Getting Started with Cloud Connectivity on the FSP DA16XXX MQTT On-chip Client

This document demonstrates a quick cloud MQTT connectivity solution using the FSP DA16XXX MQTT On-chip Client driver with an EK-RA6M4 evaluation kit. The application example provided in the package uses Amazon AWS IoT to send temperature and humidity data from the EK-RA6M4 and to control the user LED on the EK-RA6M4 remotely. The steps in this document show the complete setup to run and test the application.

Target Devices

- RA6M4 MCU Group

Required Resources

To build and run the MQTT application example, the following resources are required.

Development tools and software:

- Flexible Software Package (FSP) v5.3.0 (GitHub – renesas/fsp: Flexible Software Package (FSP) for Renesas RA MCU Family)
- SEGGER J-Link RTT Viewer (see segger.com)
- e² studio version 2024-04 (Platform Installer)

Hardware:

- EK-RA6M4 Evaluation Kit for the RA6M4 MCU Group
- Windows PC with any browser
- Micro-USB cable
- DA16200 or DA16600 Wi-Fi module

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1. Setting Up the EK-RA6M4 Kit

This section of the document covers the steps to set up the EK-RA6M4 kit and connect the hardware to the PC.

1.1 Steps

- Attach the US159-DA16200MEVZ/US159-DA16600EVZ Wi-Fi Pmod module to PMOD2 (J25, upper right) on the EK-RA6M4. Ensure the DA16xxx module and components are facing up.
- Connect the EK-RA6M4 dev kit to the PC using a USB Micro-B cable connected to DEBUG (J10) on the board (right side of the board above the Ethernet jack).
- When completed, the LEDs should be illuminated as in Figure 1, and the board should appear as follows:
  - LED4 (middle of board) – Illuminating white
  - LED5 (right side, near USB debug port) – Illuminating yellow

1.2 Connection

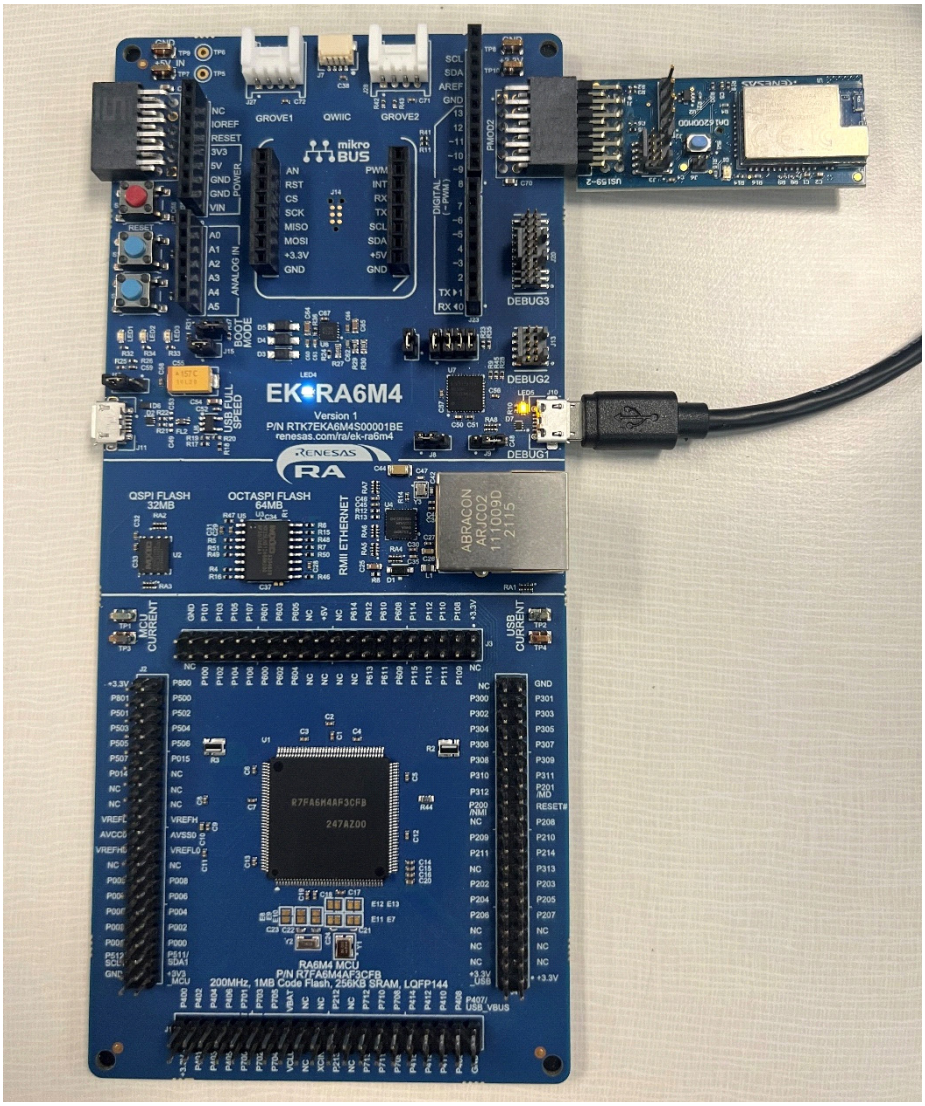

Figure 1. EK-RA6M4 Connections

2. Application Overview

This section discusses the application overview, detailing the architecture and overall functionality of the MQTT cloud connectivity with AWS IoT.

