

## Renesas Synergy™ Platform

# Synergy MQTT/TLS Google Cloud Connectivity Solution

## Introduction

This application note describes the IoT Cloud connectivity solution in general and introduces you briefly to the IoT Cloud provider, Google Cloud. It covers the Synergy MQTT/TLS module, its features, and operational flow sequence (Initialization/Data flow). The application example provided in the package uses Google Cloud IoT Core. The detailed steps in this document show first-time Google Cloud IoT Core users how to configure the Google Cloud IoT Core platform to run this application example demonstration.

This application note enables you to effectively use the Synergy MQTT/TLS modules in your own design. Upon completion of this guide, you will be able to add the MQTT/TLS module to your own design, configure it correctly for the target application, and write code using the included application example code as a reference and efficient starting point. References to more detailed API descriptions, and other application projects that demonstrate more advanced uses of the module, are in the *Synergy Software Package (SSP) User's Manual* (see Next Steps section), and serve as valuable resources in creating more complex designs.

Currently, the Synergy MQTT/TLS Connectivity solution is implemented and tested using Google Cloud IoT Core on PK-S5D9, AE-CLOUD1 and AE-CLOUD2 kit. Support for other Synergy kits and IoT Cloud providers will be provided in upcoming releases.

## Required Resources

To build and run the MQTT/TLS application example, you need:

### Development tools & software

- e<sup>2</sup> studio ISDE v6.2.1 or IAR Embedded Workbench® for Renesas Synergy™ v8.23.1, available at [www.renesas.com/synergy/tools-kits](http://www.renesas.com/synergy/tools-kits).
- Synergy Software Package (SSP) 1.5.3 ([www.renesas.com/synergy/ssp](http://www.renesas.com/synergy/ssp)) or Synergy Standalone Configurator (SSC) 6\_2\_1 ([www.renesas.com/synergy/ssc](http://www.renesas.com/synergy/ssc))
- SEGGER J-link® USB driver ([www.renesas.com/synergy/jlinksynergy](http://www.renesas.com/synergy/jlinksynergy))
- When migrating to future SSP versions, follow the corresponding SSP release note to acquire the required development environment.

### Hardware

- Renesas Synergy™ **PK-S5D9 kit** ([www.renesas.com/synergy/pk-s5d9](http://www.renesas.com/synergy/pk-s5d9)); **AE-CLOUD1 kit** ([www.renesas.com/synergy/ae-cloud1](http://www.renesas.com/synergy/ae-cloud1)), which includes a Wi-Fi board; and, **AE-CLOUD2 kit** ([www.renesas.com/synergy/ae-cloud2](http://www.renesas.com/synergy/ae-cloud2)), which includes a Pillar board, Wi-Fi board, BG96 Cellular shield, and a CAT-M1 SIM card.
- Renesas Synergy™ Application Example kit PMOD based Wi-Fi Module ([www.renesas.com/synergy/kits/ae-wifi1](http://www.renesas.com/synergy/kits/ae-wifi1)).
- PC running Windows® 7 or 10; the Tera Term console, or similar application, and an installed web browser (Google Chrome, Internet Explorer, Microsoft Edge, Mozilla Firefox, or Safari).
- Micro USB cables
- Ethernet cable

## Prerequisites and Intended Audience

This application note assumes that you have some experience with the Renesas e<sup>2</sup> studio ISDE and Synergy Software Package (SSP). Before you perform the procedures in this application note, follow the procedure in the *SSP User Manual* to build and run the Blinky project. Doing so enables you to become familiar with the e<sup>2</sup> studio and the SSP, and validates that the debug connection to your board functions properly. In addition, this application note assumes that you have some knowledge of MQTT/TLS and its communication protocols.

The intended audience are users who want to develop applications with MQTT/TLS modules using Renesas Synergy™ S5 or S7 MCU Series.

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## 1. Introduction to Cloud Connectivity

### 1.1 Overview

Internet of Things (IoT) is a sprawling set of technologies described as connecting everyday objects, like sensors or smart-phones, to the World Wide Web. IoT devices are intelligently linked together to enable new forms of communication between things and people, and among things.

These devices, or things, connect to the network. Using sensors, they provide the information they gather from the environment or allow other systems to reach out and act on the world through actuators. In the process, IoT devices generate massive amounts of data, and cloud computing provides a pathway, enabling data to travel to its destination.

### 1.2 Major Components

The IoT Cloud Connectivity Solution includes the following major components:

1. Devices or Sensors
2. Gateway
3. IoT Cloud services
4. End user application/system

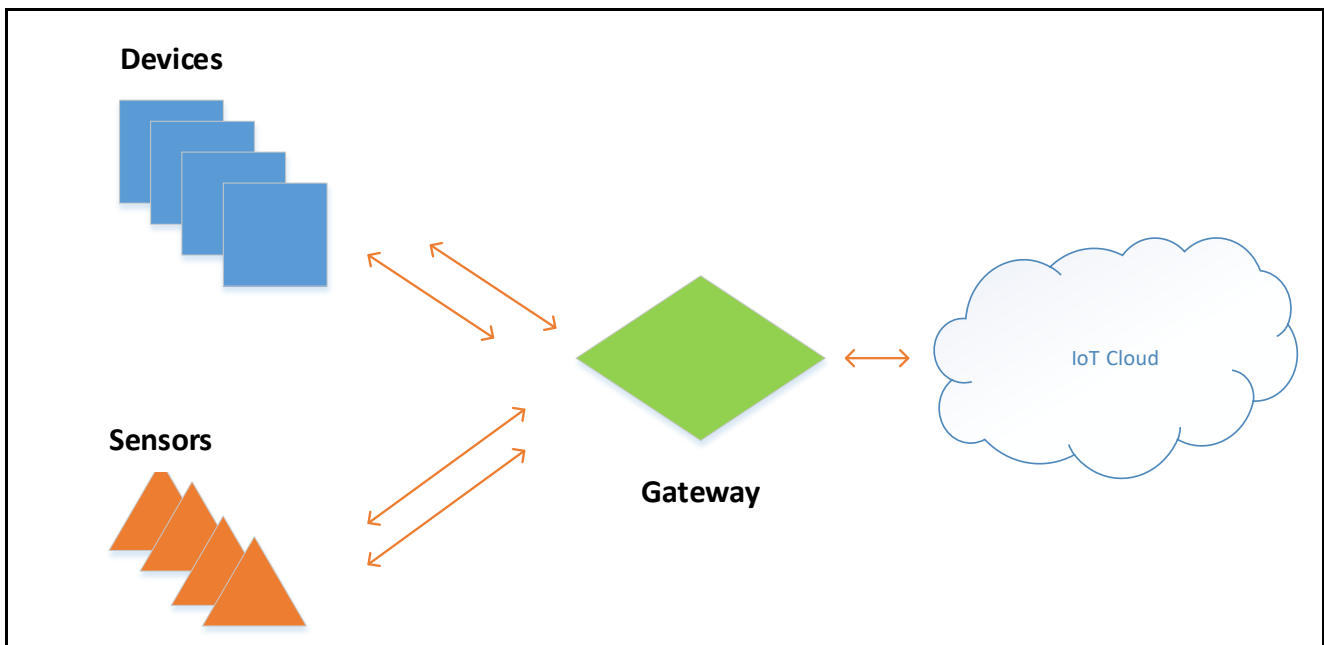


Figure 1. IoT Cloud Connectivity Architecture

#### Devices or Sensors

A device includes hardware and software that interact directly with the world. Devices connect to a network to communicate with each other, or to centralized applications. Devices may connect to the Internet either directly or indirectly.

#### Gateway

A gateway enables devices that are not directly connected to the Internet to reach cloud services. The data from each device is sent to the Cloud Platform, where it is processed and combined with data from other devices, and potentially with other business-transactional data. Most of the common communication gateways support one or more communication technologies such as Wi-Fi, Ethernet, or cellular.

#### IoT Cloud

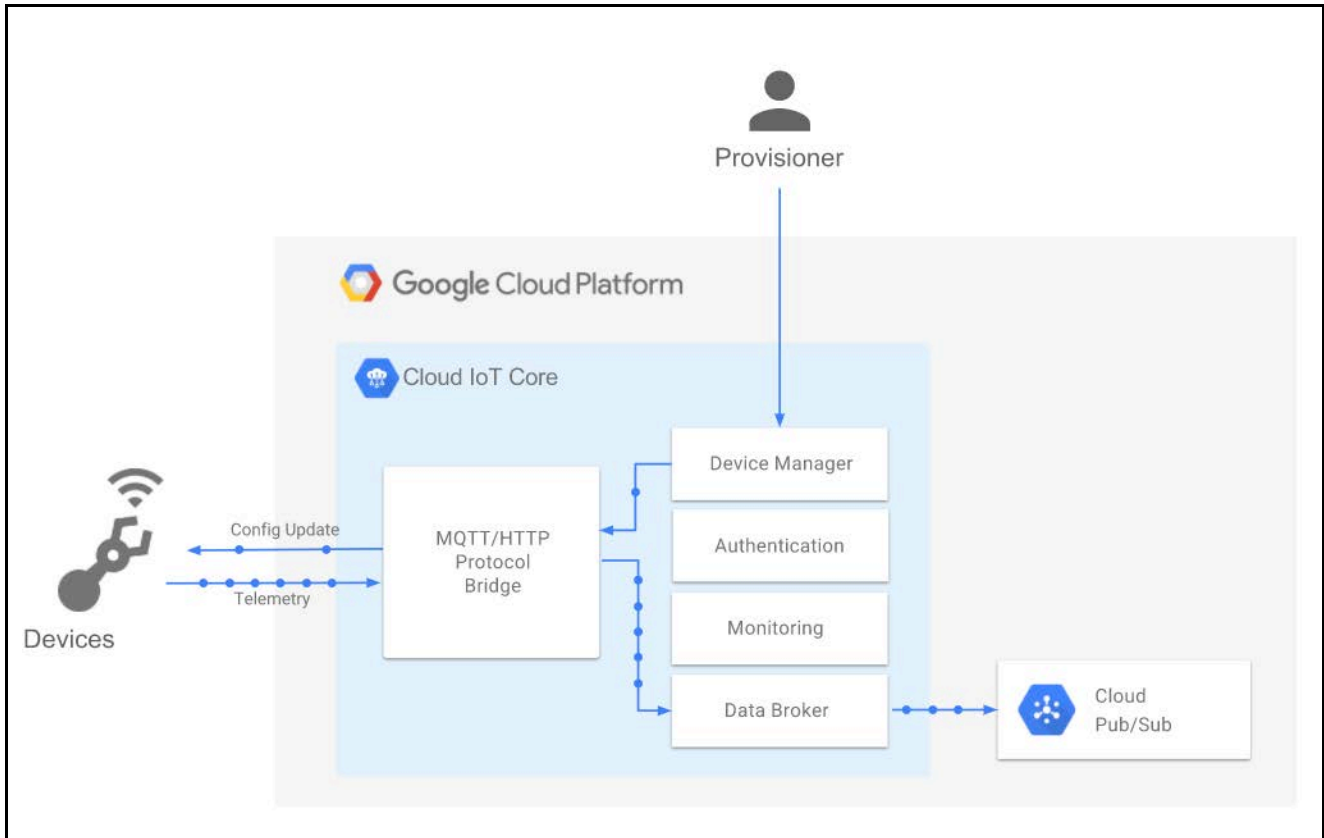
Many IoT devices produce lots of data. You need an efficient, scalable, affordable way to manage those devices, handle all that information, and make it work for you. When it comes to storing, processing, and analyzing data, especially big data, it is hard to surpass the cloud.

### 1.3 Cloud Provider Overview

#### 1.3.1 Google Cloud IoT Core Overview

Google Cloud IoT Core is a fully managed service that allows users to easily and securely connect, manage, and ingest data from millions of globally dispersed devices. Google Cloud IoT Core, in combination with other services on Cloud IoT platform, provides a complete solution for collecting, processing, analyzing, and visualizing IoT data in real time to support improved operational efficiency.

The following diagram summarizes the service components and the flow of data.



**Figure 2. Google IoT Cloud Solution**

The main components of Google Cloud IoT Core are the device manager and the protocol bridges:

- **Device Manager**

For a device to connect, it must first be registered with Cloud IoT Core. Registration consists of adding a device to a collection (the registry) and defining some essential properties. You can register a device with Cloud Platform Console, gcloud commands, or the REST-style API.

Collectively, the features that allow you to register, monitor, and configure devices are called the device manager.

- **Protocol bridges (MQTT and HTTP)**

Cloud IoT Core supports two protocols for device connection and communication: MQTT and HTTP. Devices communicate with Cloud IoT Core across a "bridge" — either the MQTT bridge or the HTTP bridge. When you create a device registry, you select protocols to enable MQTT, HTTP, or both.

Device telemetry data is forwarded to a Cloud Pub/Sub topic, which can then be used to trigger Cloud functions. You can also perform streaming analysis with Cloud Dataflow or custom analysis with your own subscribers. With Cloud IoT Core, you can control a device by modifying its configuration. A device configuration is an arbitrary, user-defined blob of data that may or may not be structured. If your devices use MQTT, configurations are automatically propagated to them. If your devices connect over HTTP, they must explicitly request configurations.

### 1.3.1.1 Key Features

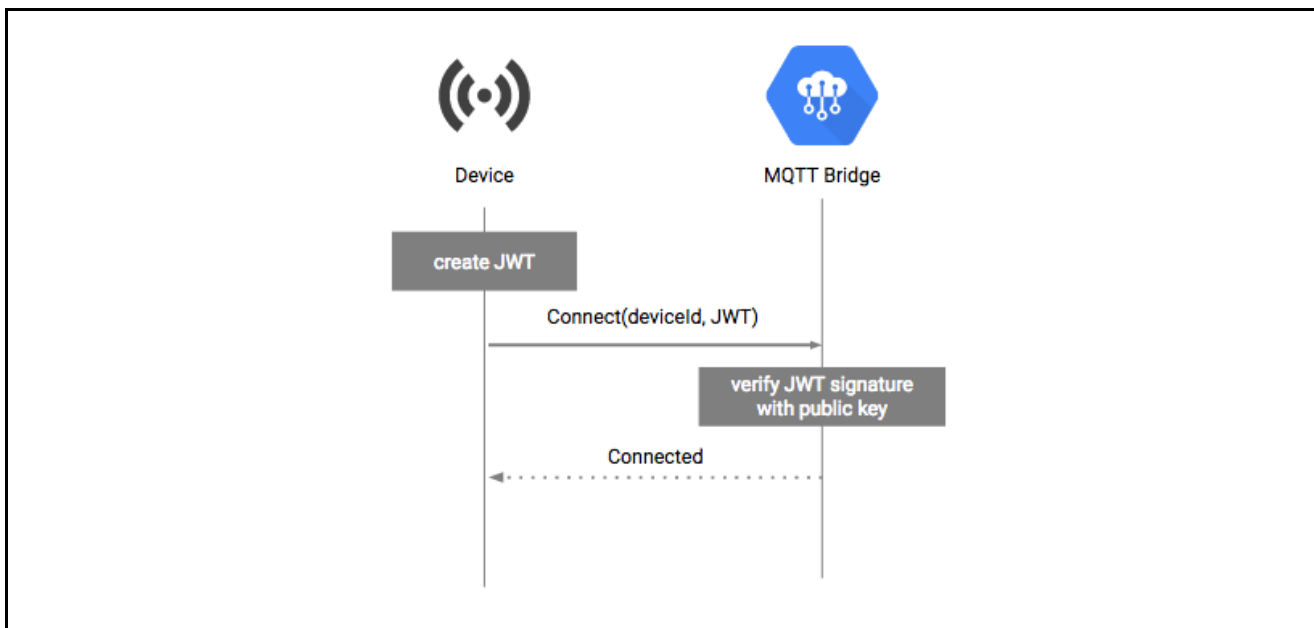
#### (1) Device Security

Security is a critical concern when deploying and managing IoT devices. Cloud IoT Core offers the following security features:

- Per-device public/private key authentication using JSON Web Tokens (JWTs).  
This limits the surface area of an attack, because a compromised key would affect only a single device and not the whole fleet.
- Support for RSA or Elliptic Curve algorithms to verify signatures, with enforcement for strong key sizes.
- Support to rotate keys per device by allowing concurrent keys to be registered, and support for expiration time per credential.
- TLS 1.2 connection, using root certificate authorities (required for MQTT).
- Cloud IoT Core API access is controlled by Cloud Identity and Access Management (IAM) roles and permissions.

#### (2) Per-device Key Authentication

The following diagram shows authentication in Cloud IoT Core:



The aspects involved in authentication are as follows:

- The device prepares a JSON Web Token (JWT). The JWT is signed with the private key from the authentication flow.
- When connecting to the MQTT bridge, the device presents the JWT as the password in the MQTT CONNECT message. The username content is ignored; however, some MQTT client libraries will not send the password unless the username is specified. For best results, set the username to an arbitrary value like unused or ignored.
- The MQTT bridge verifies the JWT against the device's public key.
- The MQTT bridge accepts the connection.
- The connection is closed when the JWT expires.

