RX65N Group

Visualizing and Controlling Sensor Information Using Amazon Web Services with RX65N Cloud Kit and FreeRTOS

Introduction

This document describes a system that uses the RX65N Cloud Kit board from Renesas. This system incorporates the RX65N running Amazon FreeRTOS and via a Wi-Fi connection visualizes (light) sensor information on Amazon Web Services (AWS) and controls LEDs on the board using the AWS shadow service.

Amazon FreeRTOS is a realtime operating system that enhances the FreeRTOS kernel with functionality for connections, security, and over-the-air (OTA) updates. It includes demo applications for demonstrating the functionality of Amazon FreeRTOS.

e^2 studio is a development environment based on the open-source Eclipse CDT (C/C++ Development Tooling) project. In addition to a debugging interface, it provides support for building projects (editor, compiler, linker control). It also supports integration of Amazon FreeRTOS demo applications, enabling them to run on Renesas evaluation boards.

Note: The Amazon Elasticsearch service is scheduled to be renamed the Amazon OpenSearch service, but the name Amazon Elasticsearch service is used in the descriptions in this document.

Purpose of This Document

This document explains in an easy-to-understand manner the procedure for connecting and controlling AWS using an Amazon FreeRTOS demo application (from connecting to AWS to running the demo).

Operating Environment

Operation on the following environment has been confirmed.

Integrated development environment	e^2 studio 2021-04
Board	RX65N Cloud Kit
Toolchain	CC-RX Compiler v3.03
	GCC for Renesas RX 8.3.0.202004
Emulator	E2 emulator Lite (on-board)

Visit the following webpage for information on boards, related programs, and development environments needed for development work using RX cloud solutions.

https://www.renesas.com/rx-cloud

Related Document

RX Family Troubleshooting when Using Amazon Web Services (R20AN0624)

Contents

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1. Terms

Terms used in this document are explained below.

Table 1.1 Terms

Term	Meaning
AWS	Amazon Web Service
shadow	Used to store and retrieve information on the current status of a device.
Amazon Elastic Service	A managed service for deploying, manipulating, and scaling AWS clusters in the Elasticsearch cloud.

2. Preparation

This document describes the process from importing the project to running the demo using RX65N Cloud Kit.

2.1 Hardware Configuration

The hardware configuration of the demo project is listed in the table below.

Table 2.1 Hardware Configuration

Item	Content	Provider	Description
Board used (packaged with RX65N Cloud Kit)	Target board for RX65N	Renesas Electronics Corporation	Evaluation board mounted with RX65N MCU*1
	RX cloud option board		Cloud communication evaluation board capable of connecting to AWS*1
	Silex Pmod module		Communication board mounted with wireless LAN module*1
Wi-Fi	Wireless router	—	Wireless LAN standard: IEEE 802.11b/g/n (2.4 GHz) Encryption method: ES
PC	Windows 10	—	Recommended OS
	Google Chrome	—	Web browser used

Note: 1. The target board for RX65N, RX65N cloud option board, and Silex Pmod module are included in RX65N Cloud Kit.

2.2 Software Configuration

The software configuration of the demo project is listed in the table below.

Table 2.2 Software Configuration

Item	Content	Version
Integrated development environment	e^2 studio	2021-04
Compiler	CC-RX	V3.03
	GCC for Renesas RX	8.3.0.202004
Communication software	Tera Term	Version 4.71
Emulator	E2 emulator Lite (on-board)	—

To secure sufficient heap area for the application, change the value of the BSP_CFG_HEAP_BYTES macro in r_bsp_config.h from 0x400 to 0x1000.

2.3 Tera Term Settings

The Tera Term settings for the demo project are listed in the table below.

Table 2.3 Tera Term Settings

Item	Setting
Baud rate	115,200
Data length	8 bits
Parity	none
Stop bits	1 bit
Flow control	none

3. System Diagram

The system diagram below shows the steps from the acquisition of light sensor information to visualization, and the use of the shadow service to control RX65N Cloud Kit.

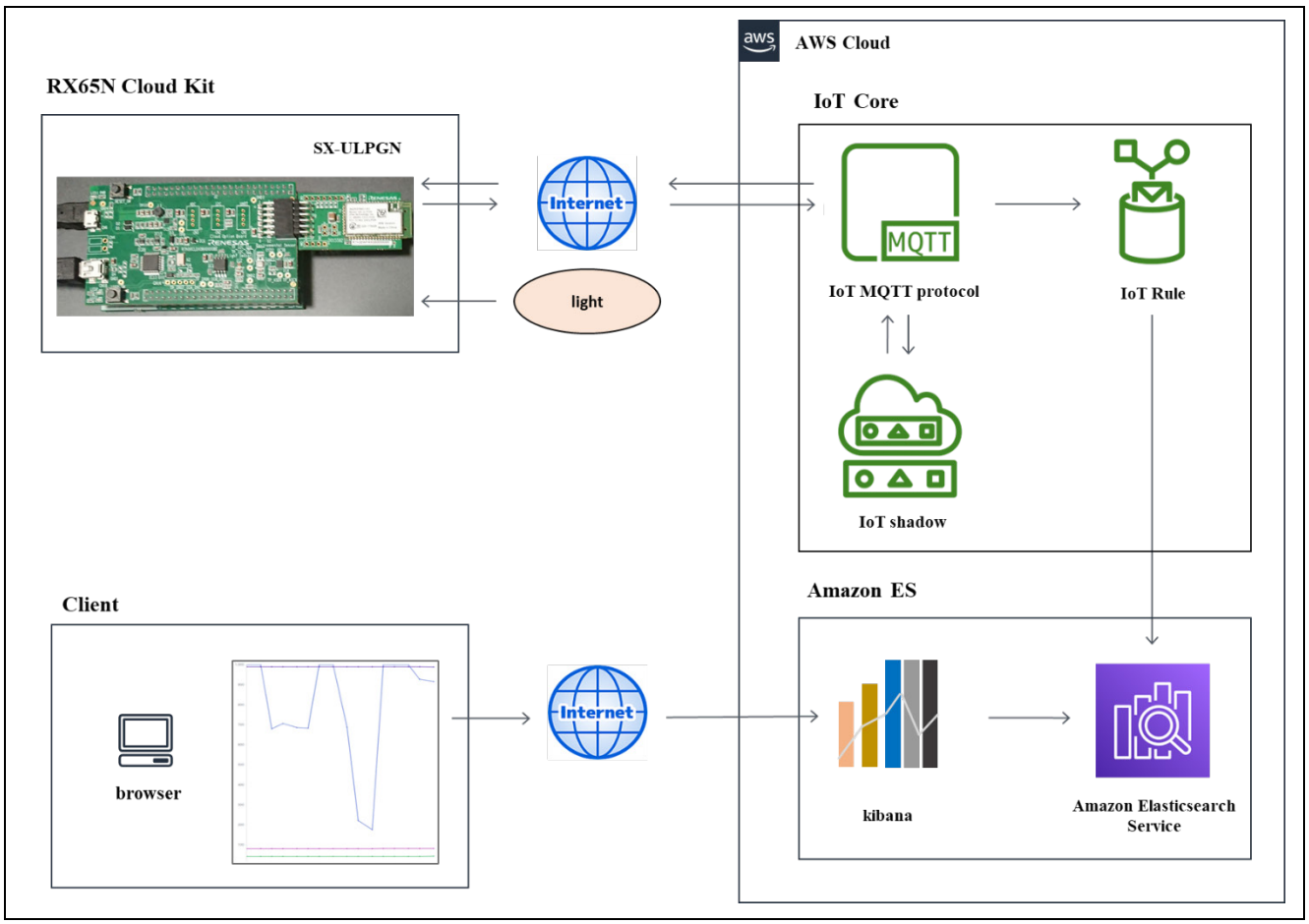

Figure 3.1 System Diagram of Steps from Acquisition of Sensor Information to Visualization

4. Connecting to AWS

The following preparation is necessary in order to connect RX65N Cloud Kit to AWS.

4.1 AWS Preparation

Refer to the tutorial below and make AWS settings.

Register device to AWS IoT

Link: https://github.com/renesas/amazon-freertos/wiki/Register-device-to-AWS-IoT

Note: Complete the steps up to “Check AWS IoT endpoints.”

4.2 Hardware Preparation

Follow the steps below to prepare the hardware for the demo program.

1. Remove the jumper from the EJ2 pins on the target board (bottom board).
2. Connect the ECN1 connector on the target board (bottom board) to the PC via a USB cable.
3. Connect the CN18 connector on the cloud option board (top board) to the PC via a USB cable.

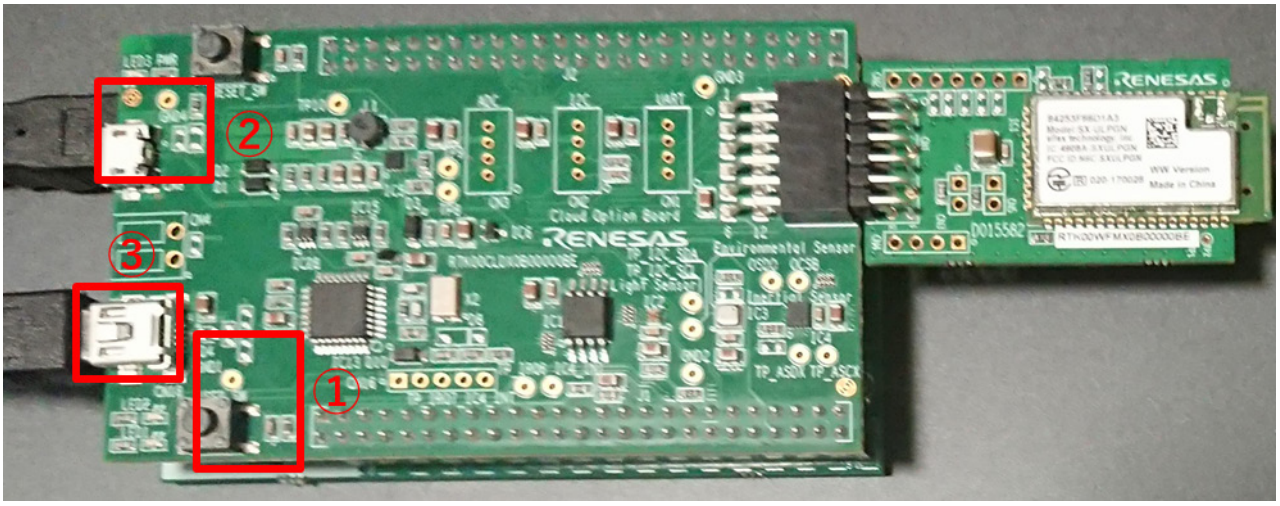

Figure 4.1 RX65N Cloud Kit (Top)

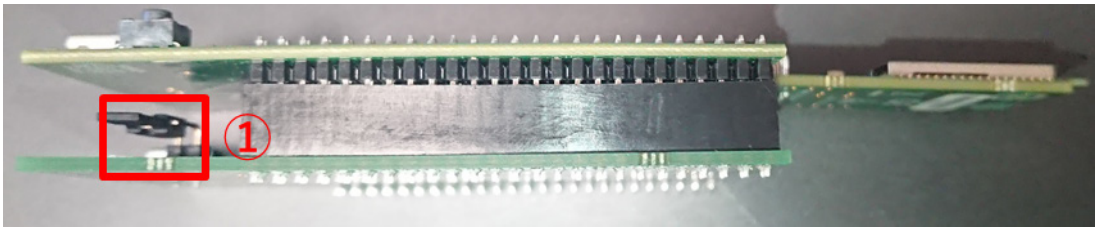

Figure 4.2 RX65N Cloud Kit (Bottom)

4.3 Software Preparation

Follow the steps below to prepare the software for the demo program.