2.1 Overview

This application demonstrates the use of the Renesas FSP DA16XXX Wi-Fi APIs and Wi-Fi module to establish quick connectivity to the AWS IoT MQTT cloud service. This document provide an example that demonstrates Subscribe and Publish messaging with an MQTT broker. It provides periodic publication of temperature and humidity data and asynchronous publication of a **User Push Button** event from the MCU to the cloud. The device is also subscribed to receive actuation events (LED ON/OFF) from the cloud, showing two-way control.

2.2 Architecture

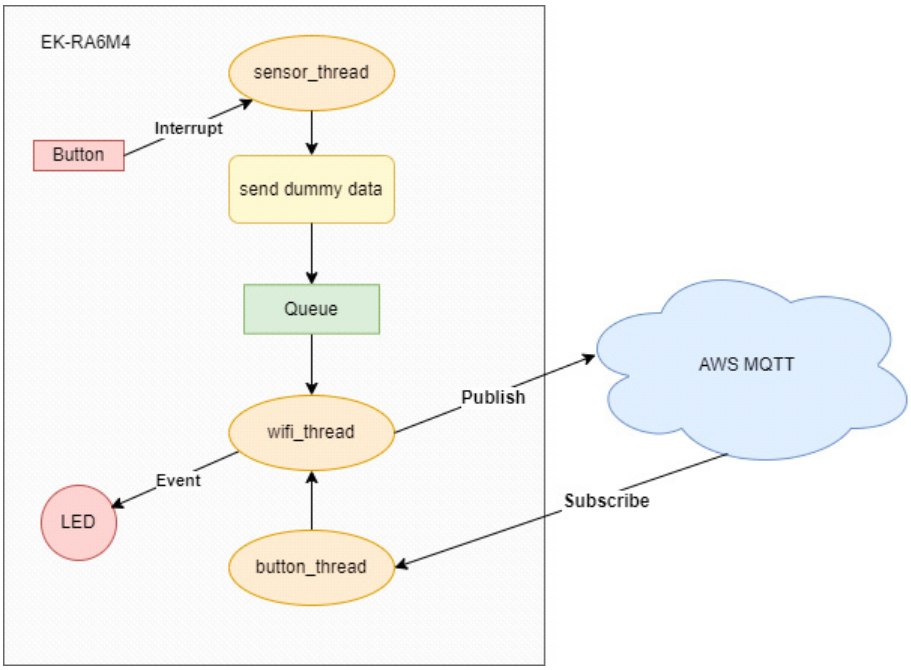

Figure 2. Architecture Diagram

2.3 Functional Flowchart

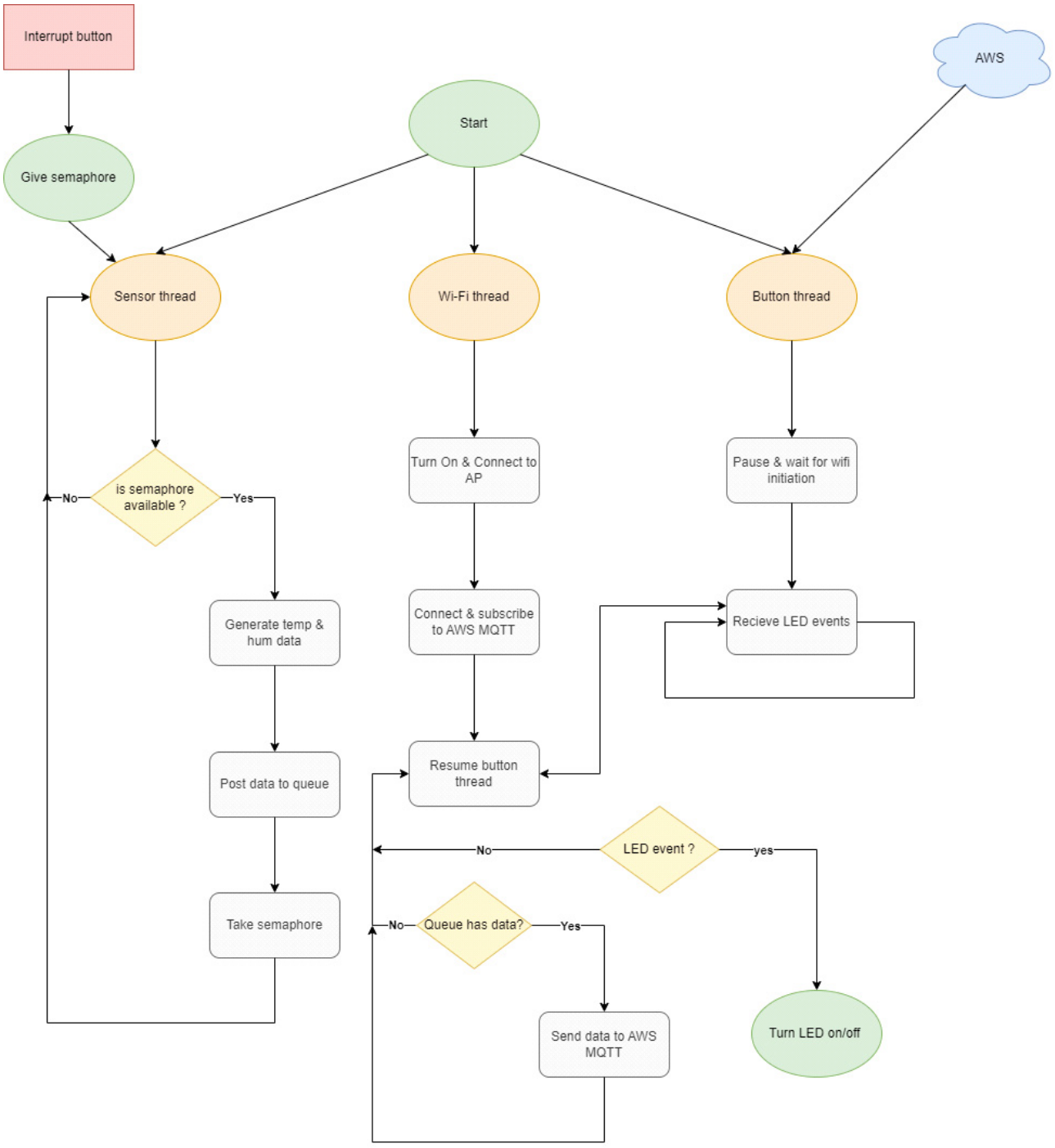

Figure 3. Functional Flow Diagram