#### (3) Key Rotation

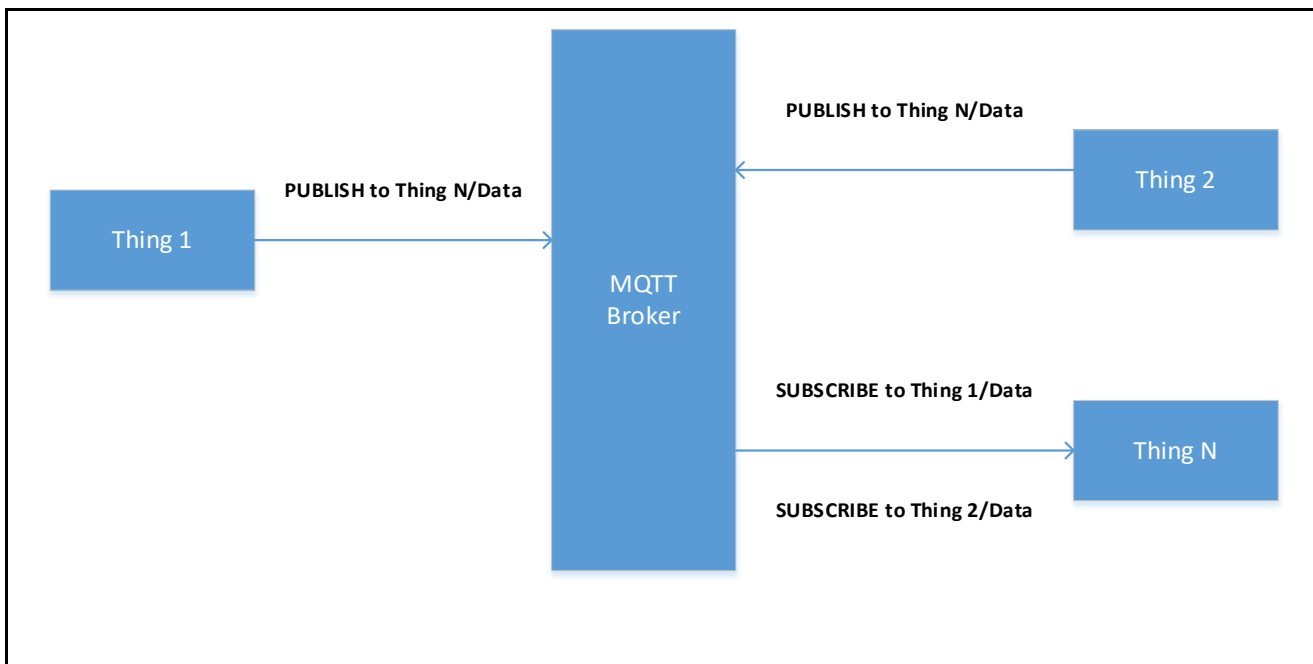
Cloud IoT Core supports multiple active keys (up to 3 per device) to allow for uninterrupted rotation. The service will try to verify JWTs with each of the active keys, and will accept a connection if any active key matches.

The API allows you to define an **expirationTime** for each device credential (public key). After it expires, the key will be ignored, but it will not be automatically deleted. A 10-minute clock-skew allowance applies. If no expiration time is specified for a key, it will never expire.

## 1.4 MQTT Protocol Overview

MQTT stands for Message Queuing Telemetry Transport. MQTT is a Client Server publish-subscribe messaging transport protocol. It is an extremely light weight, open, simple messaging protocol, designed for constrained devices, as well as low-bandwidth, high-latency, or unreliable networks. These characteristics make it ideal for use in many situations, including constrained environments, such as communication in Machine to Machine (M2M) and IoT contexts, where a small code footprint is required, and/or network bandwidth is at a premium.

A MQTT client can publish information to other clients through a broker. A client, if interested in a topic, can subscribe to the topic through the broker. A broker is responsible for authentication, authorization of clients, as well as delivering published messages to any of its clients who subscribe to the topic. In this publisher/subscriber model, multiple clients may publish data with the same topic. A client will receive the messages published if the client subscribes to the same topic.



**Figure 3. MQTT Client Publish/Subscribe Model**

In this model, there is no direct connection between a publisher and the subscriber. To handle the challenges of a pub/sub system, the MQTT generally uses quality of service (QoS) levels. There are three QoS levels in MQTT:

- At most once (0)
- At least once (1)
- Exactly once (2)

### **At most once (0)**

A message will not be acknowledged by the receiver or stored and redelivered by the sender.

### **At least once (1)**

It is guaranteed that a message will be delivered at least once to the receiver. But the message can also be delivered more than once. The sender will store the message until it gets an acknowledgment in form of a PUBACK command message from the receiver.

### **Exactly once (2)**

It is guaranteed that each message is received only once by the counterpart. It is the safest and the slowest quality of service level. The guarantee is provided by two flows, there and back, between sender and receiver.

## 1.5 TLS Protocol Overview

Transport Layer Security (TLS) protocol and its predecessor, Secure Sockets Layer (SSL), are cryptographic protocols that provide communications security over a computer network.

The TLS/SSL protocol provides privacy and reliability between two communicating applications. It has the following basic properties:

**Encryption:** The messages exchanged between communicating applications are encrypted to ensure that the connection is private. Symmetric cryptography mechanism such as AES (Advanced Encryption Standard) is used for data encryption.

**Authentication:** A mechanism to check the peer's identity using certificates.

**Integrity:** A mechanism to detect message tampering and forgery to ensure that connection is reliable. Message Authentication Code (MAC) such as Secure Hash Algorithm (SHA) is used to ensure message integrity.

TLS/SSL uses TCP but provides secure communication for application layer protocols, such as HTTP and MQTT.

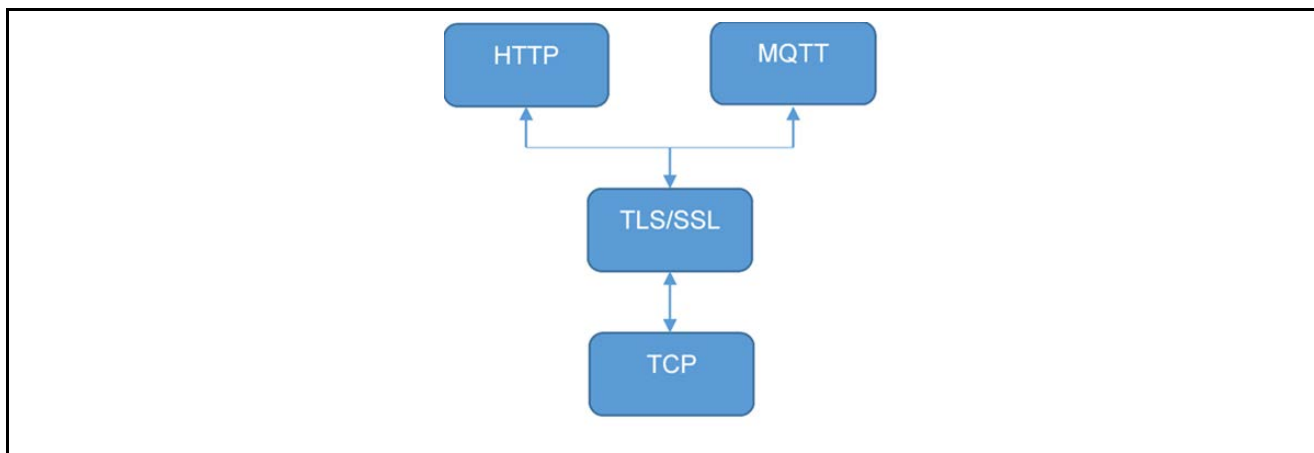


Figure 4. TLS/SSL Hierarchy

### 1.5.1 Device Certificates and Keys

Devices certificates, public and private keys, and the ways they can be generated, is discussed in this section.

#### 1.5.1.1 Device Certificates

Security is a critical concern when deploying and managing IoT devices. In general, each of the IoT devices needs an identity before they can communicate with the Cloud. Digital certificates are the most common method for authenticating a remote host in TLS. Essentially, a digital certificate is a document with specific formatting that provides identity information for a device.

TLS normally uses a format called X.509, a standard developed by the International Telecommunication Union (ITU), though other formats for certificates may apply if the TLS hosts can agree on the format to use. X.509 defines a specific format for certificates and various encoding that can be used to produce a digital document. Most X.509 certificates used with TLS are encoded using a variant of ASN.1, another telecommunication standard. Within ASN.1 there are various digital encodings, but the most common encoding for TLS certificates is the Distinguished Encoding Rules (DER) standard. DER is a simplified subset of the ASN.1 Basic Encoding Rules (BER) and designed to be unambiguous to make parsing easier.

Though DER-formatted binary certificates are used in the actual TLS protocol, they may be generated and stored in a number of different encodings, with file extensions such as `.pem`, `.crt`, and `.p12`. The most common of the alternative certificate encodings is Privacy-Enhanced Mail (PEM). The PEM format is a base-64 encoded version of the DER encoding.

Depending on your application, you may generate your own certificates, be provided certificates by a manufacturer or government organization, or purchase certificates from a commercial certificate authority.

#### 1.5.1.2 Loading Certificates onto your Device

To use a digital certificate in your NetX™ Secure application, you must first convert your certificate into a binary DER format, and optionally, convert the associated private key into a binary format, typically, a PKCS#1-formatted, DER-encoded RSA key. Once converted, it is up to you how to load the certificate and the private key on to the device. Possible options include using a flash-based file system or generating a C



array from the data (using a tool such as `xxd` from Linux® with the `-i` option) and compiling the certificate and key into your application as constant data.

Once your certificate is loaded on the device, you can use the TLS API to associate your certificate with a TLS session.

### 1.5.1.3 Generating Self-Signed Certificates

You may also choose to generate a self-signed certificate for testing purposes. The command to generate such a certificate is:

```
openssl req -x509 -newkey rsa:2048 -keyout private.key -out cert.pem -days 365  
-nodes -subj "/C=US/ST=Oregon/L=Portland/O=Company  
Name/OU=Org/CN=www.example.com"
```

In this situation, a self-signed certificate `www.example.com` is generated. The certificate and private key files are `cert.pem` and `private.key`. You may generate a certificate for **localhost** by replacing **www.example.com** for **localhost**. In that case, pass **localhost** as the first argument to the installation script.

### 1.5.2 Device Security Recommendations

The following security recommendations are not enforced by Cloud IoT Core but will help you secure your devices and connections.

- The private key should be kept secret.
- Use TLS 1.2 when communicating with IoT Cloud and verify that the server certificate is valid using root certificate authorities.
- Each device should have a unique public/private key pair. If multiple devices share a single key and one of those devices is compromised, an attacker could impersonate all the devices that have been configured with that one key.
- Keep the public key secure when registering it with Cloud IoT Core. If an attacker can tamper with the public key and trick the provisioner into swapping the public key and registering the wrong public key, the attacker will subsequently be able to authenticate on behalf of the device.
- The key pair is used to authenticate the device to Cloud IoT Core and should not be used for other purposed or protocols.
- Depending on the device's ability to store keys securely, key pairs should be rotated periodically. When practical, all keys should be discarded when the device is reset.
- If your device runs an operating system, make sure you have a way to securely update it. Android Things provides a service for secure updates. For devices that do not have an operating system, ensure that you can securely update the device's software if security vulnerabilities are discovered after deployment.

## 2. Synergy MQTT/TLS Cloud Solution

### 2.1 MQTT Client Overview

The NetX Duo MQTT Client module provides high-level APIs for a Message Queuing Telemetry Transport (MQTT) protocol-based client. The MQTT protocol works on top of TCP/IP and therefore the MQTT client is implemented on top of NetX Duo IP and NetX Duo Packet pool. NetX Duo IP attaches itself to the appropriate link layer frameworks, such as Ethernet, Wi-Fi, or cellular.

The NetX Duo MQTT client module can be used in normal or secure mode. In normal mode, the communication between the MQTT client and broker is not secure. In secure mode, the communication between the MQTT client and broker is secured using the TLS protocol.

## 2.2 Design Considerations

- By default, the MQTT client does not use TLS; communication is not secure between a MQTT client and broker.
- The Synergy MQTT client does not add the NetX Duo TLS session block. It only adds NetX Duo TLS common block. This block defines/controls the common properties of NetX secure.
- It is the responsibility of the user/application code to create the TLS session, configure the security parameters, and load the relevant certificates manually under the TLS setup callback provided by `nxd_mqtt_client_secure_connect ()` API.

### 2.2.1 Supported Features

NetX Duo MQTT Client supports the following features:

- Compliant with OASIS MQTT Version 3.1.1 Oct 29<sup>th</sup>, 2014. The specification can be found at <http://mqtt.org/>.
- Provides an option to enable/disable TLS for secure communication using NetX Secure in SSP.
- Supports QoS and provides the ability to choose the levels that can be selected while publishing the message.
- Internally buffers and maintains the queue of received messages.
- Provides a mechanism to register callback when a new message is received.
- Provides a mechanism to register callback when connection with the broker is terminated.

### 2.2.2 Operational Flow Sequence

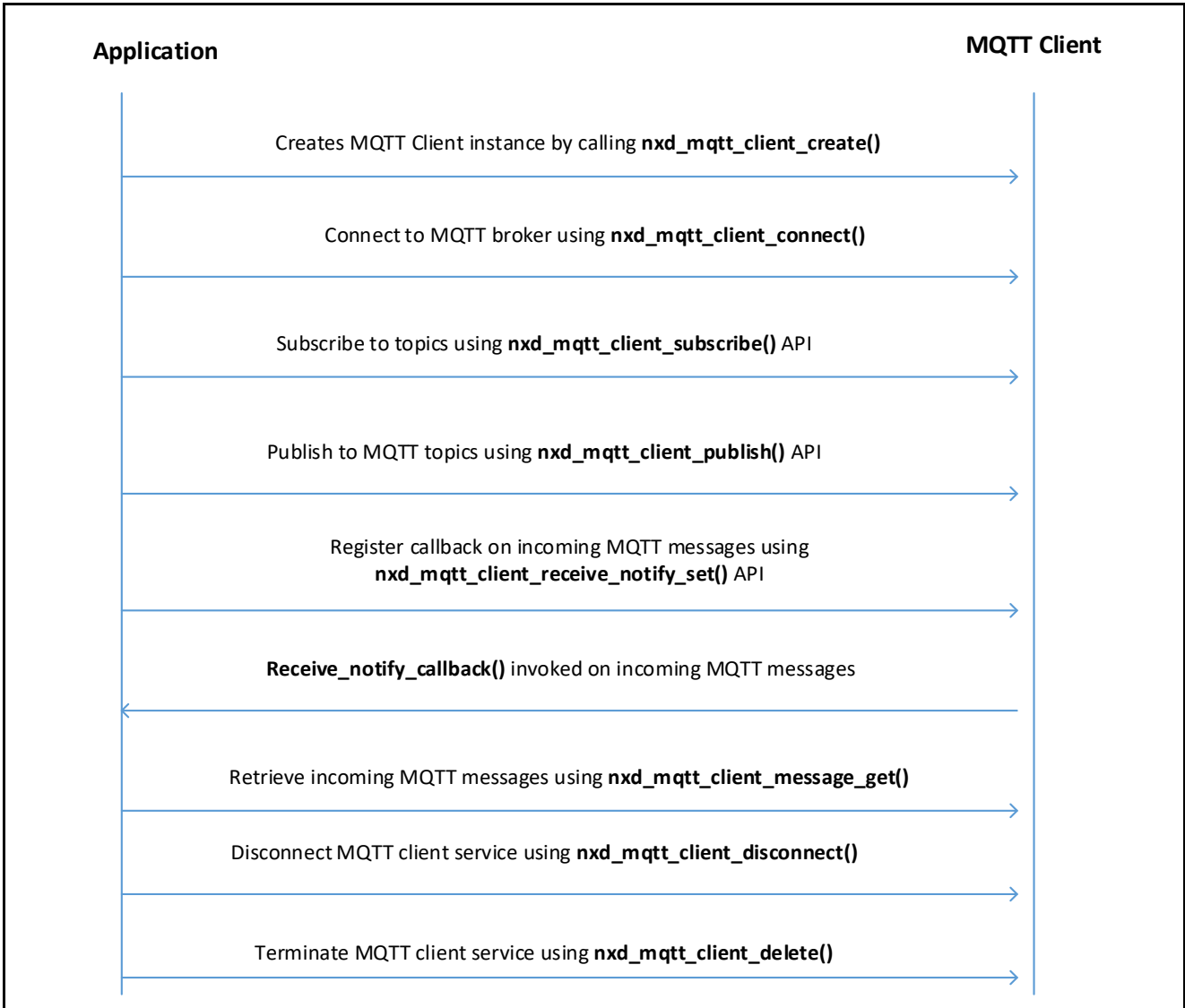


Figure 5. Synergy MQTT Client Flow Sequence

### 2.3 TLS Session Overview

The NetX Duo TLS session module provides high-level APIs for the TLS protocol-based client. It uses services provided by the Synergy Crypto Engine (SCE) to carry out hardware-accelerated encryption and decryption.

The NetX Duo TLS Session module is based on Express Logic’s NetX Secure which implements the Secure Socket Layer (SSL) and its replacement, TLS protocol, as described in RFC 2246 (version 1.0) and 5246 (version 1.2). NetX Secure also includes routines for the basic X.509 (RFC 5280) format. NetX Secure is intended for applications using ThreadXRTOS in the project.

### 2.3.1 Design Considerations

- NetX Secure TLS performs only basic path validation on incoming server certificates.
- Once the basic path validation is complete, TLS then invokes the certificate verification callback supplied by the application.
- It is the responsibility of the application to perform any additional validation of the certificate.
- To help with the additional validation, NetX Secure provides X.509 routines for common validation operations, including DNS validation and Certificate Revocation List checking.
- Software-based cryptography is processor-intensive.
- NetX Secure software-based cryptographic routines have been optimized for performance, but depending on the power of the target processor, performance may result in very long operations. When hardware-based cryptography is available, it should be used for optimal performance of the NetX secure TLS.
- Due to the nature of embedded devices, some applications may not have the resources to support the maximum TLS record size of 16 KB.
- NetX Secure can handle 16 KB records on devices with sufficient resources.