1. Extract the project files from the archive and copy them to a suitable location. (In the description below, the root folder containing the project files is designated as ${base_folder}.)

   Note: After extracting the project files from the archive, copy them to a location with a short file path, such as the root folder on the C: drive. If the file path is too long, a build error may result.

2. Launch e² studio and specify a workspace directory.

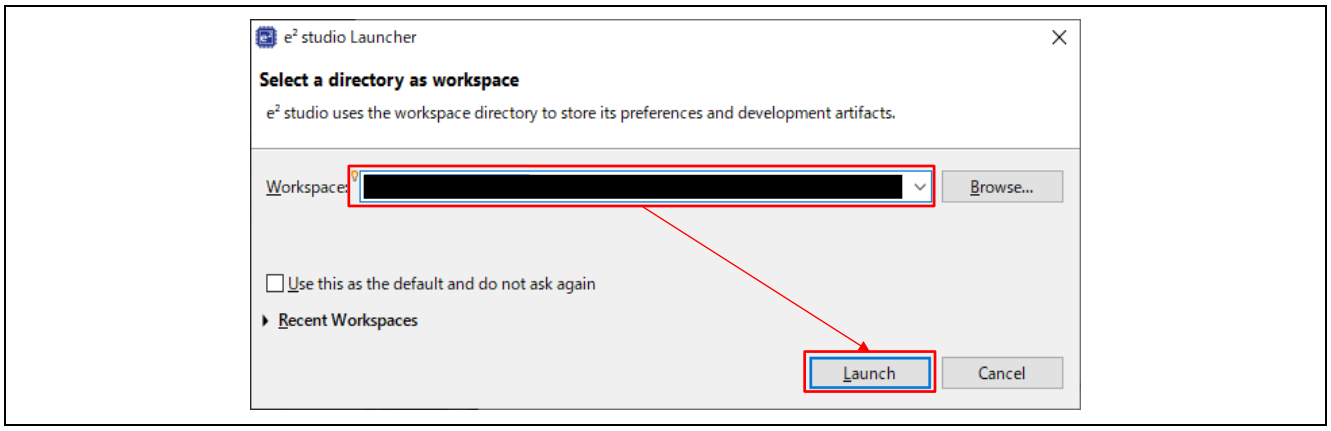

Figure 4.3 Workspace Selection Menu

3. Select **File** → **Import…**.

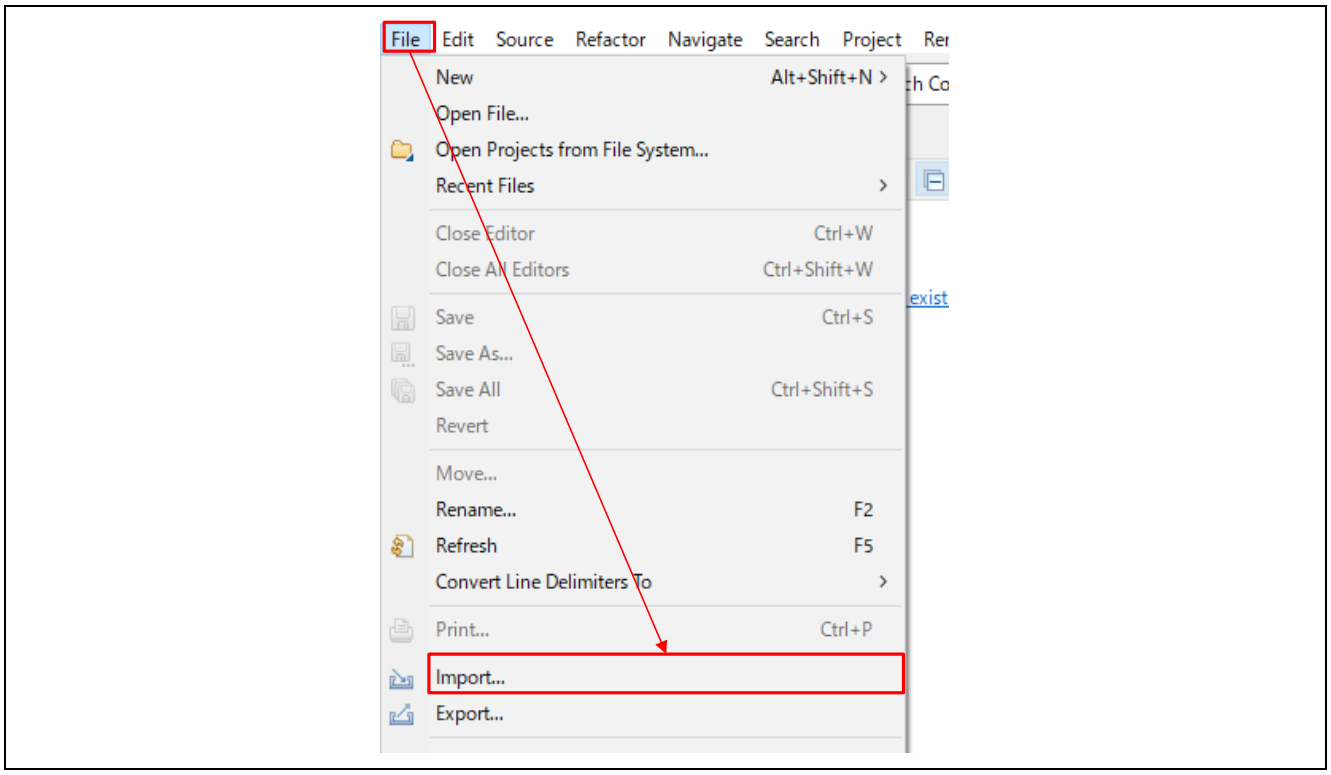

Figure 4.4 File → Import…

4. Click **General** → **Existing Projects into Workspace** → **Next >**.

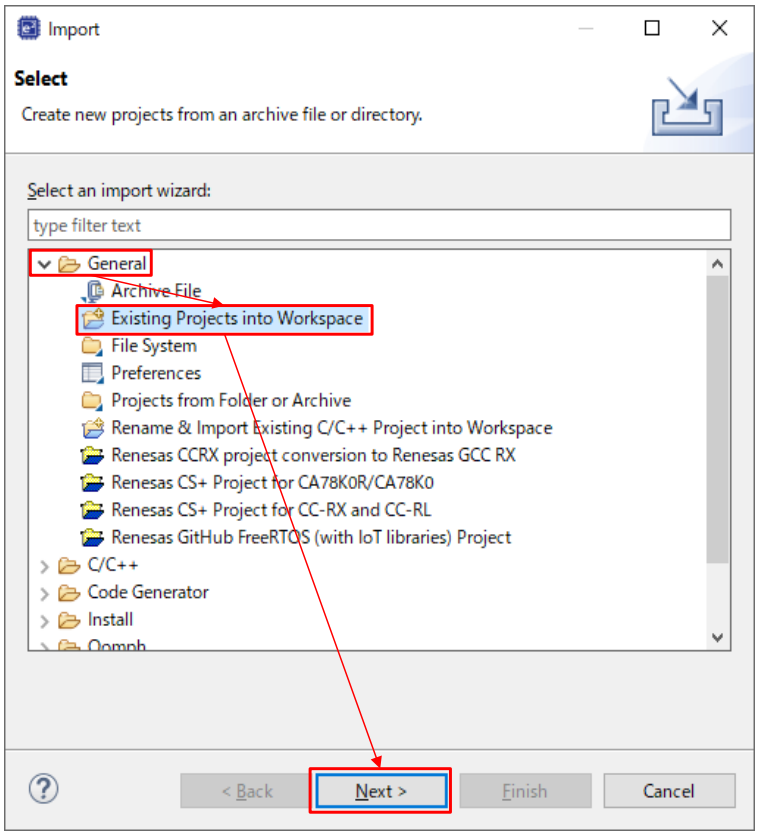

Figure 4.5 General → Existing Projects into Workspace → Next >

5. Click **Browse…**, then specify the root directory as follows.
   — ${base_folder}\projects\renesas\rx65n-cloud-kit-uart-sx-ulpgn\e2studio\aws_demos
   (When using CC-RX as the compiler)
   — ${base_folder}\projects\renesas\rx65n-cloud-kit-uart-sx-ulpgn\e2studio-gcc\aws_demos
   (When using GCC for Renesas RX as the compiler)
   Finally, click **Finish**.

   Note: Make sure **Copy projects into workspace** is unchecked.