3. Setting Up AWS IoT

This section covers setting up AWS IoT, including instructions on creating an AWS account and setting up IoT things for MQTT.

3.1 Create an AWS IoT Account

Sign up for a new AWS IoT account or log in to an existing account on the AWS website.

3.2 Create and Setup an IoT Thing

Open AWS IoT Core and create an MQTT thing and generate certificates. Navigate to **Manage** > **All devices** > **Things** and click on the **Create things** button.

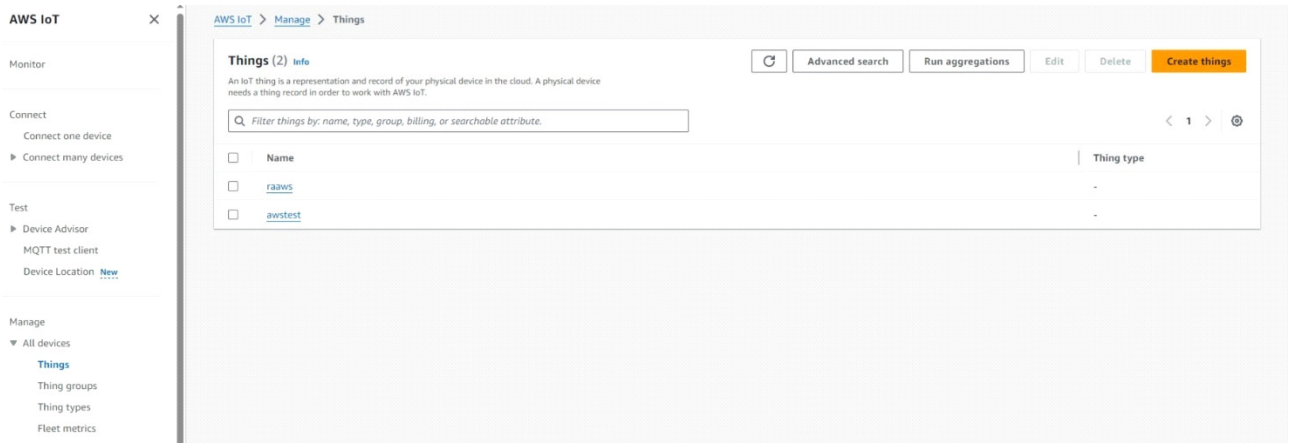

Figure 4. AWS IoT Create Thing Settings Menu

Reference: What is AWS IoT? – AWS IoT Core (amazon.com)

Choose **Create single thing** and click **Next**. Provide a thing name and click on **Next**.