### 2.3.2 Supported Features

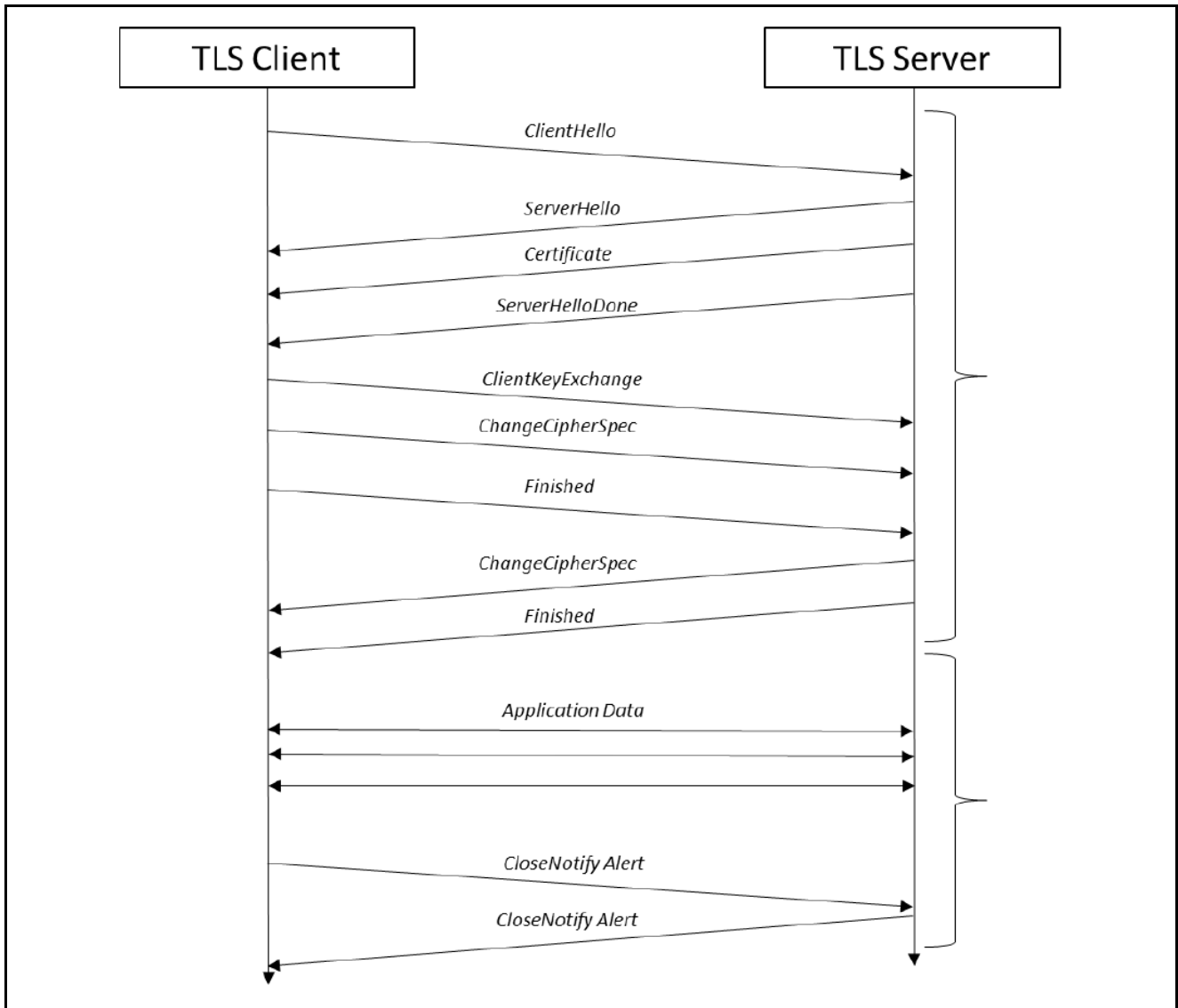
- Support for RFC 2246 The TLS Protocol Version 1.0
- Support for RFC 5246 The Transport Layer Security (TLS) Protocol Version 1.2
- Support for RFC 5280 X.509 PKI Certificates (v3)
- Support for RFC 3268 Advanced Encryption Standard (AES) Cipher suites for Transport Layer Security (TLS)
- RFC 3447 Public-Key Cryptography Standards (PKCS) #1: RSA Cryptography Specifications Version 2.1
- RFC 2104 HMAC: Keyed-Hashing for Message Authentication
- RFC 6234 US Secure Hash Algorithms (SHA and SHA-based HMAC and HKDF)
- RFC 4279 Pre-Shared Key Cipher suites for TLS

### 2.3.3 Operational Flow Sequence

This section describes the TLS handshake operational sequence.

#### 2.3.3.1 TLS Handshake

The following figure shows a typical TLS handshake between the TLS Server and Client.



**Figure 6. TLS Handshake**

- A TLS handshake begins when the TLS client sends a **ClientHello** message to a TLS server, indicating its desire to start a TLS session.
- The message contains information about the encryption that the client would like to use for the session, along with information used to generate the session keys.
- The TLS server responds to the **ClientHello** with a **ServerHello** message, indicating a selection from the encryption options provided by the client.
- It is followed by a Certificate message, in which the server provides a digital certificate to authenticate its identity to the client.
- Finally, the server sends a **ServerHelloDone** message to indicate it has no more messages to send.
- Once Client has received all the server’s messages, it has enough information to generate the session keys. TLS does this by creating a shared bit of random data called the Pre-Master Secret, which is a fixed size and is used as a seed to generate all the keys needed once encryption is enabled.
- The Pre-Master Secret is encrypted using the public key algorithm (such as RSA) specified in the Hello messages and the public key provided by the server in its certificate.
- The encrypted Pre-Master Secret is sent to the server in the **clientKeyExchange** message. The server, upon receiving the **ClientKeyExchange** message, decrypts the Pre-Master Secret using its private key and proceeds to generate the session keys in parallel with the TLS client.

- Once the session keys are generated, all further messages can be encrypted using the private-key algorithm (such as AES) selected in the Hello messages. One final un-encrypted message called **ChangeCipherSpec** is sent by both the client and server to indicate that all further messages will be encrypted.
- The first encrypted message sent by both the client and server is also the final TLS handshake message, called **Finished**. This message contains a hash of all the handshake messages received and sent. This hash is used to verify that none of the messages in the handshake have been tampered with or corrupted.
- Now the application begins sending and receiving data. All data — sent by either side — is first hashed using the hash algorithm chosen in the Hello messages, and then encrypted using the chosen private-key algorithm with the generated session keys.
- Finally, a TLS session can only be successfully ended if either the Client or Server chooses to do so. Both the client and server must send and process a **CloseNotify** alert for a successful session shutdown.

### 2.3.3.2 Initialization Flow Sequence

A typical TLS session initialization flow sequence is given in the following figure.

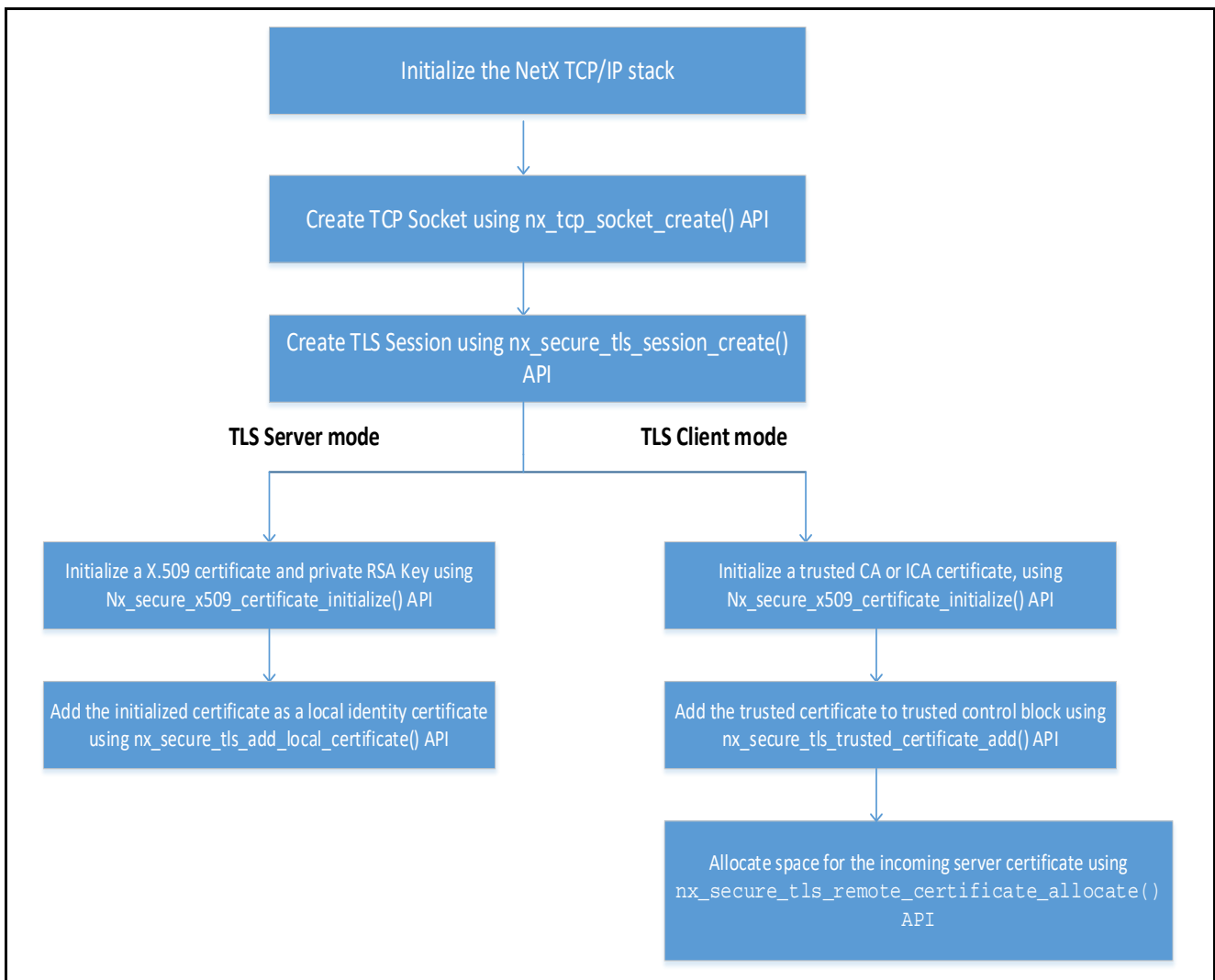


Figure 7. Synergy TLS Session Initialization

### 2.3.3.3 Data Communication Flow Sequence

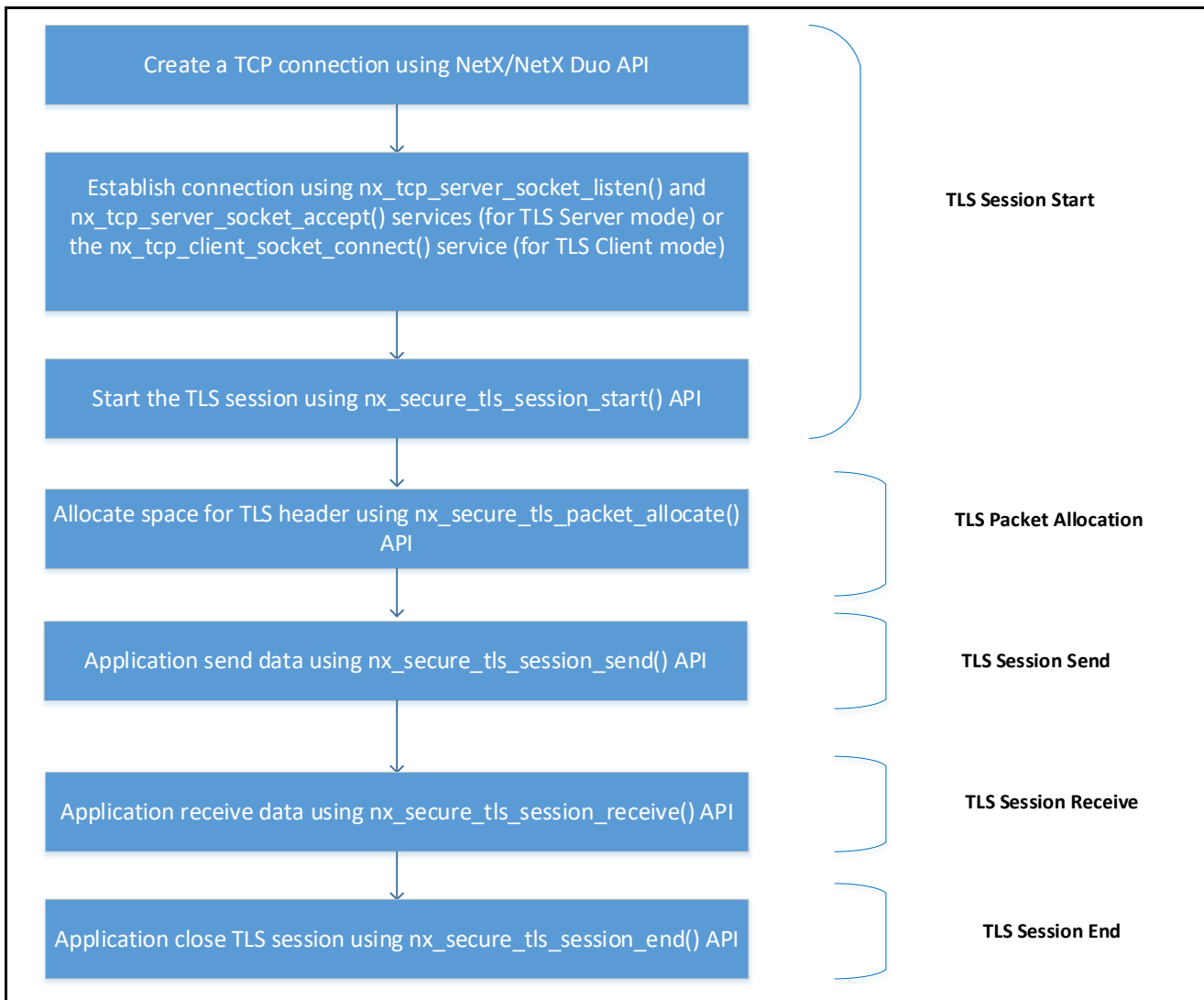


Figure 8. Synergy TLS Session Data Flow Sequence

## 3. MQTT/TLS Application Example

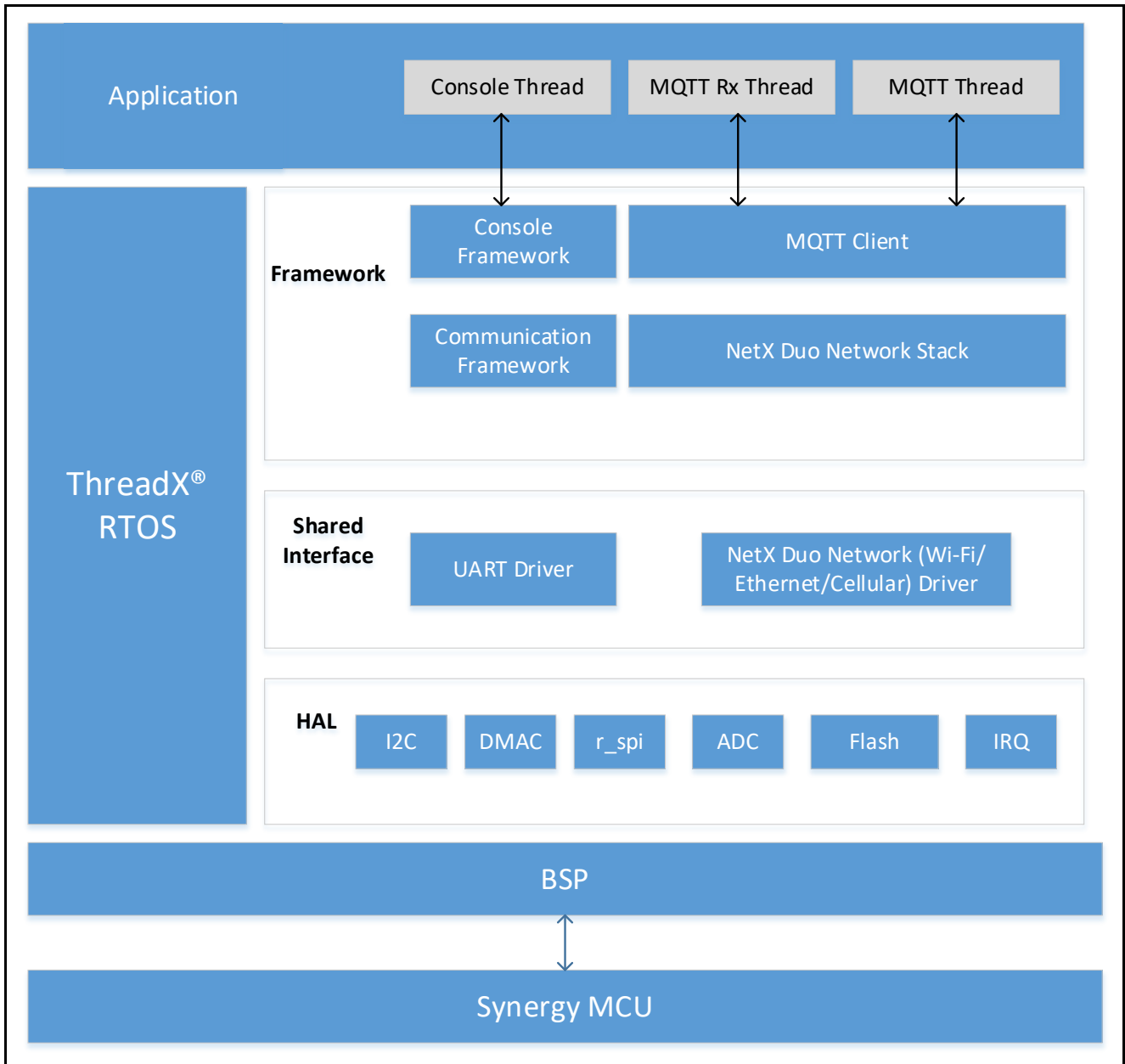
### 3.1 Application Overview

This example application project demonstrates the Renesas Synergy™ IoT Cloud Connectivity solution using the onboard Synergy MQTT/TLS modules. For demonstration purposes, this application uses Google Cloud IoT Core as the cloud provider. Ethernet or Wi-Fi or Cellular (supported only on AE-CLOUD2 kit) is used as primary communication interface between the Thing and Google Cloud IoT Core.

In this example, the PK-S5D9, AE-CLOUD1 and AE-CLOUD2 kit acts as MQTT node/Thing, connects to the Google Cloud IoT Core, periodically reads its die temperature (in case of PK-S5D9 kit) or on-board sensors (in case of AE-CLOUD1 and AE-CLOUD2 kit) values and publishes it to the Google Cloud IoT Core. It also subscribes to its User LED state MQTT topic. You can turn ON/OFF the User LEDs by publishing the LED state remotely. This application reads the updated LED state and turns ON/OFF the User LEDs.