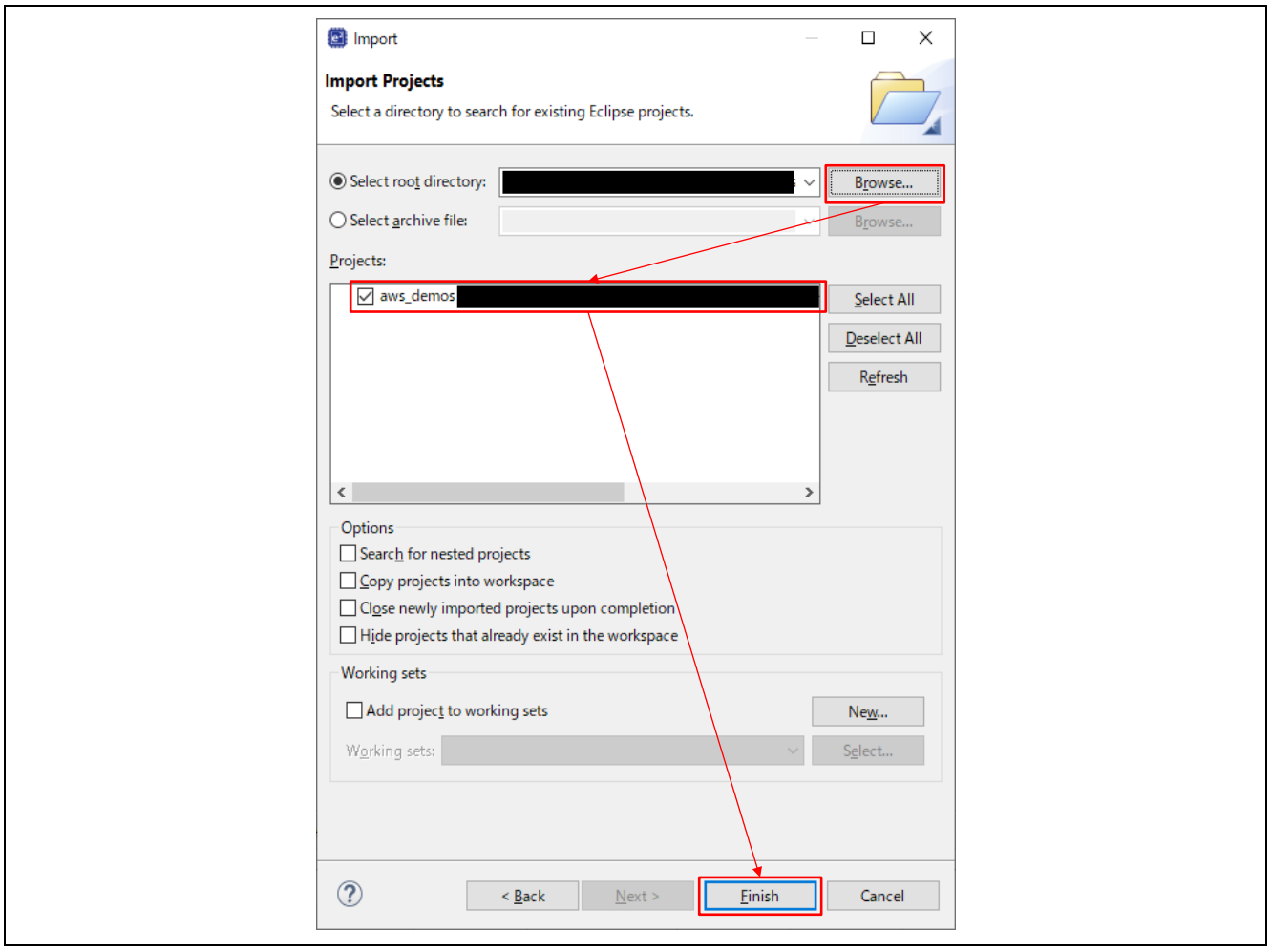

Figure 4.6 General → Existing Projects into Workspace → Next >

6. Define the following four macros in ${base_folder}\demos\include\aws_clientcredential.h.
   - clientcredentialMQTT_BROKER_ENDPOINT
     → The name of the endpoint confirmed as described in 4.1, AWS Preparation.
   - clientcredentialIOT_THING_NAME
     → The name of the thing registered as described in 4.1, AWS Preparation.
   - clientcredentialWIFI_SSID (when using Wi-Fi)
     → The SSID of the access point to connect to.
   - clientcredentialWIFI_PASSWORD (when using Wi-Fi)
     → The password of the access point to connect to.

   (Makes sure to enclose the above macro definitions in quotes (" ") as shown in the figure below.

   Note: The Wi-Fi encryption standard listed in 2.1, Hardware Configuration, is the default. To use a different encryption standard you will need to define clientcredentialWIFI_SECURITY as well.

```
/*
 * @brief MQTT Broker endpoint.
 *
 * @todo Set this to the fully-qualified DNS name of your MQTT broker.
 */
#define clientcredentialMQTT_BROKER_ENDPOINT          "[redacted]"

/*
 * @brief Host name.
 *
 * @todo Set this to the unique name of your IoT Thing.
 */
#define clientcredentialIOT_THING_NAME                "[redacted]"

/*
 * @brief Port number the MQTT broker is using.
 */
#define clientcredentialMQTT_BROKER_PORT              8883

/*
 * @brief Port number the Green Grass Discovery use for JSON retrieval from cloud is using.
 */
#define clientcredentialGREENGRASS_DISCOVERY_PORT     8443

/*
 * @brief Wi-Fi network to join.
 *
 * @todo If you are using Wi-Fi, set this to your network name.
 */
#define clientcredentialWIFI_SSID                     "[redacted]"

/*
 * @brief Password needed to join Wi-Fi network.
 * @todo If you are using WPA, set this to your network password.
 */
#define clientcredentialWIFI_PASSWORD                 "[redacted]"

/*
 * @brief Wi-Fi network security type.
 *
 * @see WIFISecurity_t.
 *
 * @note Possible values are eWiFiSecurityOpen, eWiFiSecurityWEP, eWiFiSecurityWPA,
 * eWiFiSecurityWPA2 (depending on the support of your device Wi-Fi radio).
 */
#define clientcredentialWIFI_SECURITY                 eWiFiSecurityWPA2

#endif /* ifndef __AWS_CLIENTCREDENTIAL__H__ */
```

Figure 4.7 aws_clientcredential.h

7. Double-click ${base_folder}\tools\certificate_configuration\CertificateConfigurator.html.

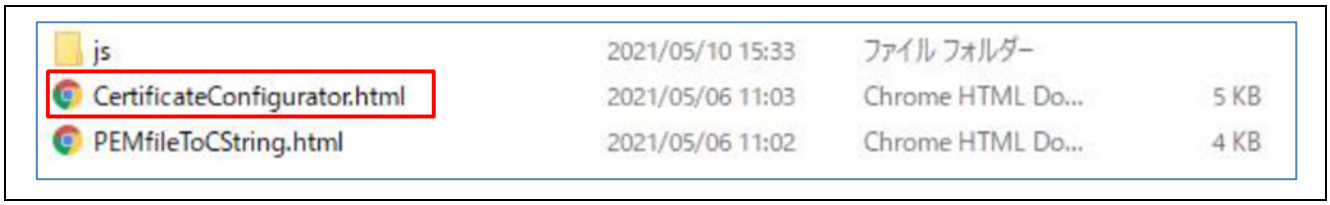

Figure 4.8 Opening CertificateConfigurator.html

8. Specify the thing certificate and private key files downloaded as described in 4.1, AWS Preparation, then click **Generate and save aws_clientcredential_key.h**.
   — xxxxxx-certificate.pem.crt (thing certificate)
   — xxxxxx-private.pem.key (private key)

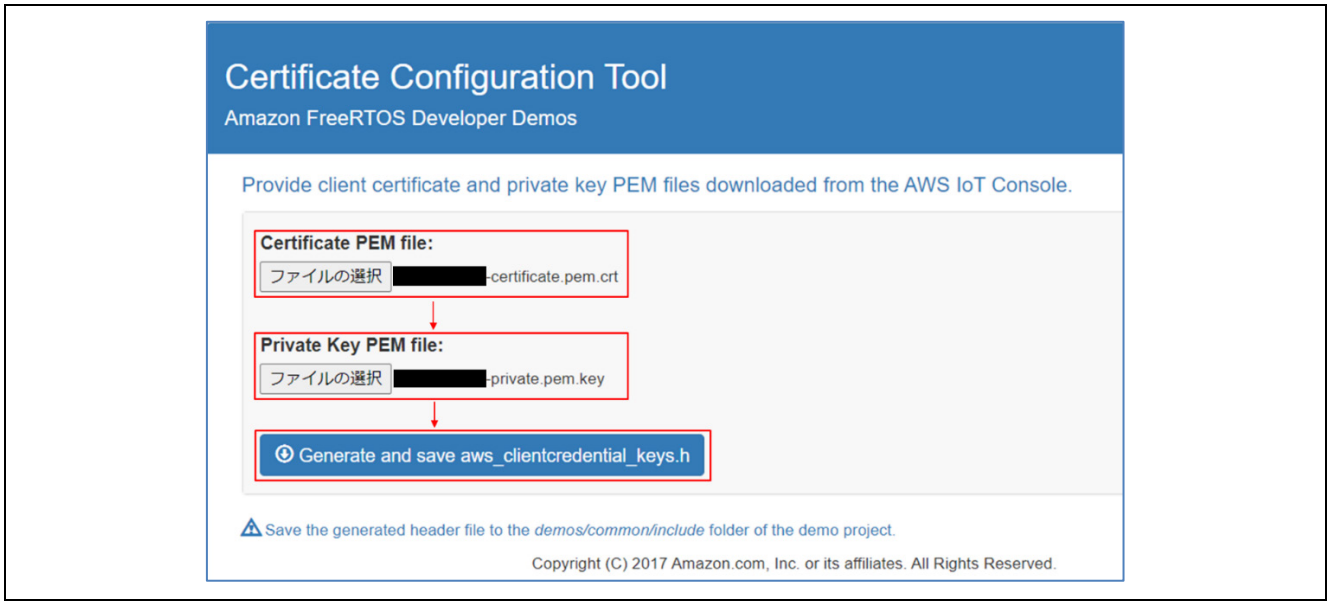

Figure 4.9 Certificate Configuration Tool

9. Overwrite the file ${base_folder}\demos\common\include\aws_clientcredential_key.h with the newly generated aws_clientcredential_key.h file.