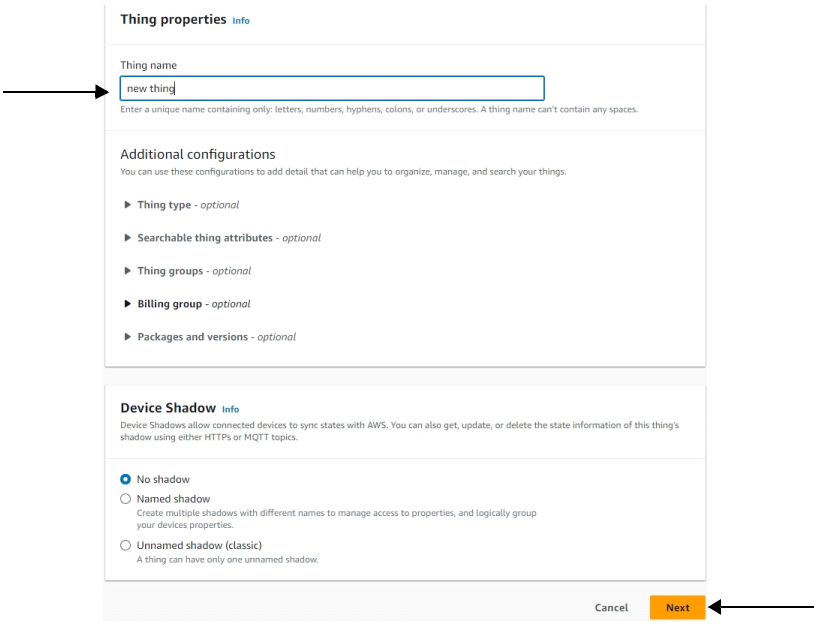

Figure 5. AWS IoT Thing Creation

Next, click on **Auto-generate a new certificate** to generate a new certificate and click **Next**. If there is no existing policy, create a new one by clicking on **Create policy**.

Figure 6. AWS IoT Policy Creation

Provide a name for the policy, select the JSON tab and give the policy statements as shown in Figure 7.

Note: This opens a new tab, which can be closed after the policy is created.

Figure 7. AWS IoT Policy Statement Configuration

Finally, select the created policy, click on **Create thing**, and download the certificates by clicking the three **Download** buttons with red boxes (see Figure 8).

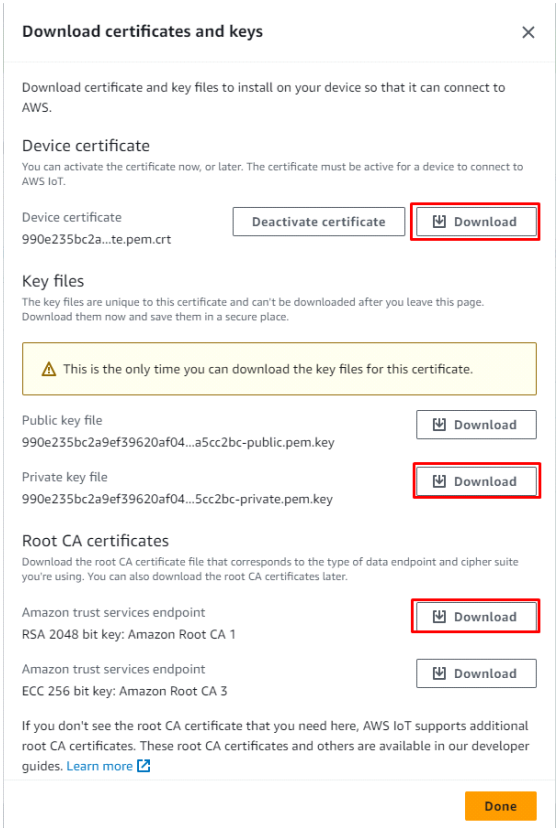

Figure 8. Certificates and Keys

4. Setting Up the FSP Project

This section details the process for setting up the FSP Project, including importing the RA project, configuring FSP, configuring user files, and setting up the MQTT AWS certificates.

4.1 Import RA Project

To import FSP projects, refer to the *Official Renesas RA Family Beginner's Guide* (PDF) and import the project from the provided zip file.

4.2 4.2 Configure FSP

Navigate to the Settings menu in AWS IoT core and copy the host name of the MQTT broker (Endpoint).