### 3.2 Software Architecture Overview

The following figure shows the overall software architecture for the Synergy Cloud Connectivity Application Example Project.



**Figure 9. Synergy Cloud Connectivity Application Software Architecture**

The main software components of this application are:

- MQTT Client
- NetX Duo IP Stack and its underlying driver components for Ethernet and Wi-Fi
- Console Framework

This application contains the following application threads:

- Console Thread
- MQTT Thread
- MQTT Rx Thread



### 3.2.1 Console Thread

This thread handles the function related to Common Line Interface (CLI). It uses the console framework, which in-turn uses the communication framework and its underlying USBX CDC device module components.

This thread reads the user inputs and stores them in the internal data flash. The stored information is read later by the MQTT Thread when it tries to run the Synergy Cloud connectivity demo.

This thread presents you with the following CLI command options.

- `Cwiz`
- `Demo start/stop`

#### **Cwiz command option**

Using this command option, you can select the following configurations:

- Network interface such as Ethernet, Wi-Fi and its associated IP mode (DHCP/Static).
- IoT cloud selection (GCloud).
- Dump the existing configuration from flash.
- Exit the menu.

#### `Demo start/stop` command option

Using this command option, you can run/stop the Synergy Cloud Connectivity Demonstration.

### 3.2.2 MQTT Thread

This is the main control thread which thread handles the following major functions:

- Initialize communication interface (Ethernet/Wi-Fi).
- Initialize IoT Cloud interface.
- Read sensor data and publish the data periodically on MQTT topics.
- Update the user LED state based on the type of MQTT message received.

On wakeup, this thread periodically checks (every 5 seconds) for user input event flag state set once you enter the demonstration start/stop command on the CLI. If the demonstration start command is issued from the CLI, this thread will read the pre-configured user information from internal flash and checks its validity. If the content is valid, it then starts the Synergy Cloud connectivity demonstration. If a demo stop command is issued, it de-initializes the IoT cloud interface.

### 3.2.3 MQTT Rx Thread

This thread handles the incoming MQTT messages from the MQTT broker. On receiving the new MQTT message, the user callback `receive_notify_callback()` will be invoked by the MQTT thread. This callback in turn sets the semaphore on which the MQTT Rx Thread is polling periodically.

On receiving the new MQTT message, it uses the `nxd_mqtt_client_message_get()` API to read the message, parse it, and act on it based on the type of the message received.

## 3.3 IoT Cloud Configuration (GCloud)

### Device Registry

A container of devices with shared properties. You “register” a device with a service (like Cloud IoT Core) so that you can manage it.

### Device

A “Thing” in the “Internet of Things”; a processing unit that can connect to the internet and exchange data with the Cloud. Devices are often called “smart devices” or “connected devices”. They communicate two types of data: telemetry and state.

### Device configuration

An arbitrary, user-defined blob of data used to modify a device's settings. Configuration data can be structured or unstructured, and flows only in the cloud-to-device direction.

## Device state

An arbitrary, user-defined blob of data that describes the status of the device. Device state data can be structured or unstructured, and flows only in the device-to-cloud direction.

## JSON

JSON is an open standard, lightweight, data-interchange format. As a text document, it is easy for users to read and write, and machines to parse and generate.

JSON is completely language independent, using conventions that are familiar to C-family programmers, including C, C++, C#, Java, JavaScript, Perl, Python and many others.

```
{
  "state": {
    "desired": {
      "LED_value": "On"
    }
  }
}
```

## Google Cloud Signup

Google Cloud offers a free account (12 months) for each user. It is expected that each user has created an account on the Google Cloud IoT service before continuing to the next section.

Each user is expected to have a Gmail account that will be used to login to the Google Cloud IoT core account. To link your Gmail account to a Google Cloud IoT core account, open to the following link in your web browser: <https://console.cloud.google.com/>

Fill in the required details and create a user account.

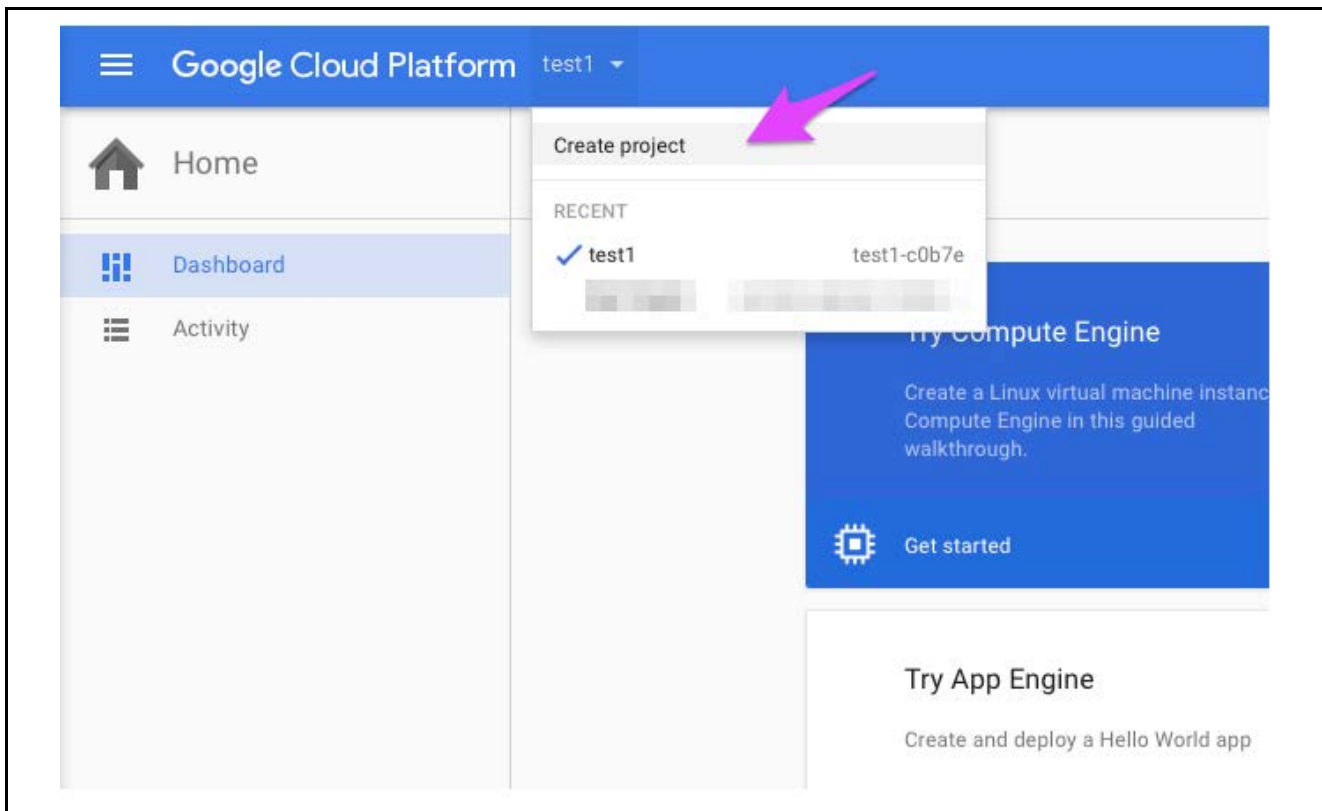
### 3.3.1 Creating a Device on Google Cloud IoT Core

The following steps show you how to create a project, registry, and how to add a device on the Google Cloud IoT Core user account. It is assumed that you created a user account in the Google Cloud IoT Core and have followed the Google Cloud signup procedure.

Note: While creating the project, registry and device, the screenshots may look slightly different from what is shown in the document and users need to navigation in the Google Cloud IoT core environment to find corresponding attribute while working on this project.

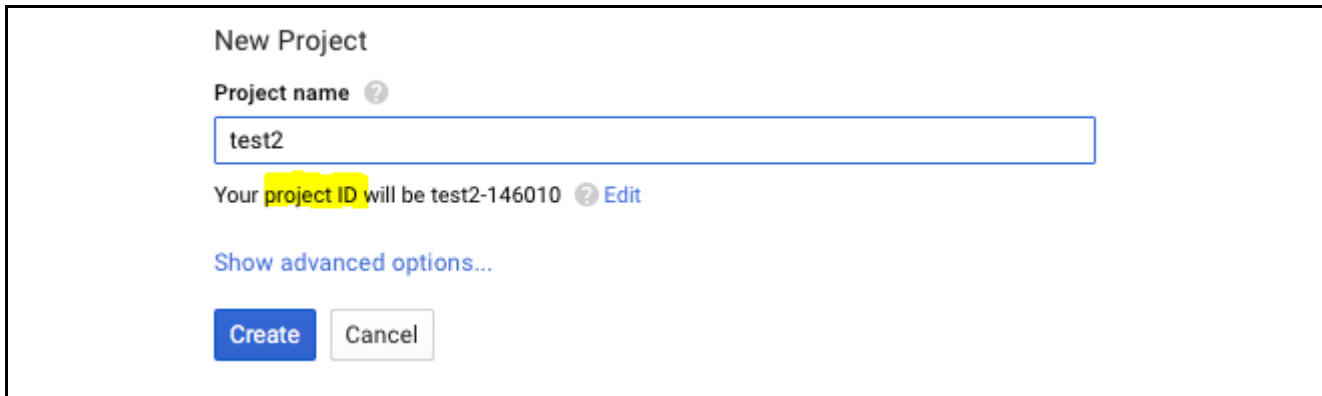
#### 3.3.1.1 Create a Project

1. After you sign up for the Google Cloud free tier, open the following link to enter the Google Cloud Platform dashboard:  
<https://console.cloud.google.com/>
2. To the right of Google Cloud Platform at the top of the window is a drop-down menu as shown in the following figure. Select **Create project**.



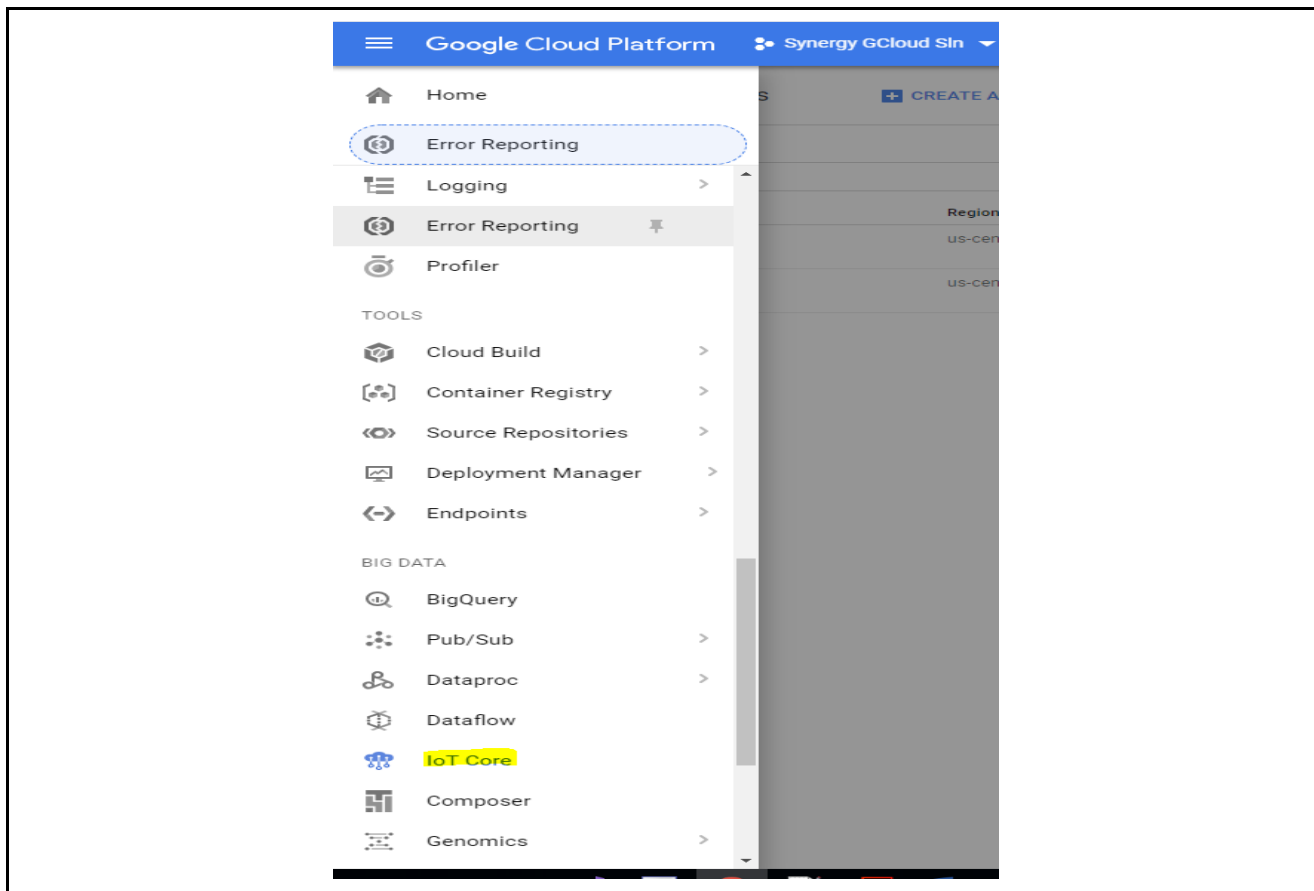
3. Enter the project name as shown and make a note of the project ID as highlighted in the following screen shot. It is a longer string with a unique number.

Note: Remember to store this project ID. This information is passed to the firmware using the serial console as part of the configuration.



### 3.3.1.2 Create a Device Registry

1. Go to the Google Cloud IoT Core page (<https://console.cloud.google.com/>) in Google Cloud Platform (GCP) Console.
2. Go to the IoT Core page as shown in the following screenshot.



3. Click **Create a registry**.
4. Enter `<my-registry>` for the **Registry ID**.
5. If you are in the US, select **us-central1** for the **Cloud region**. If you are outside the US, select your preferred region (Europe-west1 or asia-east1).
6. Select **MQTT** for the **Protocol**.
7. In the **Telemetry topic** dropdown list, select **Create a topic**.
8. In the **Create a topic** dialog, enter `<my-device-events>` in the **Name** field.
9. Click **Create** in the **Create a topic** dialog.
10. The **Device state topic** and **Certificate value** fields are optional, so leave them blank.
11. Click **Create** on the Cloud IoT Core page.

You have just created a device registry with a Cloud Pub/Sub topic for publishing device telemetry events.

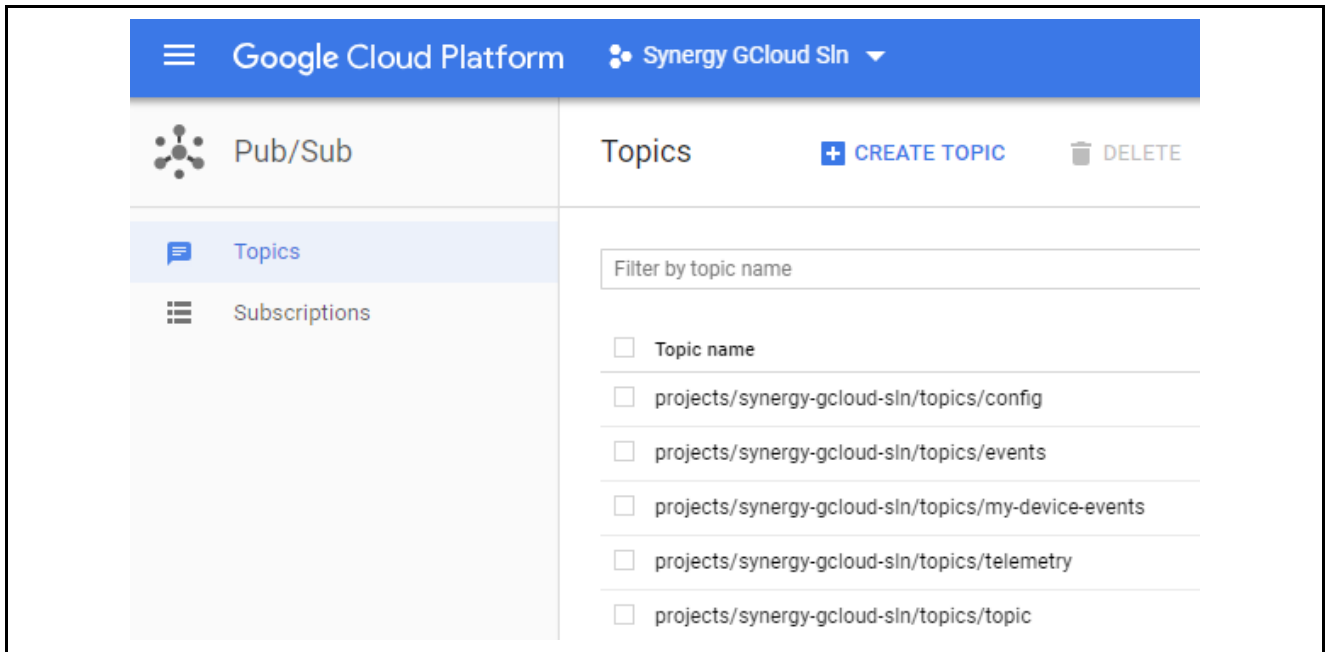
### 3.3.1.3 Add a Device to the Registry

1. On the Registry Details page, click **Add device**.
2. Enter `<my-device>` for the **Device ID**.
3. Select **Allow** for **Device communication**.
4. The Authentication fields are optional, so temporarily leave them blank or use the default values. The Authentication fields accept a public key that you'll create and implement in the next section.
5. The Device metadata field is also optional; leave it blank.
6. Click **Add**.