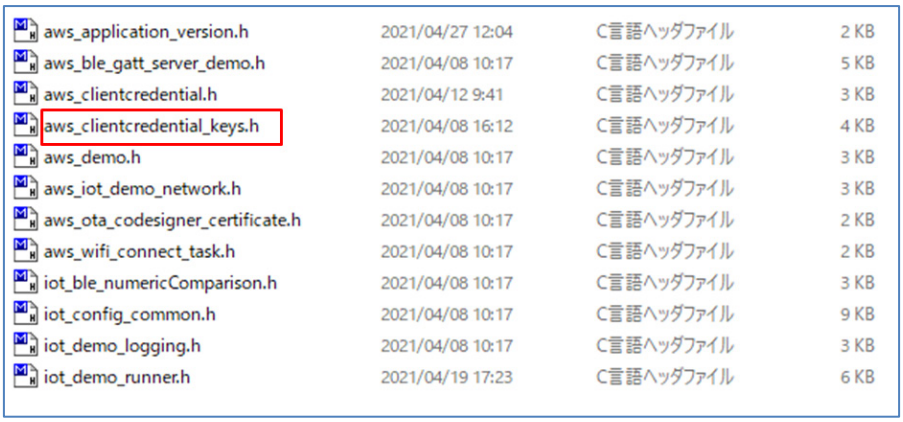

Figure 4.10 Overwriting aws_clientcredential_key.h

10. Select **Project** → **Build All** and confirm that **0 errors** are reported.

Note: Make sure to clean the project before building it for the first time. If a demo build error occurs after the initial build, clean the project again and then build it.

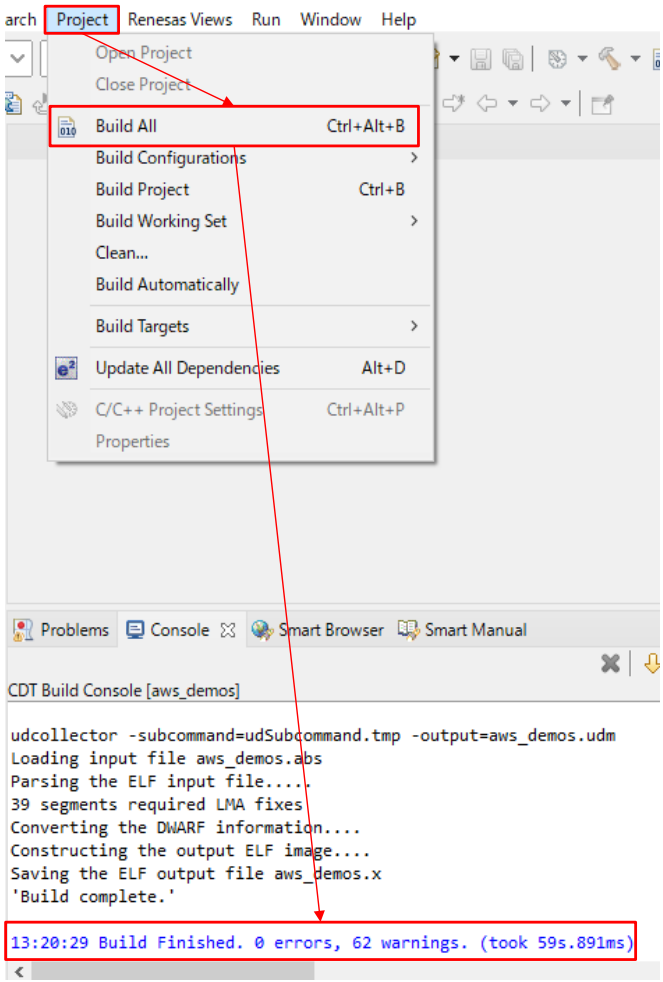

Figure 4.11 Project → Build All → 0 errors

To check the connection to AWS, perform the steps described in section 2, Confirming the Connection to AWS, in the reference document Troubleshooting when Using Amazon Web Services.

5. Shadow Service

This section describes how to use the AWS IoT Core shadow service to control an edge device (RX65N Cloud Kit) from the cloud.

The shadow service can be used not only to collect data from edge devices, but also to control edge devices from the cloud. By controlling the product remotely it is possible to realize a variety of application requests.

The sample code performs operations to switch LED control in response to data obtained about the LEDs and sensors.

5.1 Device Properties

The table below lists the device properties used by the demo.

Table 5.1 Device Properties

Property	Status	Operation
“LEDControl”	“LED_ON”	LED1 (red) and LED2 (red) on the RX65N Cloud Kit top board are on.
	“LED_OFF”	LED1 (red) and LED2 (red) on the RX65N Cloud Kit top board are off.
	“LED_LIGHT”	The light sensor value is 500 or greater: LED1 (red) and LED2 (red) off. The light sensor value is 100 or greater but less than 500: LED1 (red) on, LED2 (red) off. The light sensor value is less than 100: LED1 (red) and LED2 (red) on.
	“LED_TEMP”	The temperature sensor value is 30 or less: LED1 (red) and LED2 (red) off. The temperature sensor value is greater than 30 but no more than 40: LED1 (red) on, LED2 (red) off. The temperature sensor value is greater than 40: LED1 (red) and LED2 (red) on.
“SWVersion”	“VER_x.y.z” (Note: x, y, and z represent user-defined positive integer values.)	The software version is changed to x.y.z. (The value in aws_application_version.h is used initially.) When the software version changes, LED1 (red) and LED2 (red) flash for 10 seconds.
“IPAddress”	None	Indicates the IP address. (Uses the value of R_WIFI_SX_ULPGN_GetIpAddress.)
“sensorDataUpdateOn”	“UpdateOn”	The value obtained from the light sensor is uploaded.
	“UpdateOff”	A fixed value of 0 is uploaded.

5.2 Using the Shadow Service

The procedure for manipulating shadows is described below.

1. Perform all the steps listed in 4, Connecting to AWS.
2. On the AWS Management Console select **Services** → **All services** → **IoT** → **IoT Core**, then click **Test** → **Subscribe to a topic**, enter **#** in the topic filter field, and click the **Subscribe** button.

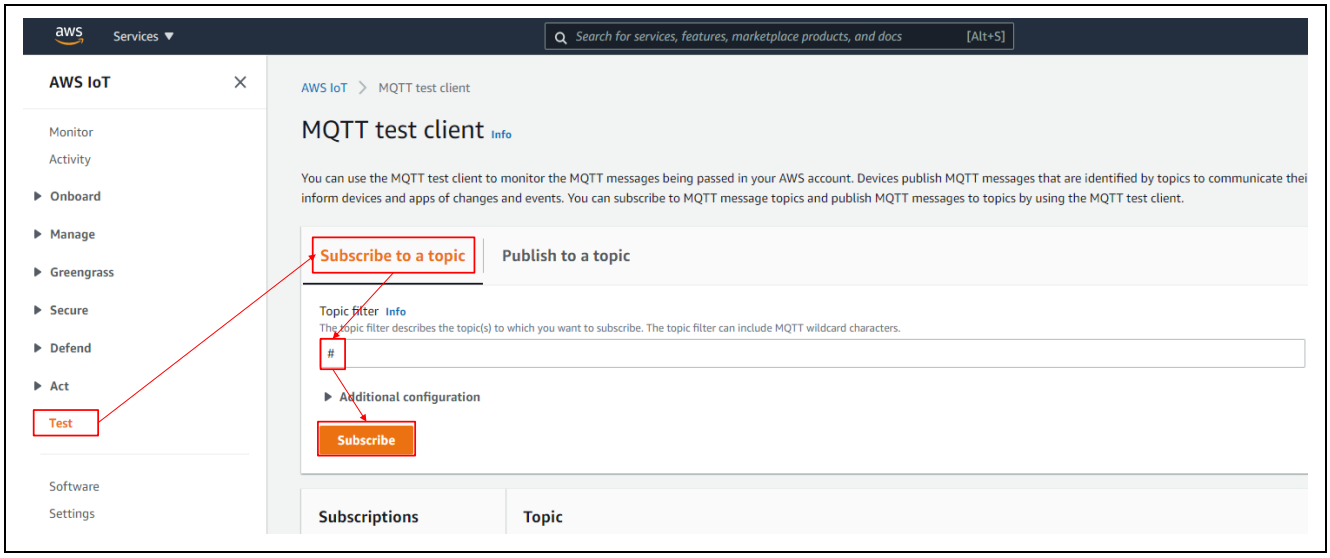

Figure 5.1 Subscribing to a Topic

3. Click the Debug icon in the upper left corner of the e² studio window.

Figure 5.2 Debug

4. A message appears asking you to confirm that you wish to switch to the Debug perspective; click the **Switch** button.

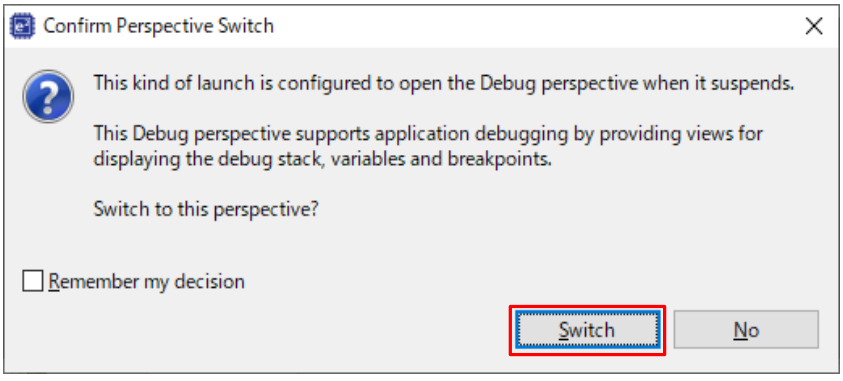

Figure 5.3 Confirm Perspective Switch

5. Click the **Resume** icon. After a short time execution pauses at the main function; click the **Resume** icon again.

Figure 5.4 Running the Demo Program

6. Return to the AWS Management Console, click **Test** → **Publish to a topic**, and enter the following code as the topic name.