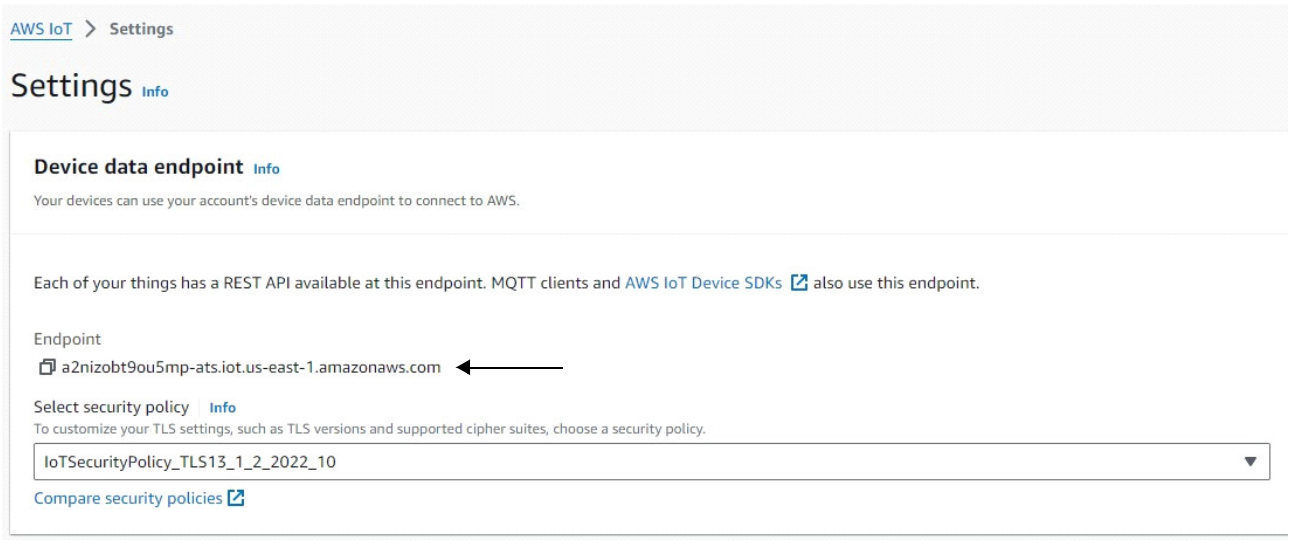

Figure 9. FSP Configuration

Double-click on the **configuration.xml** file to open the FSP configuration window. Next, click on the stacks pane to open the stacks. In the stacks window, click on the **Main thread** and click on **MQTT Client on DA 16XXX** and open the **Properties** tab and copy the host name of MQTT broker in the Host Name field.

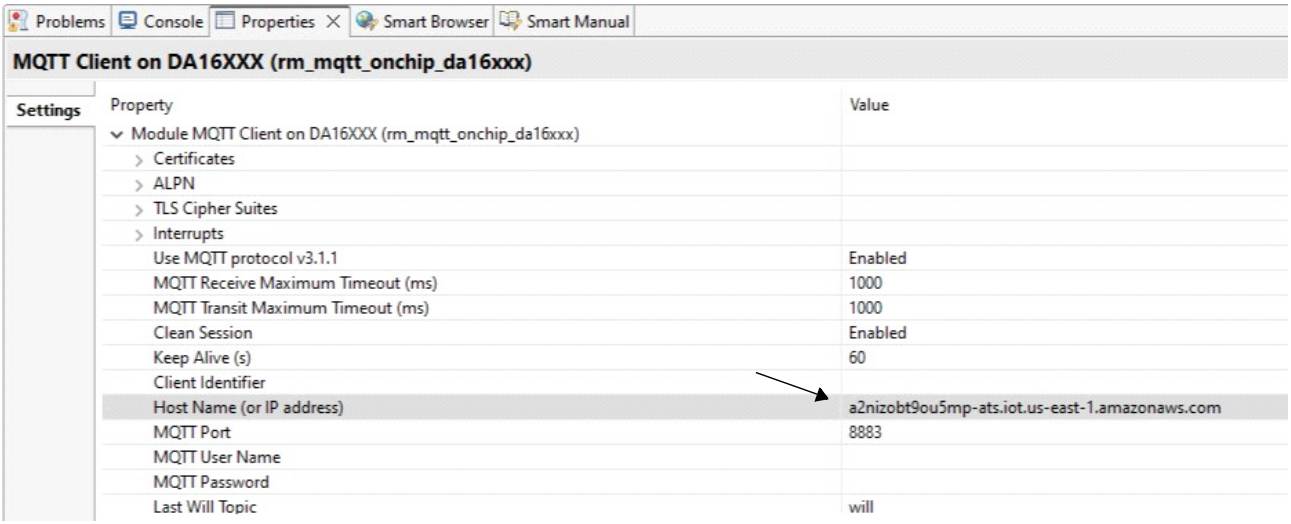

Figure 10. MQTT Client Properties Settings

4.3 Configure the User File

Modify the **user.h** file under the **src** folder and provide the Wi-Fi password and SSID information for the Access Point used.

```
#define WIFI_SSID               "WIFI SSID"
#define WIFI_PWD                "WIFI PASSWORD"

#define USER_LED_TOPIC          "feeds/led"
#define CLIENT_PUB_TOPIC        "feeds/humidity"
#define CLIENT_PUB_TOPIC_2      "feeds/temperature"
```

Figure 11. Reference for User File Configuration

4.4 Set Up the MQTT AWS Certificates

Copy the appropriate certificate files to a **mqtt_certs.h** header file under the **src** folder (see Figure 12 for formatting).

Note: Actual certificates are longer than what is shown in Figure 12.

```
#ifndef MQTT_CERTS_H_
#define MQTT_CERTS_H_

#define ROOT_CA "-----BEGIN CERTIFICATE-----\n"\
"MIIDQTCCAimgAwIBAgITBmyfz5m/jAo54vB4ikPmljZbyjANBgkqhkiG9w0BAQsF\n"\
"rqXRfboQnoZsG4q5WTP468SQvvG5\n"\
"-----END CERTIFICATE-----\n"


#define CLIENT_CERT "-----BEGIN CERTIFICATE-----\n"\
"MIIDWjCCAkKgAwIBAgIVAMKOuZEWubwgJlRYbJuP3srJYxMsMA0GCSqGSIb3DQEB\n"\
"-----END CERTIFICATE-----\n"

#define PRIVATE_KEY "-----BEGIN RSA PRIVATE KEY-----\n"\
"MIIEpAIBAAKCAQEAuuJDQWv6GupvVGwPfp5GTUw6cbDqJP+v7oqabca3Pn7wVmC5\n"\
"0l24iUGTBbL4zWqwwCdtAjCQri9/OidWbE6lKyER8AVKHCqF54TNmA==\n"\
"-----END RSA PRIVATE KEY-----\n"

#endif /* MQTT_CERTS_H_ */
```

Figure 12. Reference for MQTT Certificate File Setup

5. Adding J-Link RTT for Monitoring

This section explains adding J-Link RTT for monitoring and configuring the J-Link RTT application.