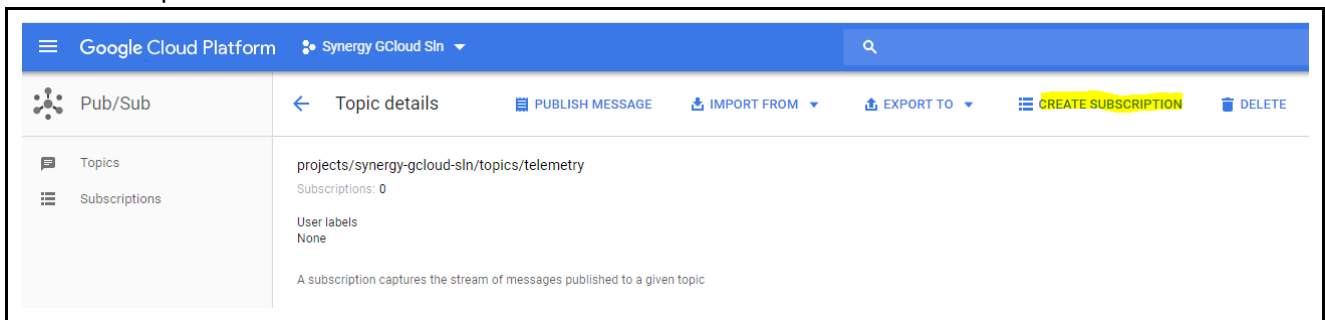
You have just added a device to your registry.

### 3.3.1.4 Create Subscription to the Topic

In the Google Cloud Platform dashboard, go to the **Pub/Sub** page as shown in the following screenshot. The telemetry topics created by the user will be displayed under the **Topics** page.



1. Find your topic from the list and click on the topic to enter Topic details page.
2. Now, you need to create subscription to capture the stream of messages published to your topic.
3. Click **CREATE SUBSCRIPTION** in the Topic details page as shown in the following screenshot to create subscription.

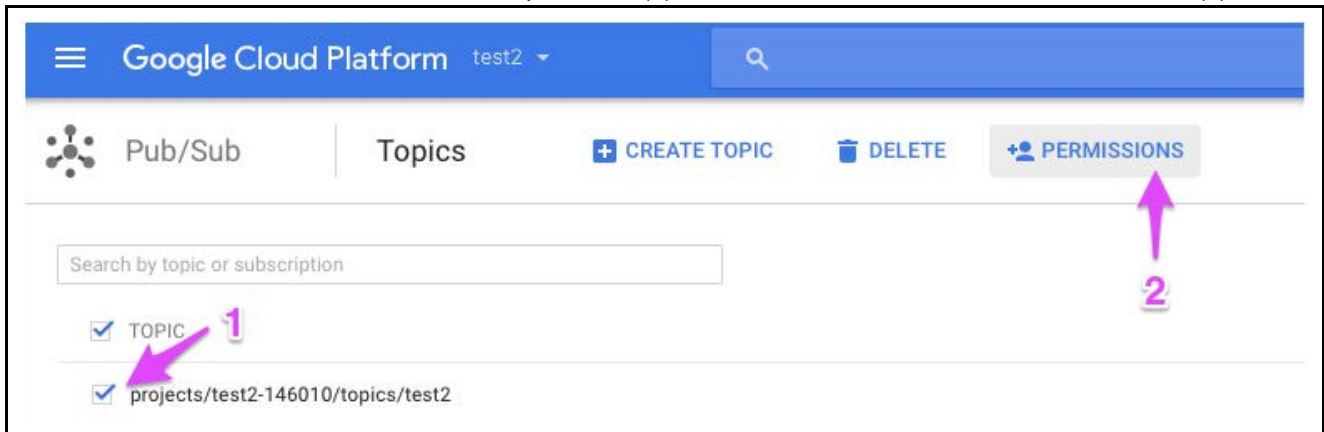


4. Enter the **subscription name** and Choose the **Delivery Type** as Pull.
5. Click **Create** button to create subscription for your topic.

### 3.3.1.5 Set Permissions for the New Topic

In the Google Cloud Platform dashboard, go to the **Pub/Subpage** as shown in the following screenshot. The telemetry topics created by the user will be displayed under the **Topics** page.

1. Select the checkbox to the left of the topic name (1), then click the **Permissions** button above it (2).



2. For testing purpose, enter the gmail address you used for the google cloud registration in the **Add members** box to grant access to all users. In real implementation, the access has to be properly given to certain group of members.
3. Select **Pub/Sub Publisher** from the drop-down menu.
4. And finally click **Add**.

### 3.3.2 Generate Device Key and Certificate

Now, you can generate device certificates and keys for the Google Cloud IoT Thing (Thing) created.

1. Make sure you install openssl library in your test PC. To download openssl.
2. Open a terminal window in your windows PC and run the following multi-line command to create an RS256 key:

```
openssl req -x509 -newkey rsa:2048 -keyout rsa_private_key.pem -nodes -out
rsa_devcert.pem -subj "/CN=unused"
```

The device private key needs to be converted into PKCS#1 format before passing it to the firmware using serial console as part of configuration. To convert `rsa_private.pem` to PKCS#1 format, run the following command in your command window:

```
openssl rsa -in rsa_private_key.pem -out rsa_private_pkcs1.pem
```

### 3.3.3 Add Public Key to the Google Cloud IoT Core

At this point, it is assumed that you followed the steps described in section 3.3.1, created the registry, and added a device to the registry.

1. Copy the contents of `rsa_devcert.pem` to the clipboard. Make sure to include lines that say  
 -----BEGIN CERTIFICATE----- and -----END CERTIFICATE-----
2. On the **Device details** page for the device you created in the preceding section, click **Add public key**.
3. Select **RS256\_X509** for the **Public key format**.
4. Paste your public key in the **Public key value** box.
5. Click **Add**.

An RS256\_X509 key appears on the Device details page for your device.

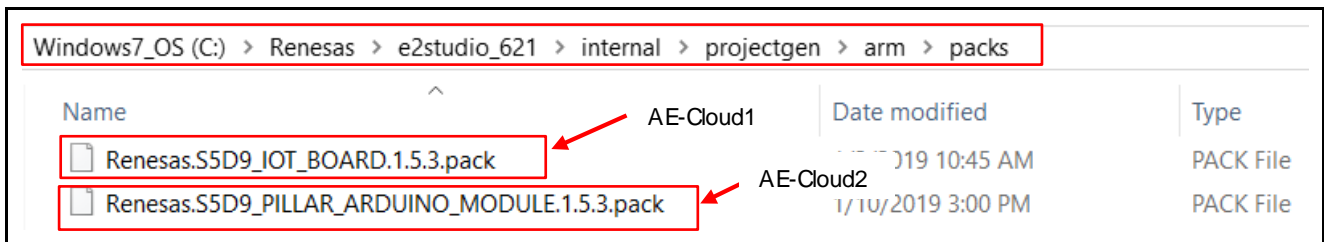
## 4. Running the MQTT/TLS Application

### 4.1 Importing, Building, and Loading the Project

See the *Renesas Synergy™ Project Import Guide* (<r11an0023eu0121-synergy-ssp-import-guide.pdf>), included in this package, for instructions to import the project into e<sup>2</sup> studio, build, and run the project.

### 4.2 Manually Adding the Board Support Package for the AE-CLOUD2 and AE-CLOUD1 Kit

- From the project bundle, locate the BSP file,  
 Renesas.S5D9\_PILLAR\_ARDUINO\_MODULE.1.5.3.pack for AE-CLOUD2 and  
 Renesas.S5D9\_IOT\_BOARD.1.5.3.pack for AE-CLOUD1.
- For **e<sup>2</sup> studio users**: Copy the file shown below to the e<sup>2</sup> studio packs folder location:  
 C:\Renesas\Synergy\e2studio\_v6.2.1\internal\projectgen\arm\packs.



**Figure 10. Load BSP Pack for AE-CLOUD1/AE-CLOUD2 Kit**

- For **IAR users**: copy the file to SSC\packs folder:  
 C:\Renesas\Synergy\ssc\_v6.2.1\internal\projectgen\arm\packs.

Note: If e<sup>2</sup> studio and IAR SSC are installed in any other location, provide the same information to copy the pack.

### 4.3 Powering up the Board

To connect power to the board, connect the SEGGER J-Link® debugger to the PC, connect the board to the PC USB port, and run the debug application, using the following instructions:

- For PK-S5D9 and AE-CLOUD2, connect the micro USB end of the supplied USB cable to the PK-S5D9 board's J19 connector (DEBUG\_USB) or the AE-CLOUD2 board's J6 connector (DEBUG\_USB).  
 Connect the other end of the USB cable to the USB port on your workstation.
- Note: The kit contains a SEGGER J-Link® On-board (OB). J-Link provides full debug and programming for the PK-S5D9/AE-CLOUD2 board.
- On the AE-CLOUD1 board, connect the J-Link Lite supplied with the kit to the J2 connector on the AE-CLOUD1 and to the 10-pin header on the J-Link lite using the supplied 10-pin, flat-ribbon cable.
- Attach the PMOD-based GT-202 Wi-Fi module in the PMOD A connector (**in case of PK-S5D9, connect to PMOD-A**).
- For the AE-CLOUD2 kit, connect the BG96 Cellular shield on the AE-CLOUD2 Arduino Connector. Next, attach the Cellular antenna to the LTE antenna connector, and then the GPS antenna to the GNSS antenna connector on the BG96 shield.
- Connect the second micro USB cable as follows, depending on your kit:
  - AE-CLOUD2 board's J9 connector
  - PK-S5D9 board's J5 connector
  - AE-CLOUD1 board's J3 connector

Connect the other end of the USB cable to the USB port on your workstation. This connection is necessary for the serial console.

### 4.4 Connect to Google IoT Cloud

The following instructions show how to run the Synergy Cloud connectivity application project and connect to the Google IoT Cloud.

Note: At this stage, it is assumed that you completed the instructions in section 3.3 to create an Google IoT account, set up your device on the Google IoT Core, and download the device certificates and keys.

- Section 4.4 shows how the command line interface can be used to configure the boards depending upon the desired interface for the cloud connectivity.
- While running the application on these boards connectivity is done using one interface at a time (Ethernet or Wi-Fi, or Cellular). Users are required to configure only the desired interface to run the application. For example, if you use Ethernet, then Wi-Fi or Cellular does not need to be configured and vice-versa.
- Note that the CLI screenshots shown, in some cases, may not apply to some boards, such as Cellular not being applicable to PK-S5D9 and AE-CLOUD1 boards.

**Table 1. Kit Connectivity Options (only one interface supported at a time)**

Board	Ethernet	Wi-Fi	Cellular
PK-S5D9	Supported	Supported	Not Supported
AE-CLOUD1	Supported	Supported	Not Supported
AE-CLOUD2	Supported	Supported	Supported

1. If you have not already done so, complete section 3 and then go to section 4.3 to power up and load the project on the PK-S5D9/AE-CLOUD2 kit.  
 Connect the USB Device port of the kit to the test PC and it will be automatically detected as an USB Serial device in case of Windows 10 PC. In case of Windows 7/8 PC, refer to the following installation guide to load the Synergy USB CDC driver:  
[www.renesas.com/en-us/products/synergy/software/add-ons/usb-cdc-drivers.html](http://www.renesas.com/en-us/products/synergy/software/add-ons/usb-cdc-drivers.html)  
 Open the serial console application, such as Tera Term, to connect it to the PK-S5D9/AE-CLOUD1/AE-CLOUD2 kit. The default Tera Term settings are **8-N-1**, and the baud rate is **9600**.
2. Press **Enter**. The following command prompt and CLI (for AE-Cloud2 only) information appears on the serial console.



**Figure 11. Command Prompt (CLI info is for AE-Cloud2 only)**

3. Wait for the GPS initialization to complete. It may take around 7-10 seconds. The GPS initialization happens only in case of AE-CLOUD2 kit.
4. Press the ? key on your keyboard to display the available CLI command options shown in the following figure.



**Figure 12. Help Menu**



### 4.4.1 Configuration Wizard Menu

Enter command `cwiz` and press the enter key in the serial console to enter the configuration menu. This command is used to configure the Network interfaces, Google Cloud IoT Core Service, dump previous configuration stored in the internal flash.

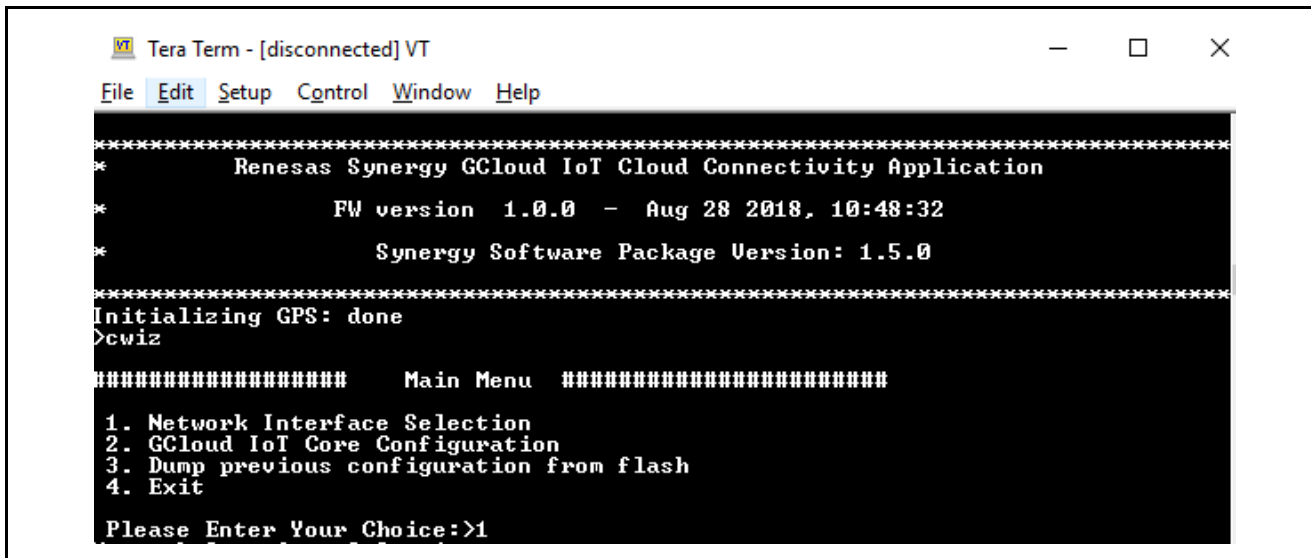


Figure 13. Configuration Menu

#### 4.4.1.1 Network Interface Selection

From the configuration menu, press the ‘1’ key to configure the Network Interface. It lists the available network interface options in this application project. Currently this application supports Ethernet, Wi-Fi, Cellular (in case of AE-CLOUD2 kit) communication interfaces.

**Note:** The user can select only one network interface at a time. For instance, when Ethernet is selected, Wi-Fi and Cellular are not available and vice-versa.

For example, if the user selects the Error! Reference source not found. as the interface for cloud connectivity, then user can move directly to **Error! Reference source not found.** (Google IoT Core Configuration). The same applies for Wi-Fi and Cellular as well.

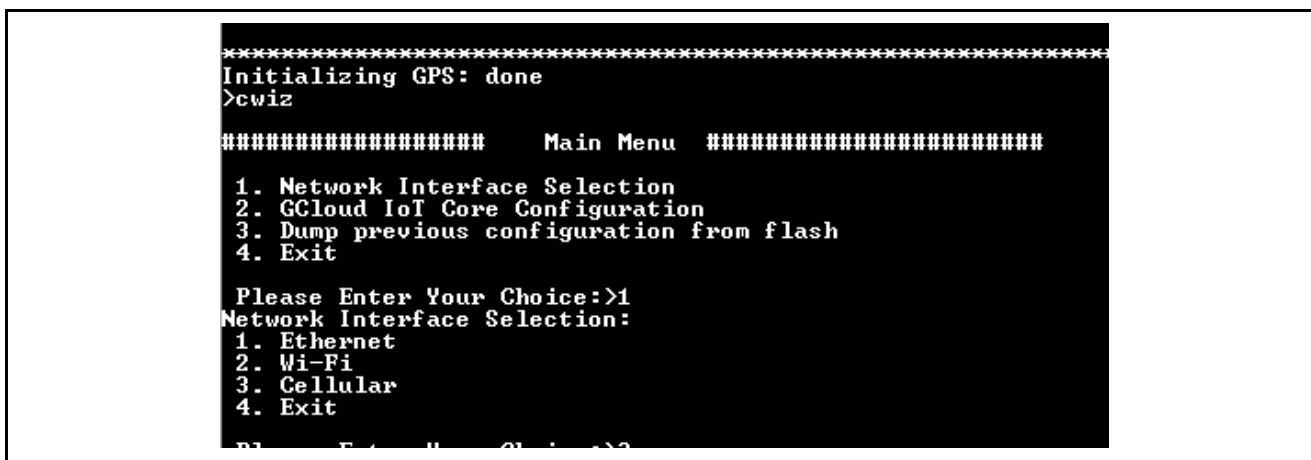


Figure 14. Network Interface Selection Menu

#### (1) Ethernet Network Interface Configuration

From the **Network Interface Selection menu**, press ‘1’ key to select the Ethernet Network Configuration.

You see the submenu where you choose the IP Address Configuration mode from the available options (DHCP/Static). Choose the **IP Address Configuration** mode. The selected Ethernet configuration setting is stored in internal flash; it is used at later stage, when communication is initialized.