   Note: In place of xxxx, enter the name of the thing registered as described in 4.1, AWS Preparation.

```
$aws/things/xxxx/shadow/update
```

Figure 5.5 Topic Name

7. Copy the following lines of code and paste them into the message payload field.
   (In this example the setting LED_ON is used, but you can make settings to tailor the operation to match the statuses listed in the Device Properties table.)

```
{
    "state": {
        "desired": {
            "LEDControl": "LED_ON",
            "SWVersion": "VER_0.9.3",
            "SensorDataUpdateOn": "UpdateOn"
        }
    }
}
```

Figure 5.6 Message Payload

8. Click **Publish** and confirm that LED1 and LED2 on the RX65N Cloud Kit top board turn on.

Figure 5.7 Publishing a Topic

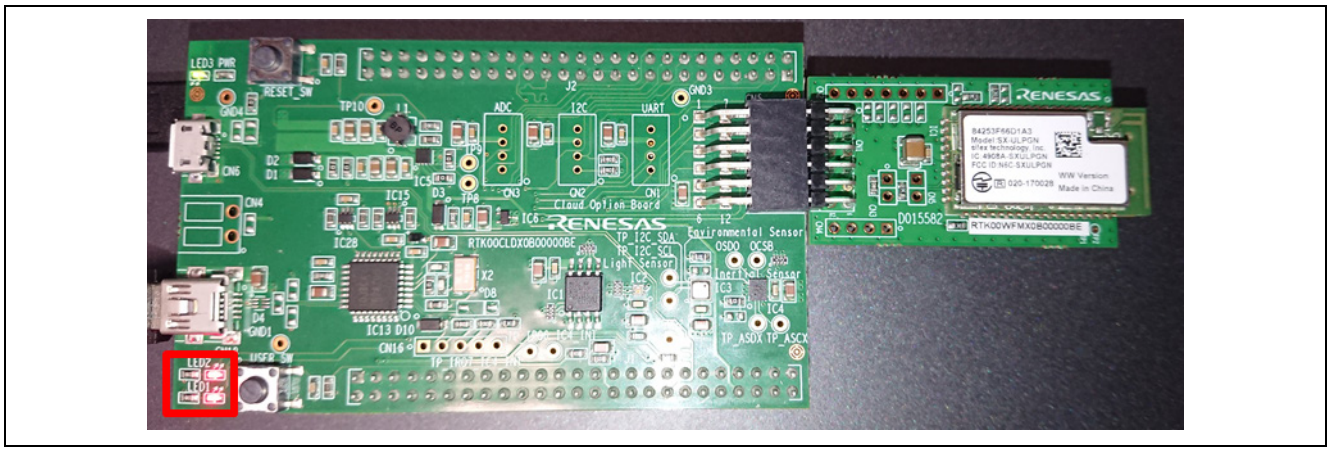

Figure 5.8 RX65N Cloud Kit LED1 and LED2 On

6. Elasticsearch

This section describes using the Elasticsearch service of AWS to visualize data obtained from the sensor module mounted on the RX65N Cloud Kit board.

Fees are incurred when using the Amazon Elasticsearch service. Make sure to delete your Elasticsearch domain after you finish using the demo program.

6.1 Elasticsearch Preparation

Follow the steps below to prepare Elasticsearch for the demo program.

Follow the steps below to set up Elasticsearch.

1. On the AWS Management Console, click **Elasticsearch Service** under **All services** → **Analytics**.

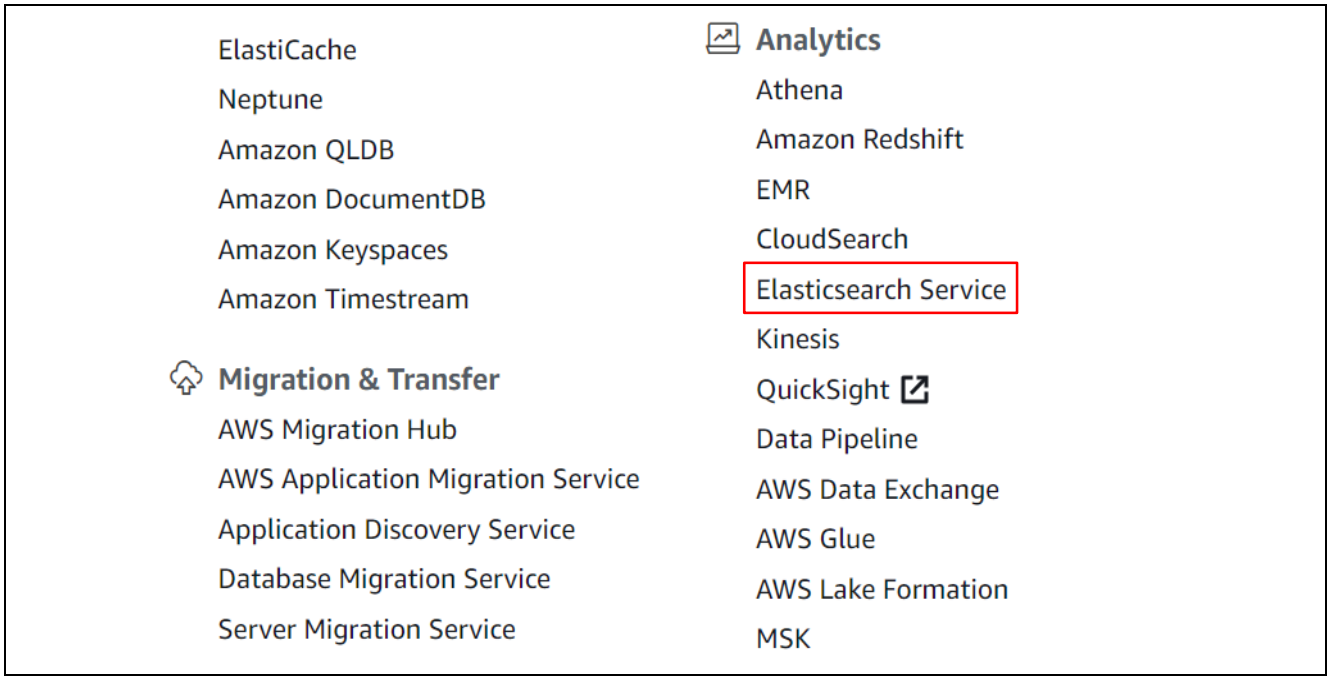

Figure 6.1 Selecting Elasticsearch Service

2. Click **Create a new domain**.

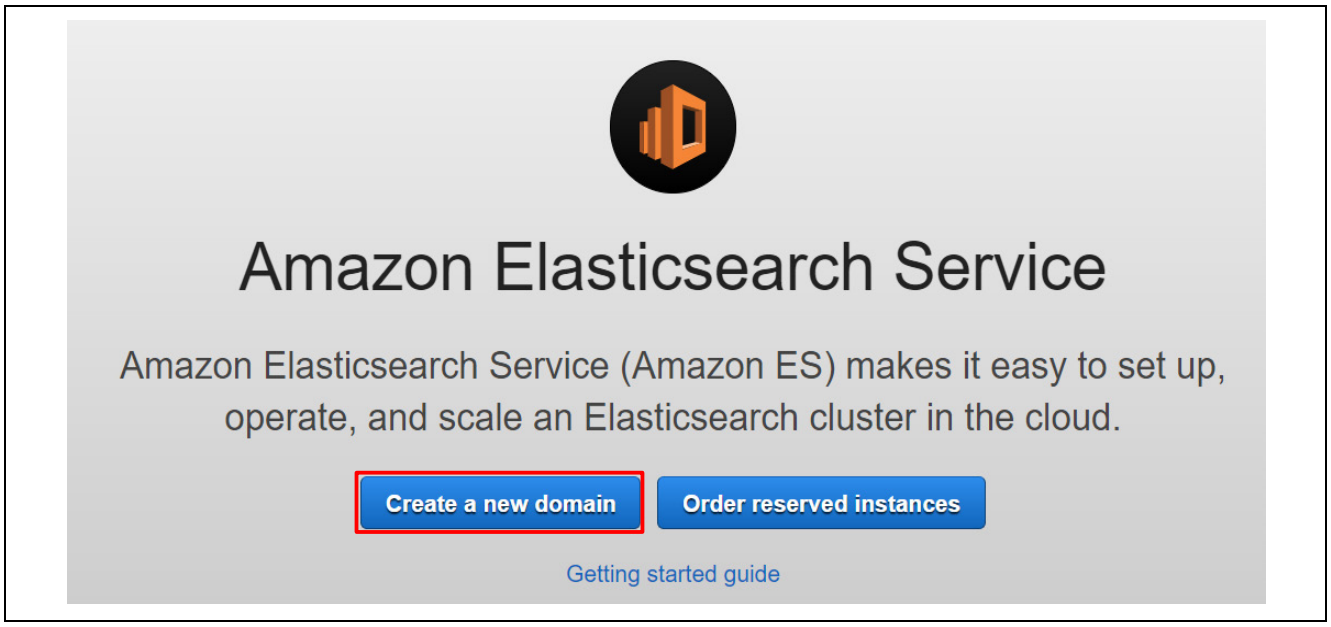

Figure 6.2 Create a new domain

3. Select the radio button next to **Development and testing** and set **Elasticsearch version** to **7.1**. Then click **Next**.