5.1 Configure J-Link RTT Application

When the MCU connections are made, open the SEGGER RTT Application. Before configuring the J-Link, open the map file present in the Debug folder, search for the " _SEGGER_RTT " keyword in the file and note down the address. Check the reference as shown below.

Note: Do not copy this address.

```
.bss._acDownBuffer
                0x20000424       0x40 ./src/SEGGER_RTT/SEGGER_RTT.o
.bss._acUpBuffer
                0x20000464      0x800 ./src/SEGGER_RTT/SEGGER_RTT.o
.bss._SEGGER_RTT
                0x20000c64       0xa8 ./src/SEGGER_RTT/SEGGER_RTT.o
                0x20000c64 <----       _SEGGER_RTT
.bss.g_rm_mqtt_onchip_da16xxx_instance
                0x20000d0c      0x40c ./src/main_thread_entry.o
                0x20000d0c            g_rm_mqtt_onchip_da16xxx_instance
.bss.g_read_queue_queue_memory
                0x20001118       0xa0 ./ra_gen/common_data.o
                0x20001118            g_read_queue_queue_memory
.bss.g_read_queue_memory
```

Figure 13. Address for SEGGER RTT

Next, open the J-Link application and set it up as in Figure 14 by pasting the address that was copied. The remaining fields should be the same as in Figure 14.

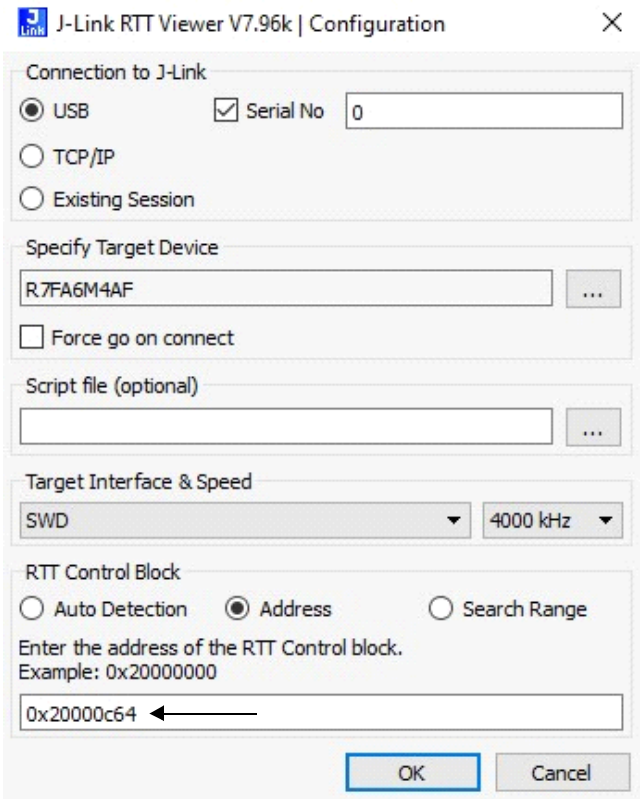

Figure 14. SEGGER RTT Configuration

6. Running the Application

This section is focused on running the application, providing step-by-step guidance on building, debugging, and testing the application. The subsections cover (1) building and debugging the application and (2) testing the application, including checking published messages and subscribed LEDs.

6.1 Build and Debug the Application

The application is completely set up. Open the FSP configuration window by double-clicking the **configuration.xml** file and click on **Generate Project Content**. Now, click on the build button and, after it has finished building, click on the **Debug** button. Next, double-click the **Resume** button.

6.2 Testing the Application

6.2.1 Checking the Published Messages

Open the **MQTT test client** menu from the AWS IoT website, navigate to the Subscribe to a topic section. Next, provide the topic names from the **user.h** file and click **Subscribe**. Repeat the process for both subscribe topics. Finally, click on the **s1** button on the MCU. The data is published continuously to the topics every time the button is clicked.