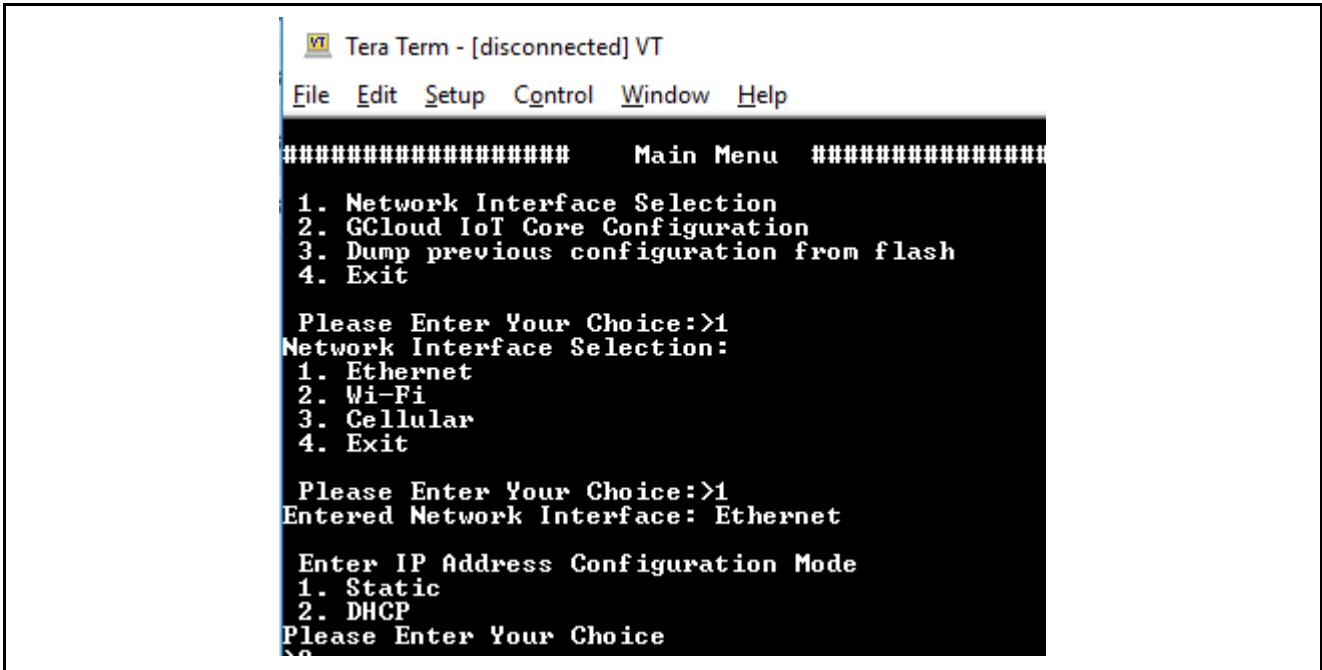


Figure 15. Ethernet Network Interface Configuration Menu

(2) Wi-Fi Network Interface Configuration

From the **Network Interface Selection** menu, press ‘2’ key to select the Wi-Fi Network Configuration.

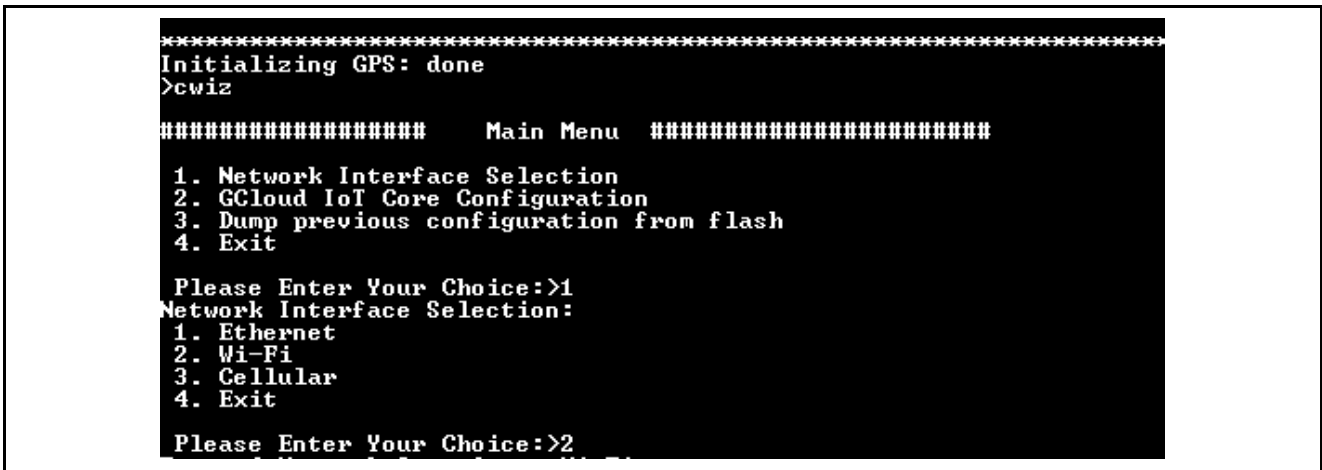


Figure 16. Wi-Fi Network Interface Configuration Menu

You are given the option to enter Wi-Fi Configuration settings, such as **SSID**, **Pass key**, **Security type** and **IP Address Configuration mode**.

The selected Wi-Fi configuration setting is stored in the internal flash to be used at a later stage, when the communication is initialized.

```
*****
Initializing GPS: done
>cwiz

##### Main Menu #####

1. Network Interface Selection
2. GCloud IoT Core Configuration
3. Dump previous configuration from flash
4. Exit

Please Enter Your Choice:>1
Network Interface Selection:
1. Ethernet
2. Wi-Fi
3. Cellular
4. Exit

Please Enter Your Choice:>2
Entered Network Interface: Wi-Fi

Wi-Fi Configuration
Enter the SSID associated with the Network
>rea-guestwifi
Enter the passphrase
>p!ay3@ck
Enter Security Type
1. WEP
2. WPA
3. WPA2
4. None
Please Enter Your Choice
>3
Entered Security Type: WPA2

Enter IP Address Configuration Mode
1. Static
2. DHCP
Please Enter Your Choice
>2
Entered IP Configuration Mode: DHCP
Network Configuration stored in flash
```

Figure 17. Wi-Fi Configuration

### (3) Cellular Network Interface Configuration

From the **Network Interface Selection** menu, press '3' key to select the Cellular Network Configuration. You will be given two choices as shown in the following figure.

- Option 1: Enter 1 in case of SIM provisioning. In this case, it is assumed that you already pre-configured the SIM card.
- Option 2: Enter 2 in case of SIM configuration. This option is ideal for users who wish to configure their brand-new SIM card using the AT shell interface.

```

*****
Initializing GPS: done
>cwiz

##### Main Menu #####

1. Network Interface Selection
2. GCloud IoT Core Configuration
3. Dump previous configuration from flash
4. Exit

Please Enter Your Choice:>1
Network Interface Selection:
1. Ethernet
2. Wi-Fi
3. Cellular
4. Exit

Please Enter Your Choice:>3
Entered Network Interface: Cellular

##### Cellular Modem Config Menu #####

1. Start Provisioning
2. Start SIM configuration

Enter Your Choice: 1
    
```

Figure 18. Cellular Configuration

**(a) Start Provisioning Option**

In the **cellular modem configuration menu**, choose **option 1** to enter the Start provisioning sub-menu as shown below.

```

VT COM24 - Tera Term VT
File Edit Setup Control Window Help

3. Cellular
4. Exit

Please Enter Your Choice:>3
Entered Network Interface: Cellular

##### Cellular Modem Config Menu #####

1. Start Provisioning
2. Start SIM configuration

Enter Your Choice: 1
Cellular Provisioning
Enter the APN associated with the Cellular Provider
>m2m.com.attz
Enter Context ID: Valid range is 1 to 5.
>1
Enter PDP Type
1. IP
2. IPU4U6
Please enter your choice
>1
Entered PDP Type: IP
    
```

Figure 19. Cellular Modem Provisioning Menu

You are given the option to enter Cellular Configuration settings, such as **APN**, **Context ID**, **PDP type**.

The selected Cellular configuration setting is stored in the internal flash to be used at a later stage, when the communication is initialized.

**(b) Start SIM Configuration Option**

In the **Cellular modem configuration menu**, choose option **2** to enter the Start SIM Configuration submenu as shown in the following figure.

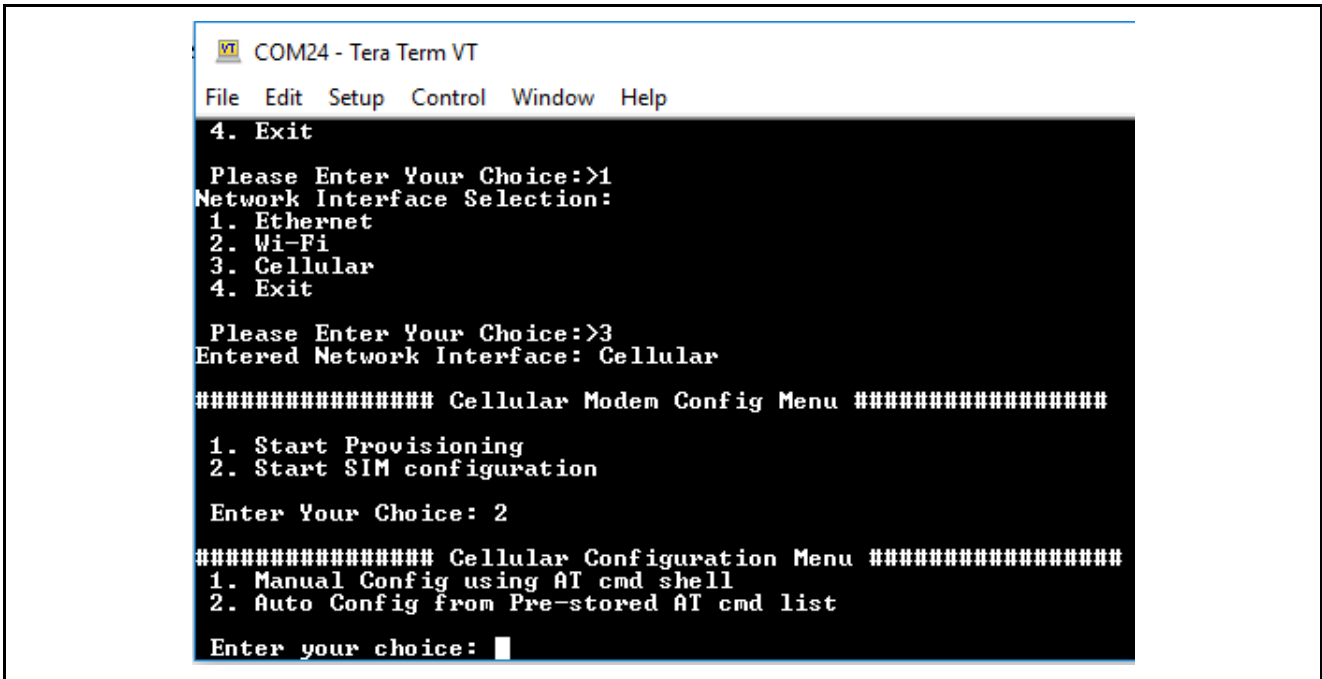


Figure 20. Cellular Configuration Menu

You can either choose **Option 1** to enter the Manual Configuration mode using AT command shell or choose **Option 2** to enter Auto Configuration from pre-stored AT command list. You generate this list at the end of previous Manual configuration.

Note: It will take few seconds to enter the Cellular Configuration menu since the firmware is opening the cellular framework instance in the background.

**Manual Configuration using AT Command Shell**

In case of **Option 1**, enter the AT command shell as shown in the following figure. You can experiment with various AT commands to configure the SIM cards.

Refer to the following knowledge base article provided by Renesas as a baseline to provisioning the SIM card using the BG96 Cellular modem:

<https://en-support.renesas.com/knowledgeBase/18027787>

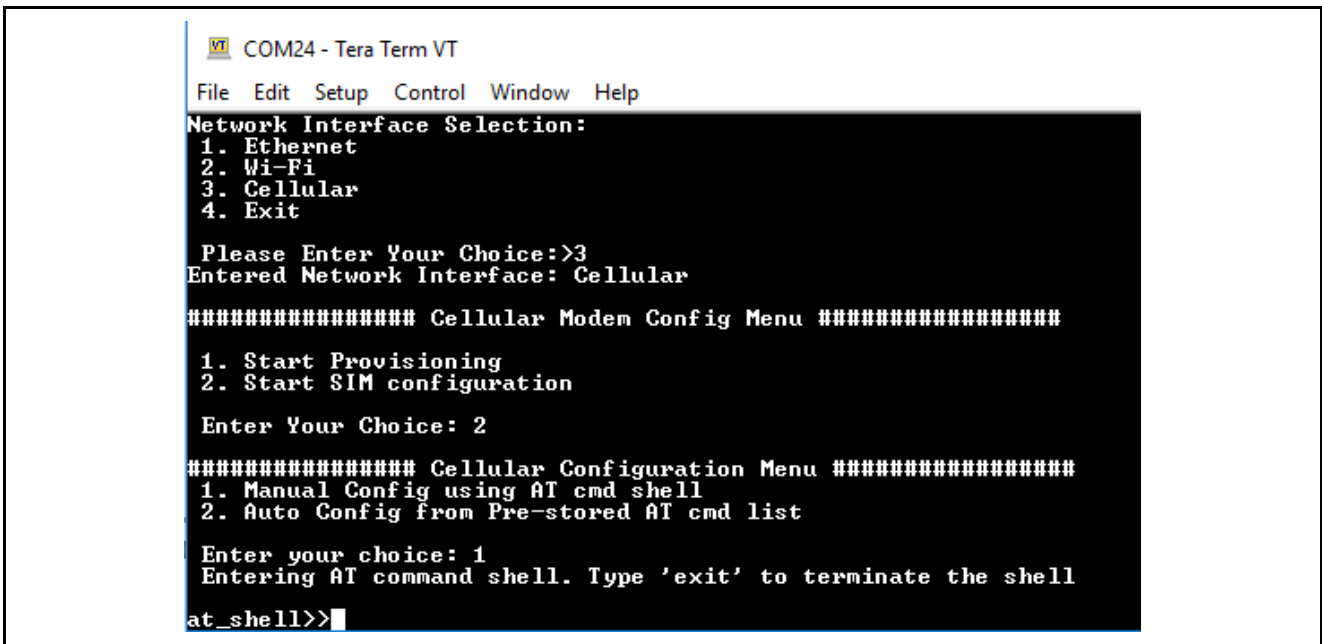


Figure 21. AT Command Shell

To exit the AT command shell, enter the command “**exit** or **EXIT**”. You will be asked whether you want to save the AT command as shown in the following figure.

```

VT COM24 - Tera Term VT
File Edit Setup Control Window Help
1. Ethernet
2. Wi-Fi
3. Cellular
4. Exit

Please Enter Your Choice:>3
Entered Network Interface: Cellular

##### Cellular Modem Config Menu #####
1. Start Provisioning
2. Start SIM configuration

Enter Your Choice: 2

##### Cellular Configuration Menu #####
1. Manual Config using AT cmd shell
2. Auto Config from Pre-stored AT cmd list

Enter your choice: 1
Entering AT command shell. Type 'exit' to terminate the shell
at_shell>>exit
Do you wish to store the AT commands for your carrier? [Y/N]: █
    
```

If you choose to save the AT commands, which can be used later to auto configure the new SIM cards, enter ‘Y’. In that case, you will be asked to enter the AT command details as shown in the following figure.

```

VT COM24 - Tera Term VT
File Edit Setup Control Window Help
2. Auto Config from Pre-stored AT cmd list

Enter your choice: 1
Entering AT command shell. Type 'exit' to terminate the shell
at_shell>>exit
Do you wish to store the AT commands for your carrier? [Y/N]: Y
***** Start Inserting AT Commands. Type exit to terminate!!! *****

AT Command: AT
Response <case sensitive>: OK
Response Wait time in MilliSeconds: 300
Retry Count: 5
Retry Delay in milli-seconds : 500

#####
AT Command: AT
Response string: OK
Response Wait time: 300
Retry Count: 5
Retry Delay: 500

#####
Do you Want to save this AT Command ? [y/n]: █
    
```

### Auto Configuration from Pre-stored AT Command List

From the Cellular Configuration menu, choose **option 2** to enter **Auto configuration from pre-stored AT command list menu** as shown in the following figure.

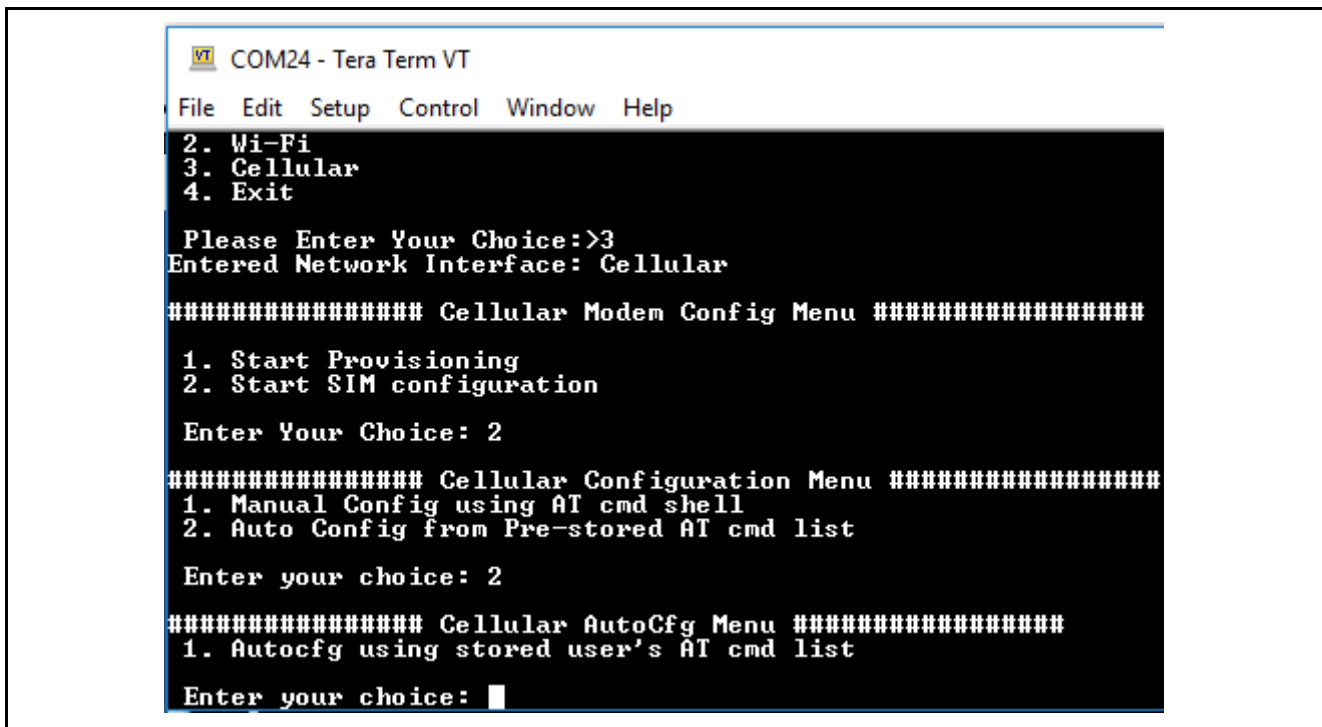


Figure 22. Auto configuration from pre-stored AT command list

The pre-stored AT commands will be sent to the cellular modem and their responses will be displayed in the console window.