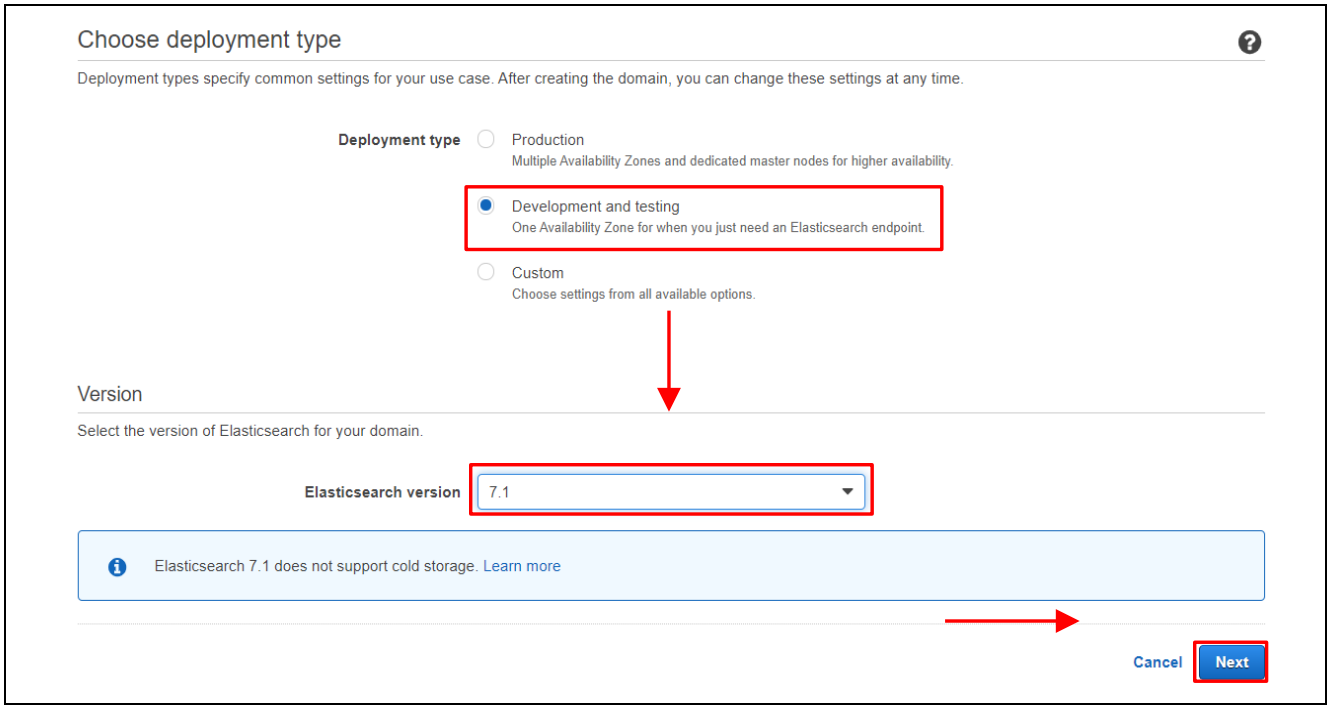

Figure 6.3 Choose deployment type

4. Enter an **Elasticsearch domain name** and change the **Instance type** selection to **t2.small.elasticsearch**, then scroll down.

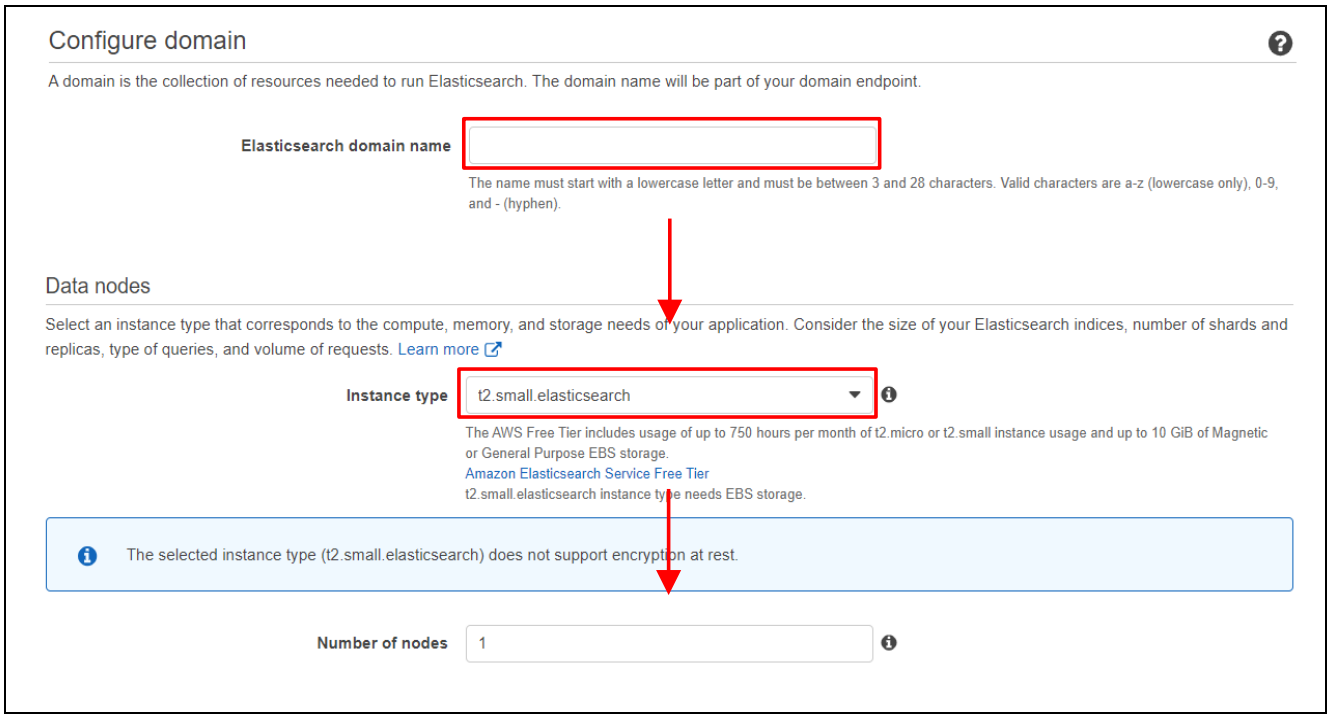

Figure 6.4 Configure domain

5. Click **Next**.

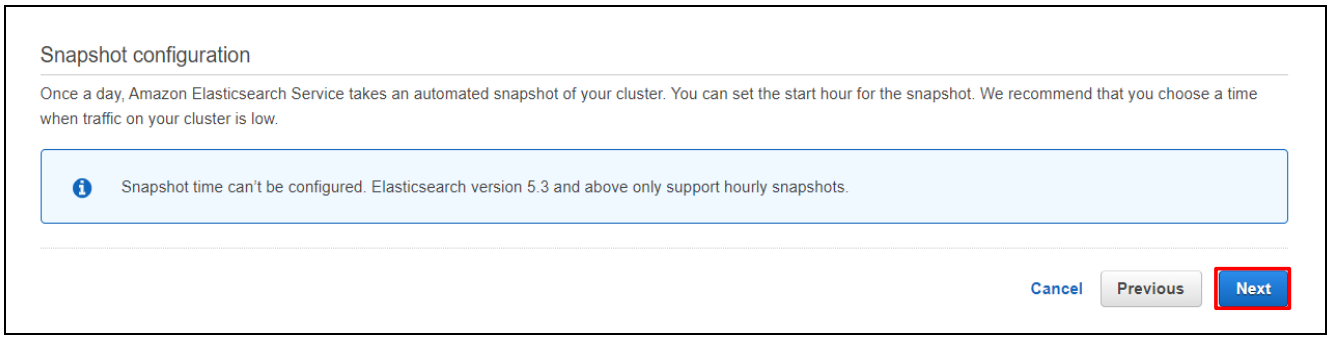

Figure 6.5 Configure domain, Next

6. Select **Public access**, then scroll down.

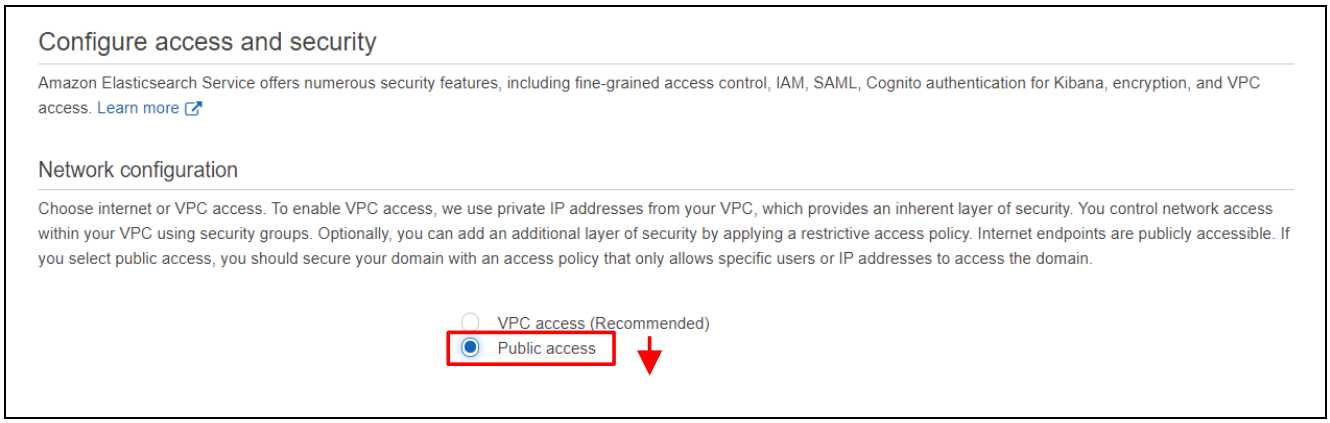

Figure 6.6 Network configuration

7. Set **Domain access policy** to **Custom access policy** and select **IPv4 address**. Enter the global IP address of your PC and select **Allow**.

   Note: Search for "check global IP address" on the internet to find out how to determine the global IP address of your PC.

