF:70:F3:44:40:AF:03:F5:2E:5B:E8:62:7E:06:97:87:9C:BB:DC:4B:BC:4B:
9A
root@imx6ulevk:~/axHostSw/linux#
root@imx6ulevk:~/axHostSw/linux# ./a71chConfig_i2c_imx info pair
a71chConfig (Rev 1.00) .. connect to A71CH. Chunksize at link layer = 256.
I2CInit: opening /dev/i2c-1
I2C driver: PEC flag cleared
I2C driver supports plain i2c-level commands.
I2C driver supports Read Block.
SCI2C_ATR=0xB8.04.11.01.05.04.B9.02.01.01.BA.01.01.BB.0C.41.37.31.30.78.43.48.32.34.32.52.31.BC.00.
HostLib Version              : 0x0130
Applet-Rev:SecureBox-Rev     : 0x0131:0x0000
Public Keys from ECC key pairs:
        idx=0x00 ECC_PUB (LEN=65):
04:20:62:0B:0C:8C:53:CD:77:39:5F:78:8A:19:5B:56:B3:6D:49:85:F9:0D:E5:2C:7B:58:A1:67:CE:10:62:43:
89:D6:05:A6:F3:83:BB:2D:79:1C:FF:70:F3:44:40:AF:03:F5:2E:5B:E8:62:7E:06:97:87:9C:BB:DC:4B:BC:4B:
9A
        idx=0x01 n.a.
        idx=0x02 n.a.
        idx=0x03 n.a.
root@imx6ulevk:~/axHostSw/linux#
root@imx6ulevk:~/axHostSw/linux# ./a71chConfig_i2c_imx refpem -c 10 -x 0 -r devi
ceRefKey.ref_key
a71chConfig (Rev 1.00) .. connect to A71CH. Chunksize at link layer = 256.
I2CInit: opening /dev/i2c-1
I2C driver: PEC flag cleared
I2C driver supports plain i2c-level commands.
I2C driver supports Read Block.
SCI2C_ATR=0xB8.04.11.01.05.04.B9.02.01.01.BA.01.01.BB.0C.41.37.31.30.78.43.48.32.34.32.52.31.BC.00.
HostLib Version              : 0x0130
Applet-Rev:SecureBox-Rev     : 0x0131:0x0000
root@imx6ulevk:~/axHostSw/linux#
root@imx6ulevk:~/axHostSw/linux# ls
A71CH                  a71chConfigCmdHistory.txt  deviceRefKey.ref_key
A71CH_i2c_imx          a71chConfig_i2c_imx        libA71CH_i2c_imx.so
A71CH_i2c_imx_dl       a71chConfig_i2c_imx_dl     libA71CH_i2c_imx.so.1.3.0
A71CH_socket_imx       a71chConfig_socket_imx     libe2a71chi2c.so
A71CHlight_i2c_imx     a71chHlse_i2c_imx          libe2a71chi2c.so.1.0.0
A71CHlight_socket_imx  buildA71CH.sh              output.bin
CACertificate_ECC.crt  clear                      packageA71chOpenSslEngine.sh
CACertificate_ECC.key  devicclear                 rjct_a71_i2c_imx
CACertificate_ECC.srl  deviceCert.crt             test.pem
CAandIoTcert.pem       deviceCsr.csr              text.txt
Makefile_A71CH         deviceKey.key              text2.txt
```

Fig 30. Injection of credentials with A71CH Configure tool

Fig 30 shows the Tera Term screen with the execution of the A71CH Configure tool commands. Each one of the commands has been highlighted. Also, the stored key and the created reference file *deviceRefKey.ref_key* have been highlighted.

8.6 Connection to AWS IoT with an MQTT client

The last step consists of establishing a TLS connection with AWS IoT.

This can be done by using the available AWS IoT SDK [AWS_IOT_SDK].

9. References

Table 1. Referenced Documents

[AWS_IOT]	**AWS IoT** - https://aws.amazon.com/iot/
[AWS_CLI]	**AWS Command Line Interface** - https://aws.amazon.com/cli/
[A71CH_ANTICOUNTERFEIT]	**AN12120 A71CH for electronic anti-counterfeit** – Application note, document number 4583**[1]
[OPEN_SSL]	**OpenSSL Cryptography and SSL/TLS Toolkit information** - www.openssl.org
[RFC4279]	**Pre-Shared Key Ciphersuites for Transport Layer Security (TLS)** - December 2005
[RFC5489]	**ECDHE_PKE Cipher Suites for Transport Layer Security (TLS)** - March 2009
[RFC5246]	**The Transport Layer Security (TLS) Protocol** - Version 1.2, August 2008
[AWS_LAMBDA]	**AWS Lambda Documentation** - https://aws.amazon.com/documentation/lambda/
[AWS_ROOT]	**AWS root certificate** - https://www.symantec.com/content/en/us/enterprise/verisign/roots/VeriSign-Class%203-Public-Primary-Certification-Authority-G5.pem
[MQTT]	**MQTT** - http://mqtt.org/
[JITR]	**Just-in-Time Registration of Device Certificates on AWS IoT** - https://aws.amazon.com/blogs/iot/just-in-time-registration-of-device-certificates-on-aws-iot/
[MQTT_MOSQUITTO]	**Eclipe Mosquitto** - https://mosquitto.org/
[A71CH_OPENSSL_ENGINE]	**A71CH OpenSSL Engine** – DocStore, um4334**[1]
[AN_A71CH_HOST_SW]	**AN12133 A71CH Host software package documentation** – Application note, document number 4643**[1]
[QUICK_START_IMX6]	**AN12119 Quick start guide for OM3710A71CHARD i.MX6** – Application note, document number 4582**[1]
[PUTTY]	**PuTTY client -** https://www.putty.org/
[CYGWIN]	**Cygwin -** https://www.cygwin.com/
[AWS_IOT_SDK]	**AWS IoT SDK -** https://github.com/aws/aws-iot-device-sdk-cpp

[1] **… document version number

10. Legal information

10.1 Definitions

10.2 Disclaimers

10.1 Licenses

ICs with DPA Countermeasures functionality

10.2 Trademarks

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