#### 4.4.1.2 Google IoT Core Configuration

At this stage, it is assumed that you followed the instructions mentioned in Section 3.3 to create a device in Google Cloud Platform. If not, complete the steps mentioned in section 3.3 before proceeding.

From the **Main Menu**, press '2' and the **Enter** key to configure the Google Cloud IoT Core service as shown in the following figure.

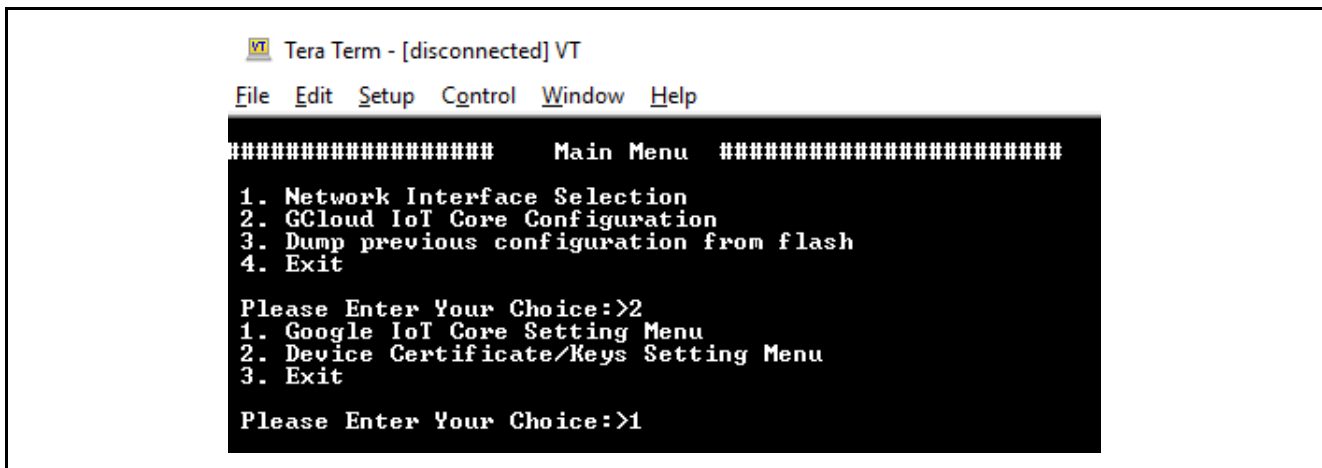


Figure 23. Google IoT Core Configuration Menu

##### (1) Google IoT Core Setting Menu

From the **Google IoT Core configuration menu**, press '1' and the **Enter** key to configure the Google IoT Core settings. In the Google IoT core configuration menu, you have the option to enter the following information as listed in the following window.

```
VT Tera Term - [disconnected] VT
File Edit Setup Control Window Help
##### Main Menu #####
1. Network Interface Selection
2. GCloud IoT Core Configuration
3. Dump previous configuration from flash
4. Exit
Please Enter Your Choice:>2
1. Google IoT Core Setting Menu
2. Device Certificate/Keys Setting Menu
3. Exit
Please Enter Your Choice:>1
##### Google Cloud Settings Menu #####
1. Enter Project Id:
2. Enter Endpoint information:
3. Enter Device Id:
4. Enter Cloud Region:
5. Enter Registry Id:
6. Exit
Please Enter Your Choice:>1
```

Note: In case of option 2 (Enter Endpoint Information), enter “[mqtt.googleapis.com](https://mqtt.googleapis.com)”

## (2) Device Certificate/Keys Setting Menu

From the **Google IoT Core configuration** menu, press ‘2’ and the **Enter** key to configure the Device Certificate/Keys settings.

In the **Device Certificate/Keys settings** menu, you have the option of entering the root CA, device certificates, and device private key in .pem format.

Open these certificates in a text editor, then copy and paste them in the serial console. Press **Enter**.

The root CA certificate (`gcloud_rootCA.pem`) for Google Cloud is enclosed as part of the package.



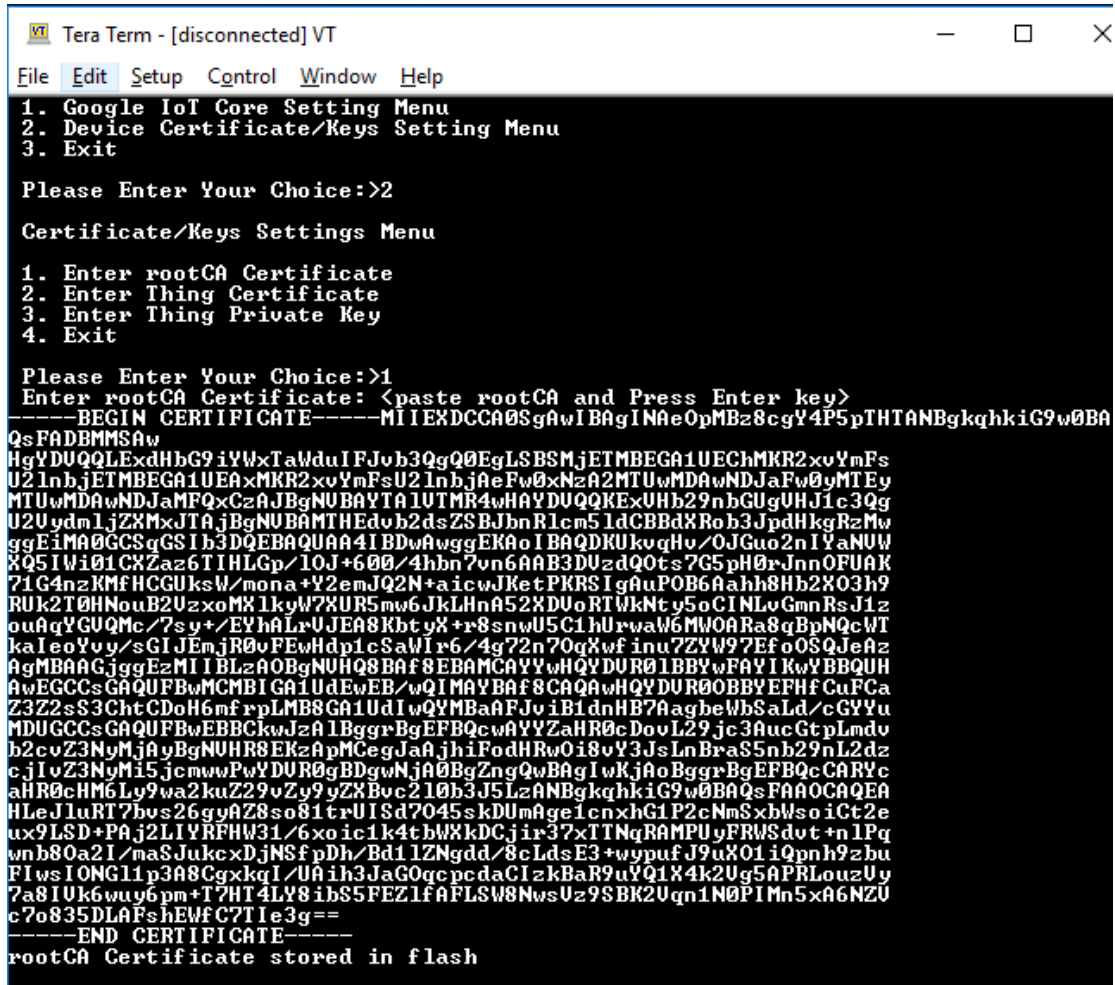


Figure 24. Certificates/Keys Setting Menu

The selected configuration setting is stored in the internal flash; it is used at later stage during the Google IoT Core connection.

#### 4.4.2 Dump the Previous Configuration

From the **Main Menu**, choose **option 3** to display the pre-selected network, the Google Cloud IoT core Service Configuration options you made from the internal flash, as shown in the following figure.

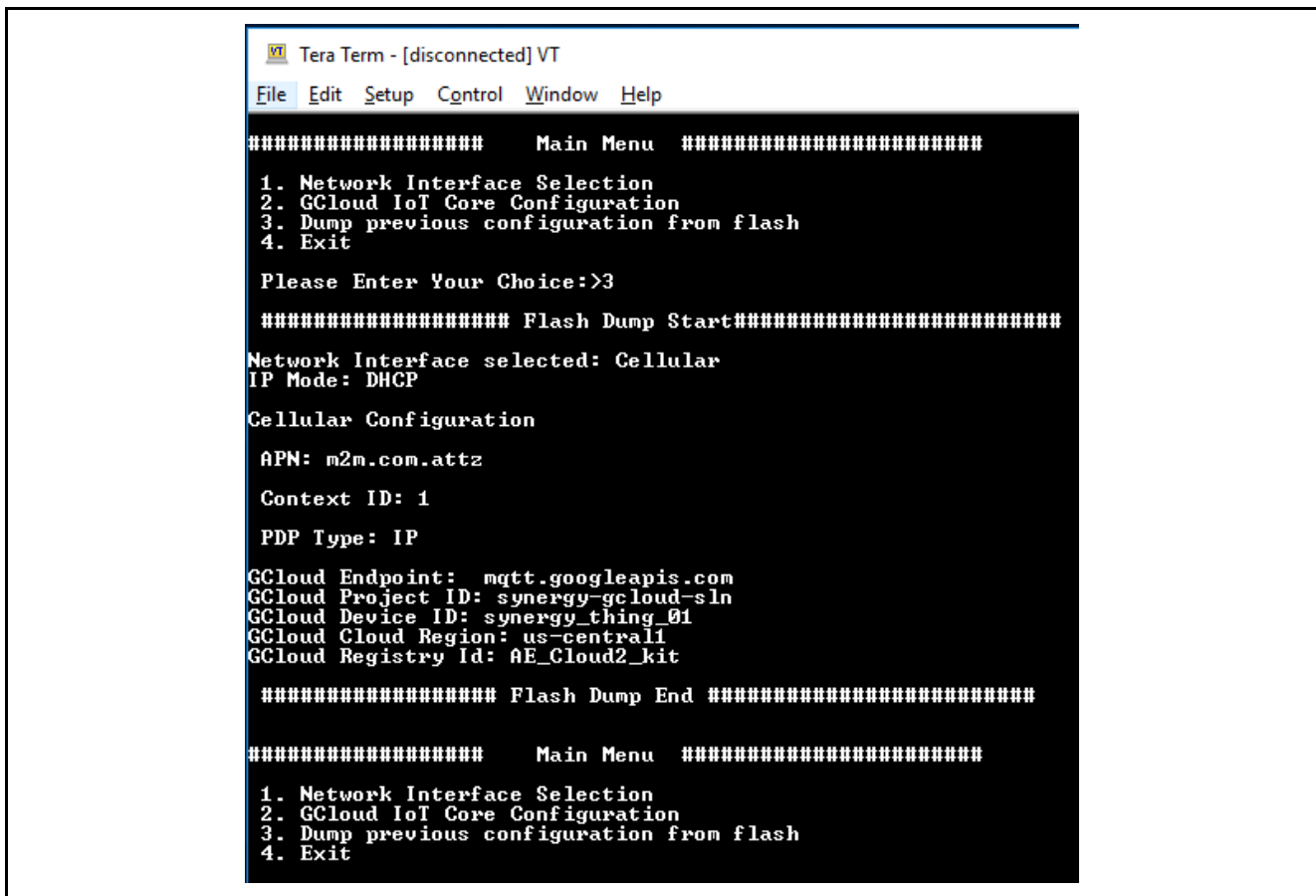


Figure 25. Dump Configuration Menu

### 4.4.3 Demo Start/Stop Command

From the CLI console, enter `demo start` command to start the Synergy Cloud Connectivity Application Demonstration.



Figure 26. Help Menu

The application framework reads your pre-configured selection options for the network interface, the IoT Service from the internal flash, and checks for its validity. If the content is valid, it then initializes the network interface and establishes a MQTT connection with the Google IoT Core.

This application wakes up periodically (every 5 seconds) and checks for your input event flag state. The flag state is set once you have entered the `demo start/stop` command on the CLI. This application performs the following functions periodically until you enter the `demo stop` command:

1. Initializes communication interface (Ethernet, Wi-Fi, or Cellular).
2. Initializes IoT Cloud interface.
3. Reads sensor data and publishes them periodically on MQTT topics.
4. Updates your LED state based on the type of MQTT message received.

If the `demo stop` command is issued, it de-initializes the IoT Cloud interface, which in turn stops MQTT messages from publishing and clears any pending MQTT messages from its internal queue.

## 4.5 Verifying the Demo

Use the following instructions to verify the functionality of this Synergy Cloud Connectivity Application Project.

Note: It is assumed you completed the instructions in section 3.3 to create a Google Cloud IoT account, set up your device on Google Cloud IoT Core, created the device certificates and keys, and compiled and downloaded the application project to the PK-S5D9/AE-CLOUD1/AE-CLOUD2 kit.

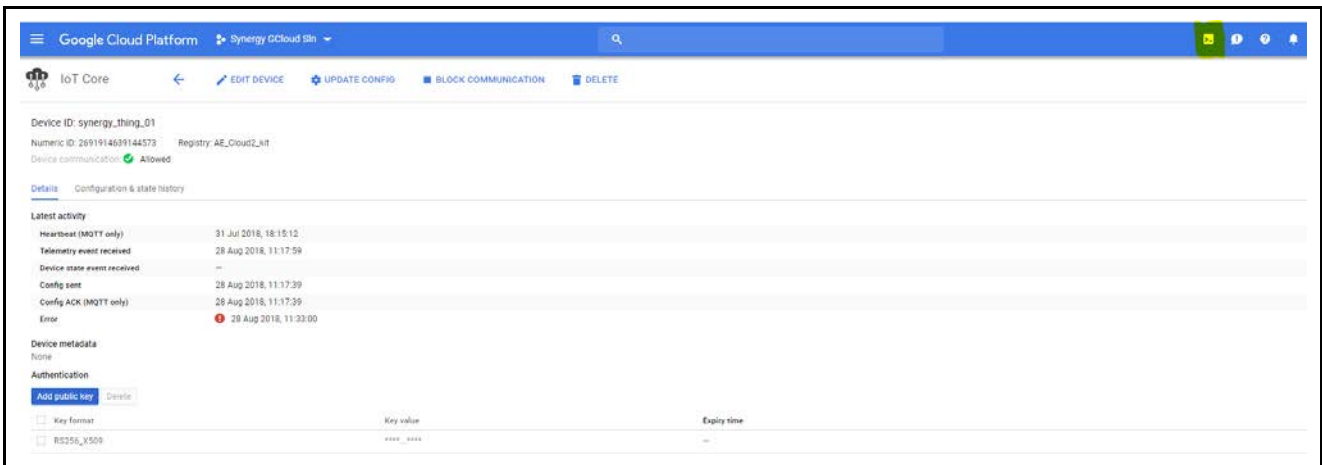
### 4.5.1 Running the Synergy Cloud Connectivity Demonstration

Run this application demonstration using the `demo start` command from the serial console.

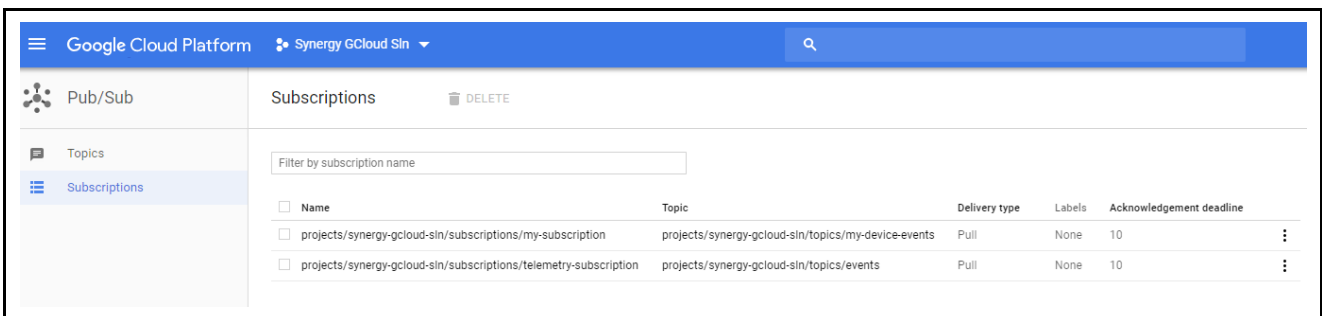
Once you run `demo start`, it begins to configure the network interface, establishes a connection with Google Cloud IoT Core, and starts publishing sensor data periodically (every 5 seconds).

### 4.5.2 Monitoring MQTT Messages on Google Cloud Platform

Once the demo is running, sensor data is periodically published to the Google Cloud IoT Core. To view the data published, open the Google Cloud shell by clicking **Activate Cloud shell** button as highlighted in the following graphic.