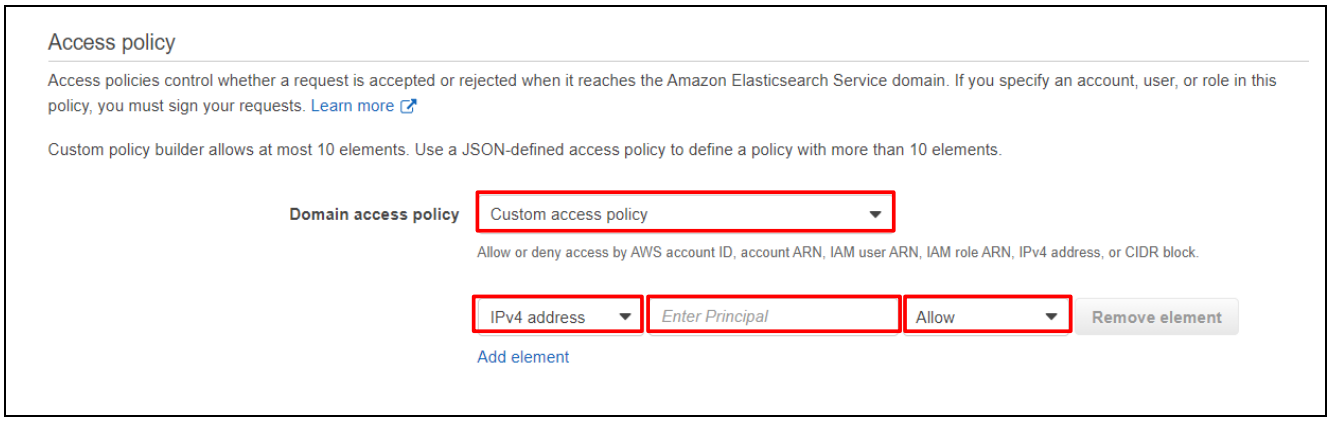

Figure 6.7 Access policy

8. Click **Next**.

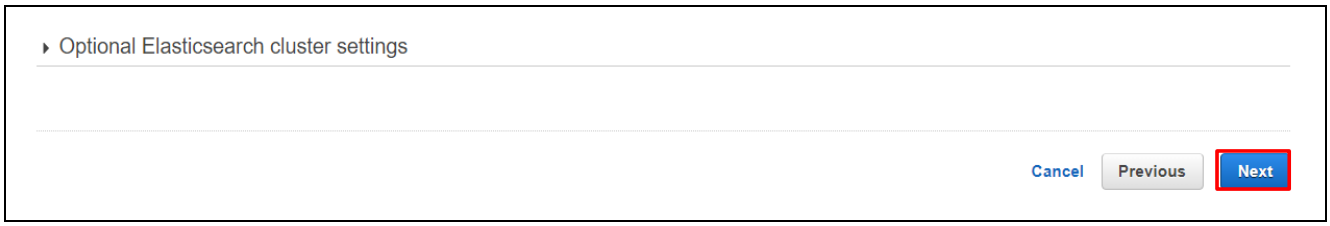

Figure 6.8 Access policy, Next

9. On the **Add tags** page, click **Next** without doing anything.

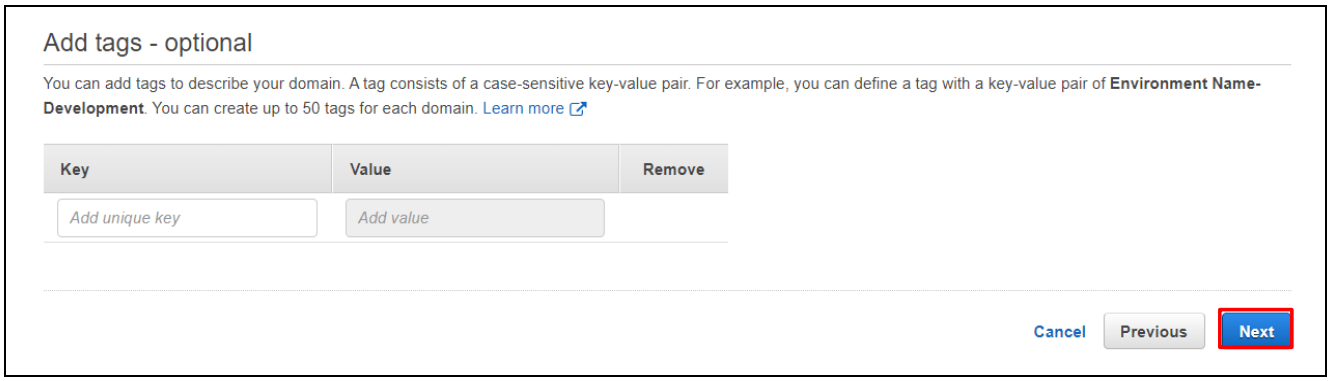

Figure 6.9 Do Nothing and Click Next

10. On the **Review** page, double-check your configuration and choose **Confirm**.

Figure 6.10 After Clicking Next, Confirm

11. Your Elasticsearch domain is created. Stand by until **Domain status** changes to **Active**.

Note: It may take one to two hours before **Domain status** changes to **Active**.

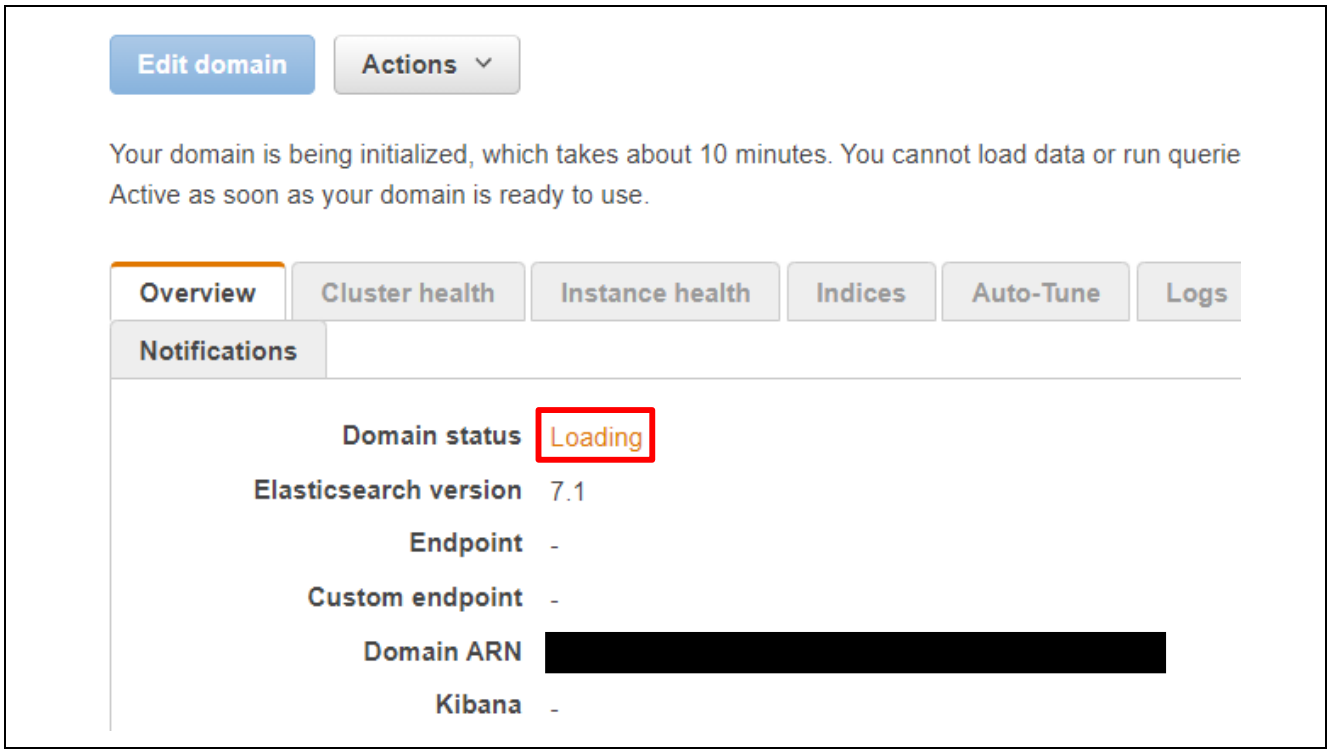

Figure 6.11 Stand by Until Domain status Changes to Active

12. Once **Domain status** changes to **Active**, access the **Kibana** URL.

Figure 6.12 Domain status: Active

6.2 Kibana Preparation

Follow the steps below to prepare Kibana for the demo program.