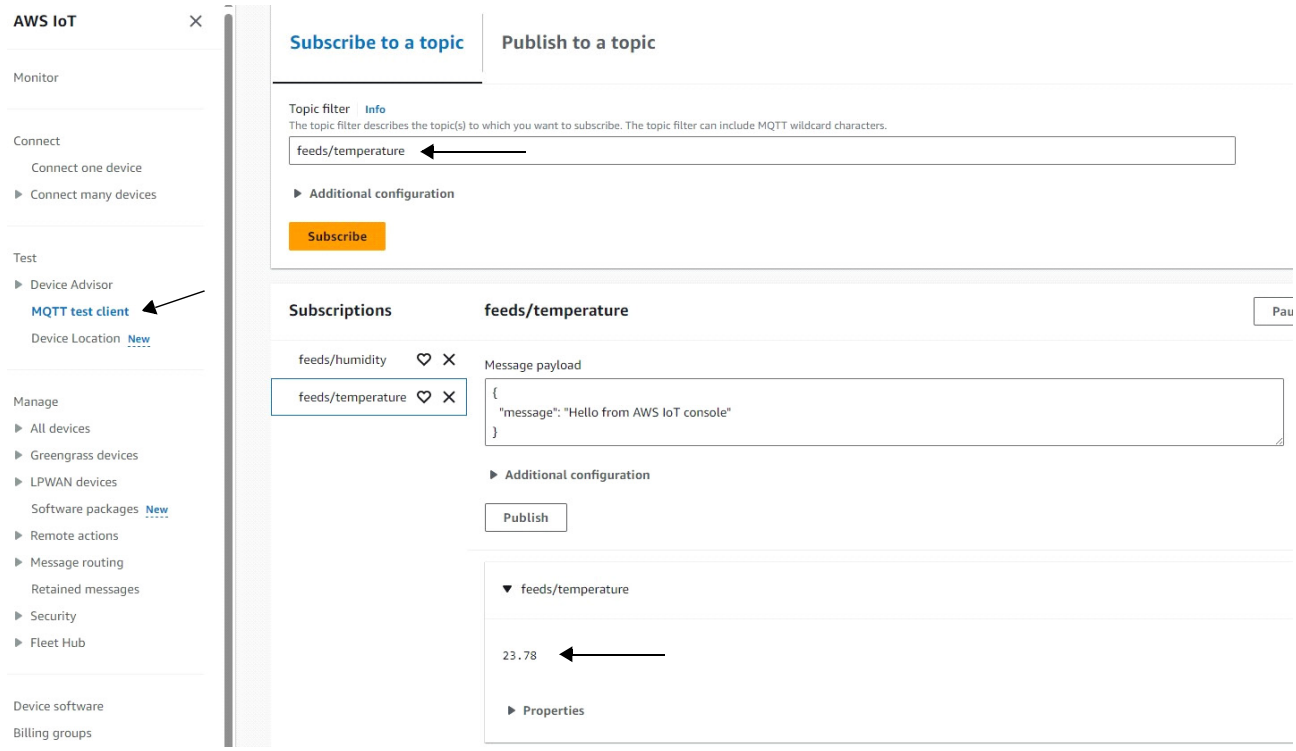

Figure 15. Testing MQTT Client Subscription

6.2.2 Checking the Subscribe LED

Similarly, navigate to the **Publish to a topic** section. Enter the topic name for LED. Enter 1 in the payload to turn on the LED, or enter 0 to turn the LED off.

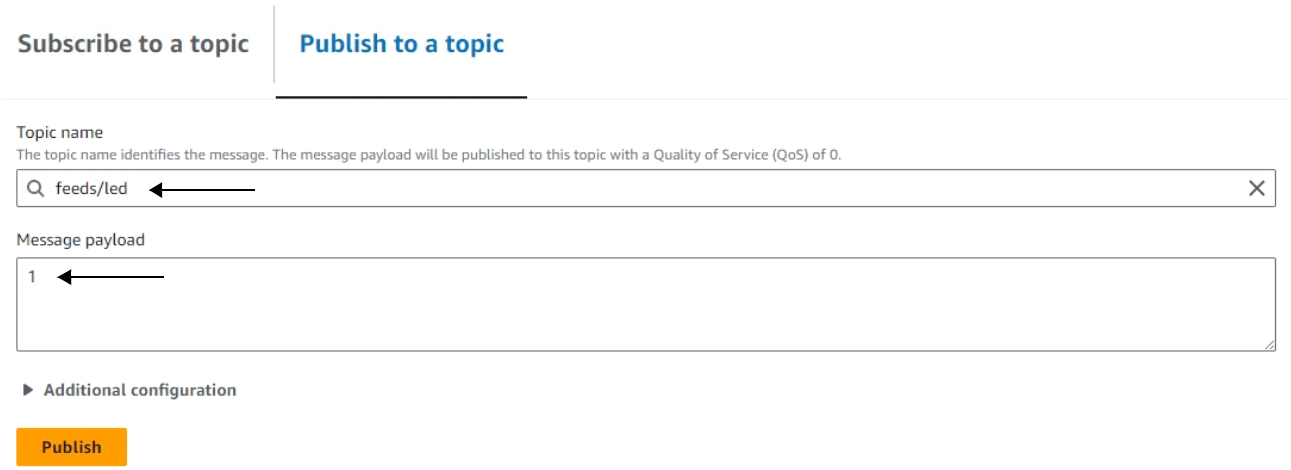

Figure 16. Testing MQTT Client Publish

6.2.3 Monitoring RTT Viewer

Logs can be monitored from the SEGGER RTT Viewer, the events are captured on the RTT viewer (see Figure 17).