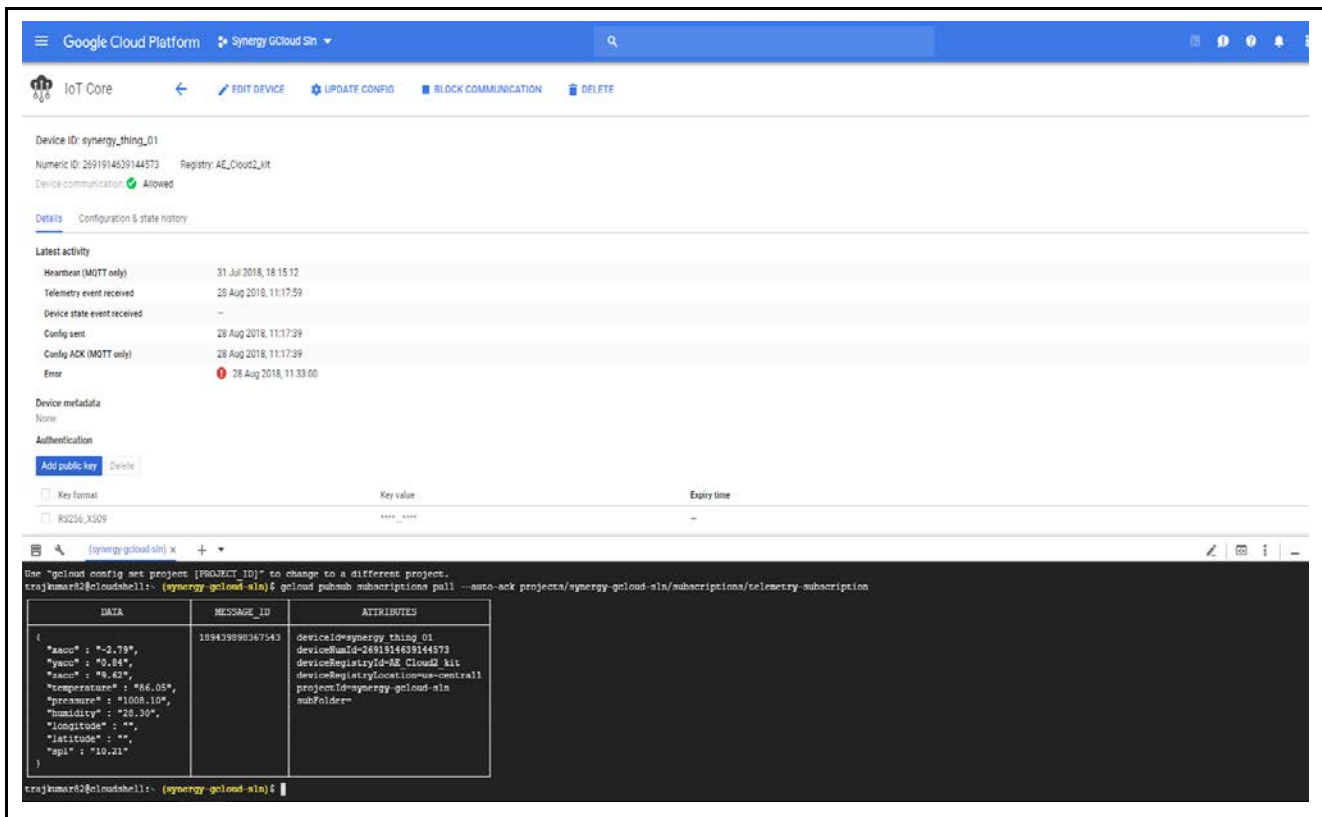


Now, find out the subscription name created for your topic. It can be found in the Pub/Sub page under Subscriptions as shown in the following graphic.



Once the shell is activated, enter the following commands to pull the published telemetry data to the MQTT topic.

```
gcloud pubsub subscriptions pull --limit 100 --auto-ack <subscription name of your publish topic>
```



### 4.5.3 Publishing the MQTT Message from Google Cloud Platform

You can publish the MQTT message to turn ON/OFF your LEDs on the PK-S5D9/AE-CLOUD1/AE-CLOUD2 kit by using the following table that shows messages for various LED states.

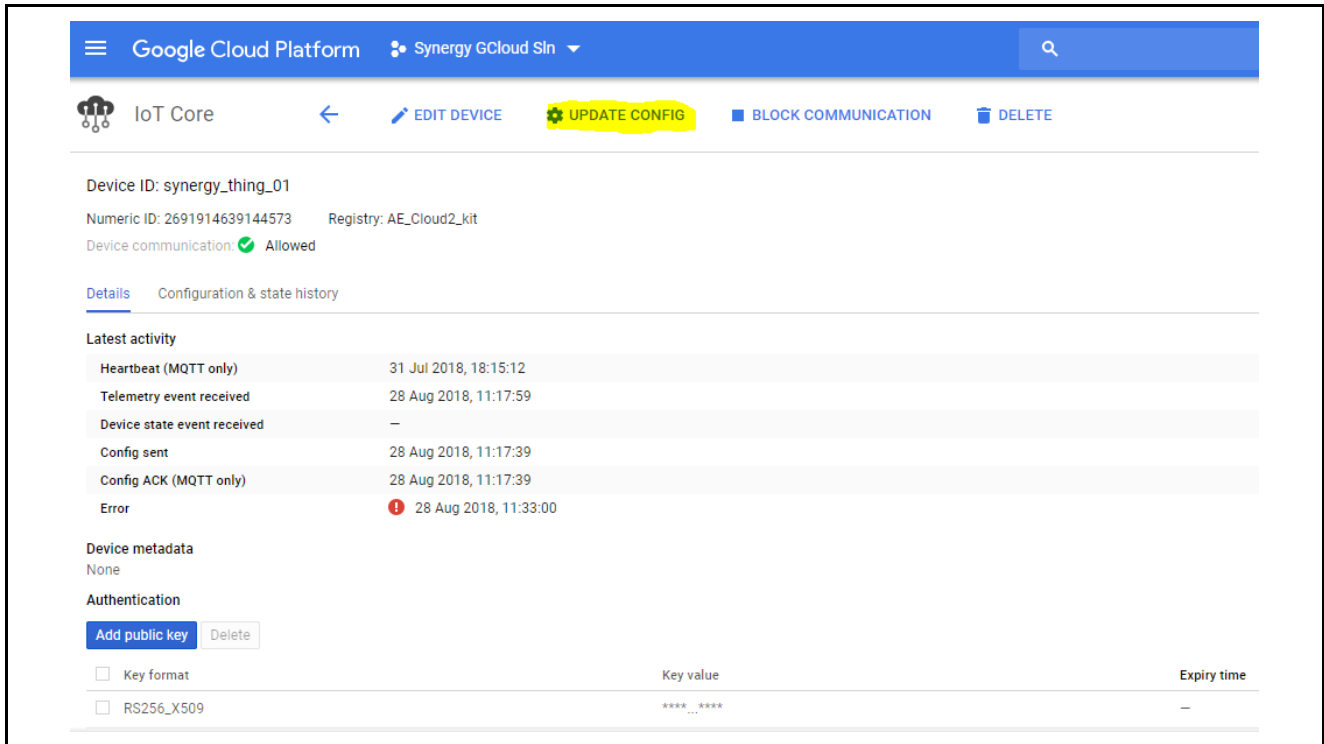
Note: The Message under Message Column are **case sensitive**, users need to take care of this while using them to turn ON/OFF the LEDs.

**Table 2. Turning the User LED ON/OFF on your PK-S5D9/AE-CLOUD1/AE-CLOUD2 kit**

LED State	Message
RED LED ON	<code>{"state":{"desired":{"Red_LED":"ON"}}</code>
RED LED OFF	<code>{"state":{"desired":{"Red_LED":"OFF"}}</code>
YELLOW LED ON	<code>{"state":{"desired":{"Yellow_LED":"ON"}}</code>
YELLOW LED OFF	<code>{"state":{"desired":{"Yellow_LED":"OFF"}}</code>
GREEN LED ON	<code>{"state":{"desired":{"Green_LED":"ON"}}</code>
GREEN LED OFF	<code>{"state":{"desired":{"Green_LED":"OFF"}}</code>

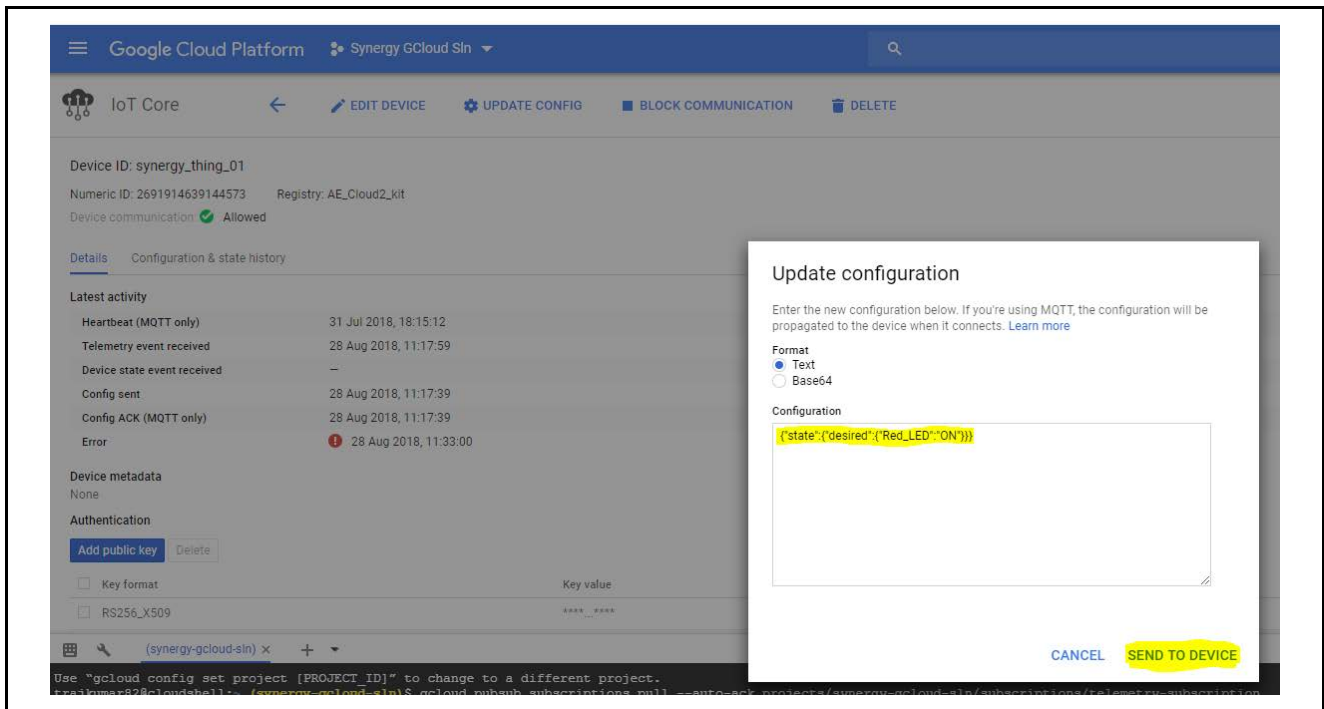
To publish the message, use the following steps:

1. Go to the IoT Core page.
2. The registry you created will be listed in the IoT Core page. Locate the registry from the list and enter the corresponding registry details page.
3. The device added under this registry will be listed. Locate the device from the list and enter the corresponding device page.
4. Click the **UPDATE CONFIG** button in the device page as shown in the following figure.



A pop-up window appears as shown in the following figure. Choose the **Message format** as Text and paste the message that need to be send to the MQTT device.

Click the **SEND TO DEVICE** button to send the message to the MQTT device. On the AE-CLOUD2/AE-CLOUD1/PK-S5D9 kit, once the message is received, the corresponding user LED toggles.



#### 4.5.4 Stopping the Synergy Cloud Connectivity Demonstration

To stop the demonstration, enter the `demo stop` command. Issuing this command de-initializes the IoT Cloud interface, stops it from publishing MQTT messages, and clears any pending MQTT messages from its internal queue.

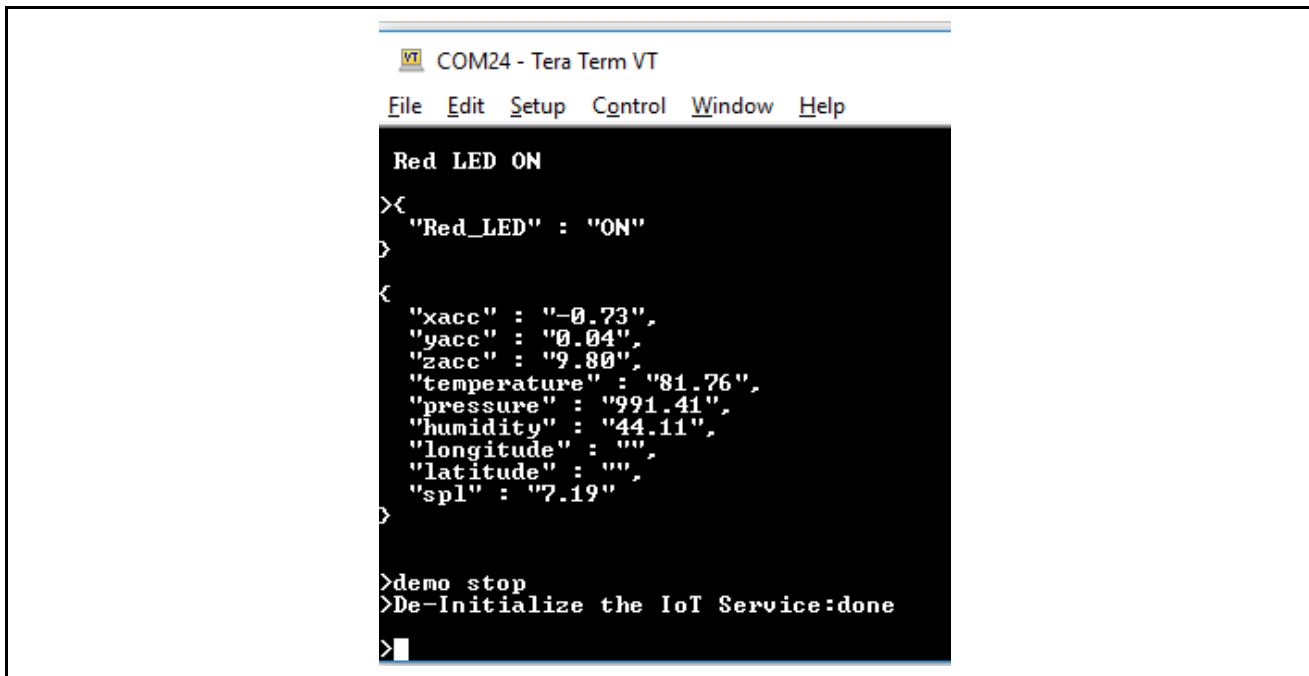


Figure 27. Application Demo Stop Sequence

### 5. Next Steps

Visit [www.renesas.com/synergy/tools](http://www.renesas.com/synergy/tools) to learn more about development tools & utilities.

Visit [www.renesas.com/synergy/gallery](http://www.renesas.com/synergy/gallery) to download development tools & utilities.

Renesas Synergy Module Guides collateral link: [www.renesas.com/synergy/applicationprojects](http://www.renesas.com/synergy/applicationprojects)

### 6. MQTT/TLS Reference

- SSP 1.5.3 User Manual can be downloaded from the Renesas Synergy™ Gallery ([www.renesas.com/synergy/ssp](http://www.renesas.com/synergy/ssp))
- Google Cloud IoT Core documentation (<https://cloud.google.com/iot/docs/?authuser=0>)

### 7. Known Issues and Limitations

If a user running this demo using Ethernet connection in some corporate network tries to stop the demo using `demo stop` command and then restart the demo using `demo start` command, the demo fails to reconnect to the Google Cloud IoT MQTT broker.

## Website and Support

Visit the following vanity URLs to learn about key elements of the Synergy Platform, download components and related documentation, and get support.

Synergy Software	<a href="http://www.renesas.com/synergy/software">www.renesas.com/synergy/software</a>
Synergy Software Package	<a href="http://www.renesas.com/synergy/ssp">www.renesas.com/synergy/ssp</a>
Software add-ons	<a href="http://www.renesas.com/synergy/addons">www.renesas.com/synergy/addons</a>
Software glossary	<a href="http://www.renesas.com/synergy/softwareglossary">www.renesas.com/synergy/softwareglossary</a>
Development tools	<a href="http://www.renesas.com/synergy/tools">www.renesas.com/synergy/tools</a>
Synergy Hardware	<a href="http://www.renesas.com/synergy/hardware">www.renesas.com/synergy/hardware</a>
Microcontrollers	<a href="http://www.renesas.com/synergy/mcus">www.renesas.com/synergy/mcus</a>
MCU glossary	<a href="http://www.renesas.com/synergy/mcuglossary">www.renesas.com/synergy/mcuglossary</a>
Parametric search	<a href="http://www.renesas.com/synergy/parametric">www.renesas.com/synergy/parametric</a>
Kits	<a href="http://www.renesas.com/synergy/kits">www.renesas.com/synergy/kits</a>
Synergy Solutions Gallery	<a href="http://www.renesas.com/synergy/solutionsgallery">www.renesas.com/synergy/solutionsgallery</a>
Partner projects	<a href="http://www.renesas.com/synergy/partnerprojects">www.renesas.com/synergy/partnerprojects</a>
Application projects	<a href="http://www.renesas.com/synergy/applicationprojects">www.renesas.com/synergy/applicationprojects</a>
Self-service support resources:	
Documentation	<a href="http://www.renesas.com/synergy/docs">www.renesas.com/synergy/docs</a>
Knowledgebase	<a href="http://www.renesas.com/synergy/knowledgebase">www.renesas.com/synergy/knowledgebase</a>
Forums	<a href="http://www.renesas.com/synergy/forum">www.renesas.com/synergy/forum</a>
Training	<a href="http://www.renesas.com/synergy/training">www.renesas.com/synergy/training</a>
Videos	<a href="http://www.renesas.com/synergy/videos">www.renesas.com/synergy/videos</a>
Chat and web ticket	<a href="http://www.renesas.com/synergy/resourcelibrary">www.renesas.com/synergy/resourcelibrary</a>

### Revision History

Rev.	Date	Description	
		Page	Summary
1.00	Sep.24.18	—	Initial version
1.01	Feb.04.19	—	Updated links and section 4, Running the MQTT/TLS Application.
1.02	Apr.03.19	—	Fixed Cellular at command shell bug.



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