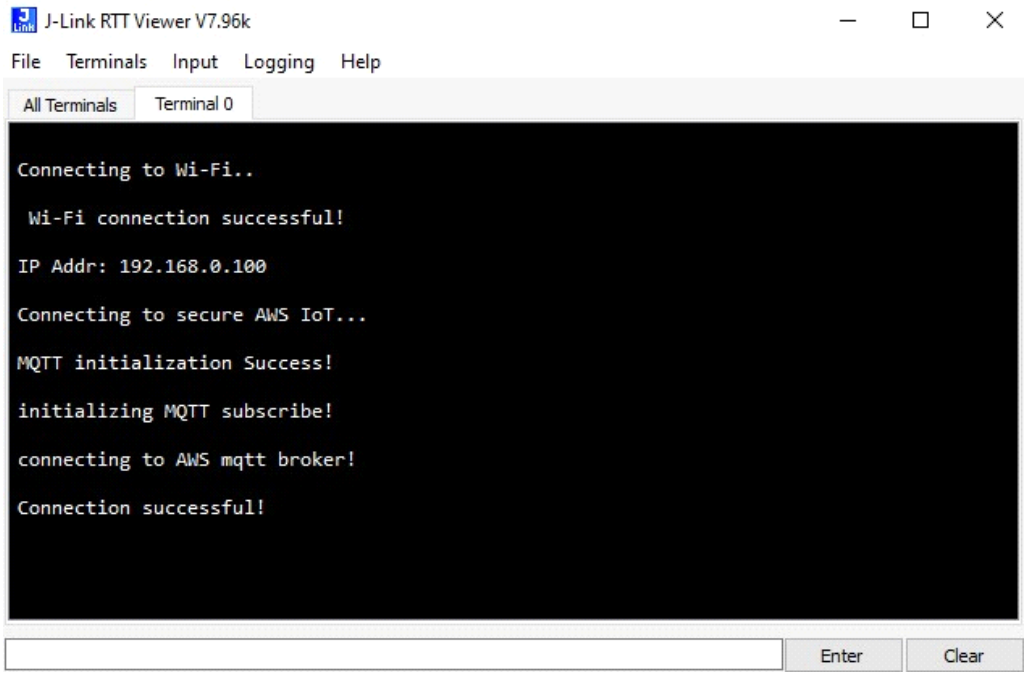

Figure 17. SEGGER RTT Logs

Website and Support

Visit the following URLs to learn about key elements of the RA family, download components and related documentation, and get support:

RA Product Information	www.renesas.com/ra
RA Product Support Forum	https://community.renesas.com/mcu-mpu/ra/
RA Flexible Software Package	www.renesas.com/FSP
Renesas Support	www.renesas.com/support

7. Revision History

Revision	Date	Description
1.00	Aug 5, 2024	Initial release

General Precautions in the Handling of Microprocessing Unit and Microcontroller Unit Products

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1. Precaution against Electrostatic Discharge (ESD)
   A strong electrical field, when exposed to a CMOS device, can cause destruction of the gate oxide and ultimately degrade the device operation. Steps must be taken to stop the generation of static electricity as much as possible, and quickly dissipate it when it occurs. Environmental control must be adequate. When it is dry, a humidifier should be used. This is recommended to avoid using insulators that can easily build up static electricity. Semiconductor devices must be stored and transported in an anti-static container, static shielding bag or conductive material. All test and measurement tools including work benches and floors must be grounded. The operator must also be grounded using a wrist strap. Semiconductor devices must not be touched with bare hands. Similar precautions must be taken for printed circuit boards with mounted semiconductor devices.
2. Processing at power-on
   The state of the product is undefined at the time when power is supplied. The states of internal circuits in the LSI are indeterminate and the states of register settings and pins are undefined at the time when power is supplied. In a finished product where the reset signal is applied to the external reset pin, the states of pins are not guaranteed from the time when power is supplied until the reset process is completed. In a similar way, the states of pins in a product that is reset by an on-chip power-on reset function are not guaranteed from the time when power is supplied until the power reaches the level at which resetting is specified.
3. Input of signal during power-off state
   Do not input signals or an I/O pull-up power supply while the device is powered off. The current injection that results from input of such a signal or I/O pull-up power supply may cause malfunction and the abnormal current that passes in the device at this time may cause degradation of internal elements. Follow the guideline for input signal during power-off state as described in your product documentation.
4. Handling of unused pins
   Handle unused pins in accordance with the directions given under handling of unused pins in the manual. The input pins of CMOS products are generally in the high-impedance state. In operation with an unused pin in the open-circuit state, extra electromagnetic noise is induced in the vicinity of the LSI, an associated shoot-through current flows internally, and malfunctions occur due to the false recognition of the pin state as an input signal become possible.
5. Clock signals
   After applying a reset, only release the reset line after the operating clock signal becomes stable. When switching the clock signal during program execution, wait until the target clock signal is stabilized. When the clock signal is generated with an external resonator or from an external oscillator during a reset, ensure that the reset line is only released after full stabilization of the clock signal. Additionally, when switching to a clock signal produced with an external resonator or by an external oscillator while program execution is in progress, wait until the target clock signal is stable.
6. Voltage application waveform at input pin
   Waveform distortion due to input noise or a reflected wave may cause malfunction. If the input of the CMOS device stays in the area between V_{IL} (Max.) and V_{IH} (Min.) due to noise, for example, the device may malfunction. Take care to prevent chattering noise from entering the device when the input level is fixed, and also in the transition period when the input level passes through the area between V_{IL} (Max.) and V_{IH} (Min.).
7. Prohibition of access to reserved addresses
   Access to reserved addresses is prohibited. The reserved addresses are provided for possible future expansion of functions. Do not access these addresses as the correct operation of the LSI is not guaranteed.
8. Differences between products
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