1. Click **Explore on my own**.

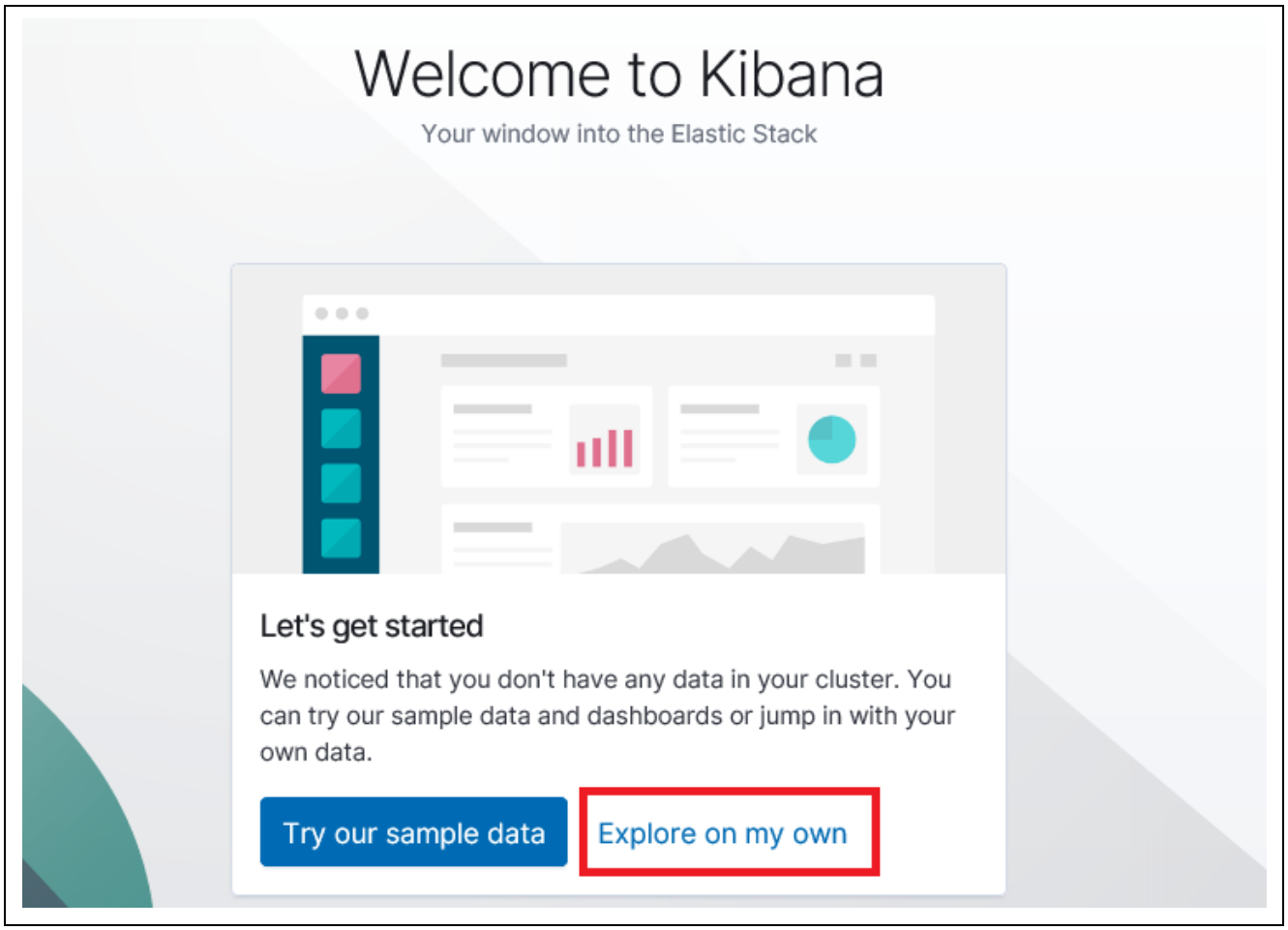

Figure 6.13 Explore on my own

2. On the menu bar on the left, click the **Dev Tools** icon.

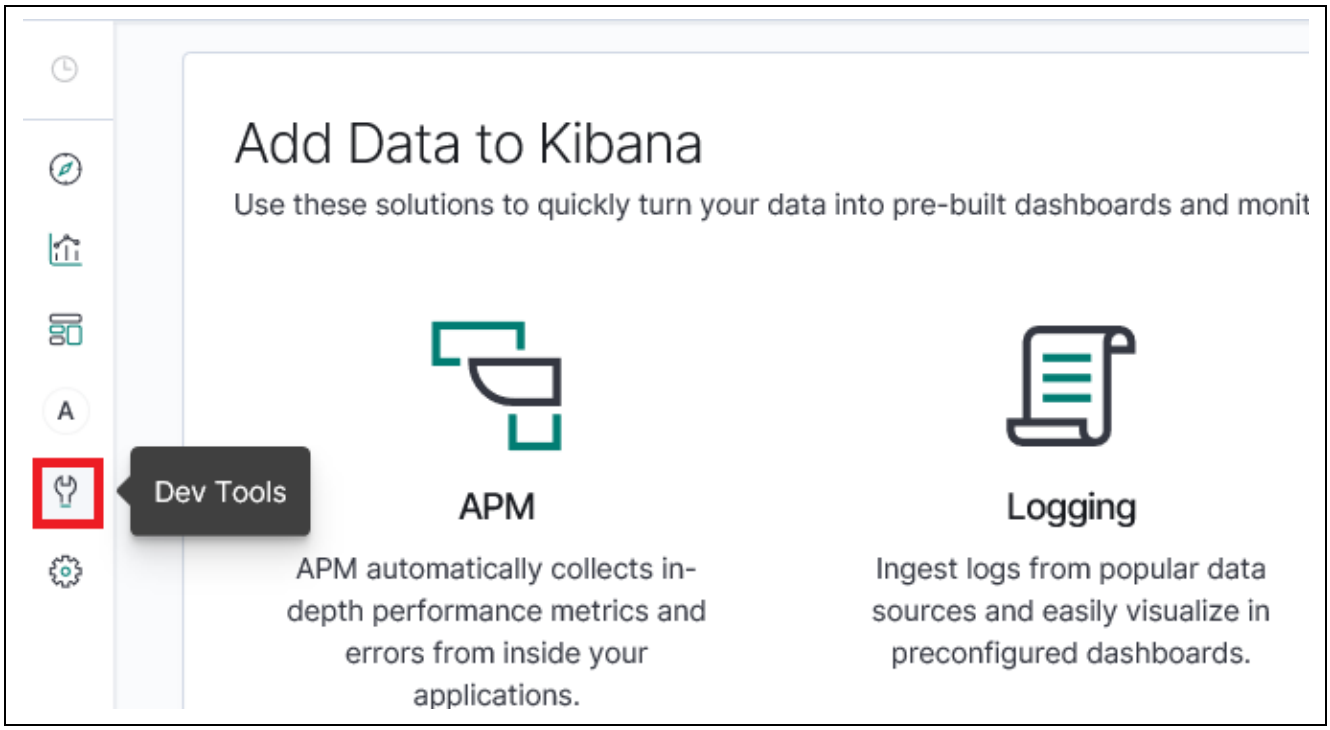

Figure 6.14 Dev Tools

3. Click **Get to work**.

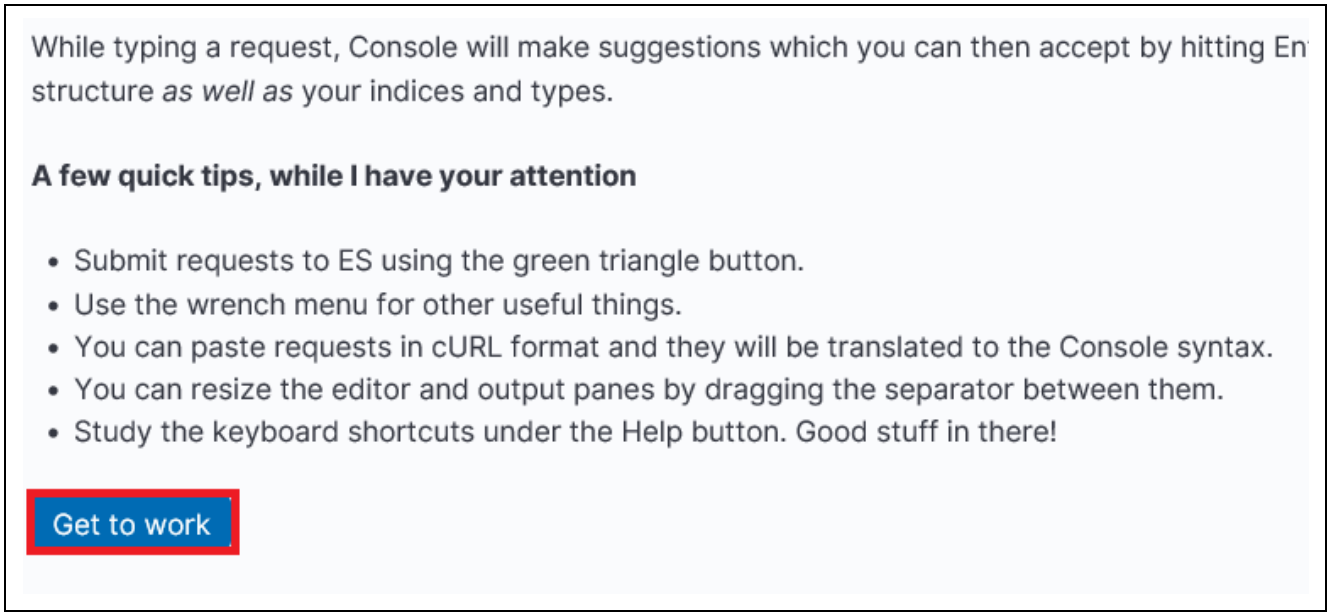

Figure 6.15 Get to work

4. In the console window on the left, enter the following code.

```
PUT /sensor?include_type_name=true
{
  "mappings": {
    "sensor": {
      "properties": {
        "timestamp": {
          "type": "long",
          "copy_to": "datetime"
        },
        "datetime": {
          "type": "date",
          "store": true
        },
        "temperature": {
          "type": "long"
        },
        "humidity": {
          "type": "long"
        }
      }
    }
  }
}
```

Figure 6.16 Code Entered in Console Window

5. Click the **click to send request** icon in the upper right corner of the console.

Figure 6.17 click to send request

6. Confirm that the following response is returned.

```
{
  "acknowledged" : true,
  "shards_acknowledged" : true,
  "index" : "sensor"
}
```

Figure 6.18 Confirming Response

6.3 IoT Rule Preparation

Follow the steps below to prepare an IoT rule for the demo program.

1. Go to the IoT Core control panel, select **Act** → **Rules**, and click **Create a rule**.

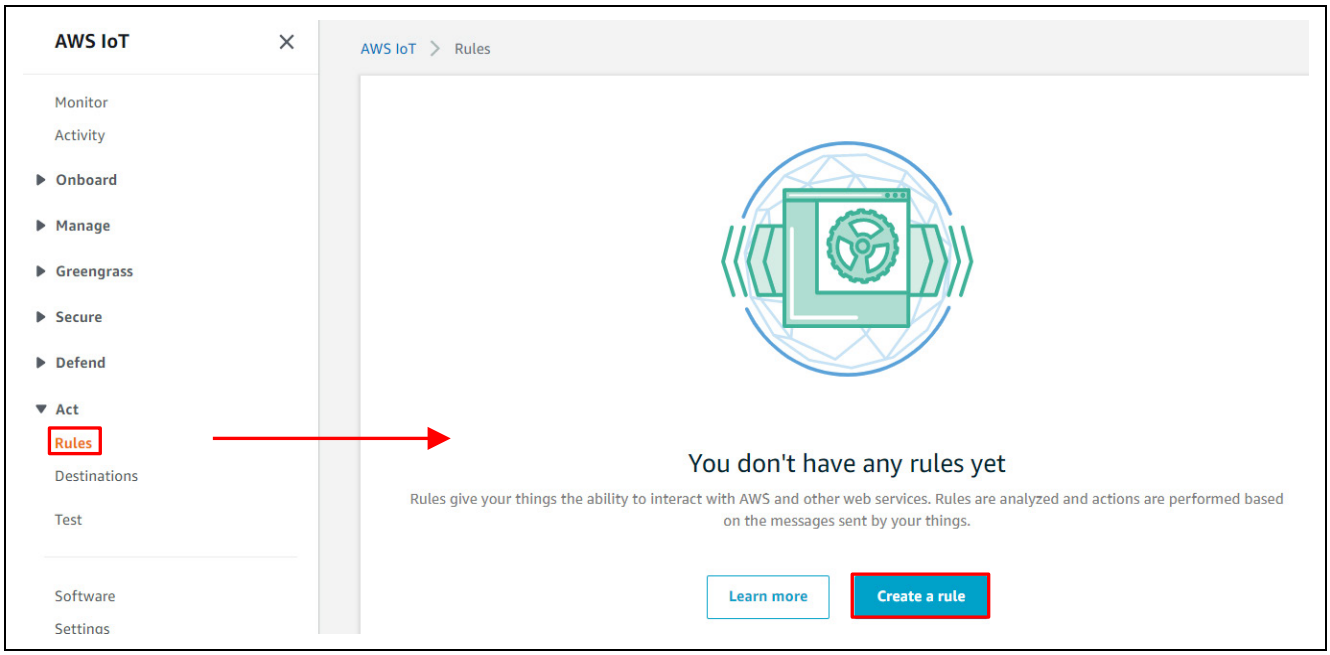

Figure 6.19 Create a rule

2. Enter a name for the rule, then enter the following code under **Rule query statement**.
   SELECT *, timestamp() as timestamp FROM 'iotdemo/topic/sensor'

   Note: After entering the rule query statement make sure to enter a line break.

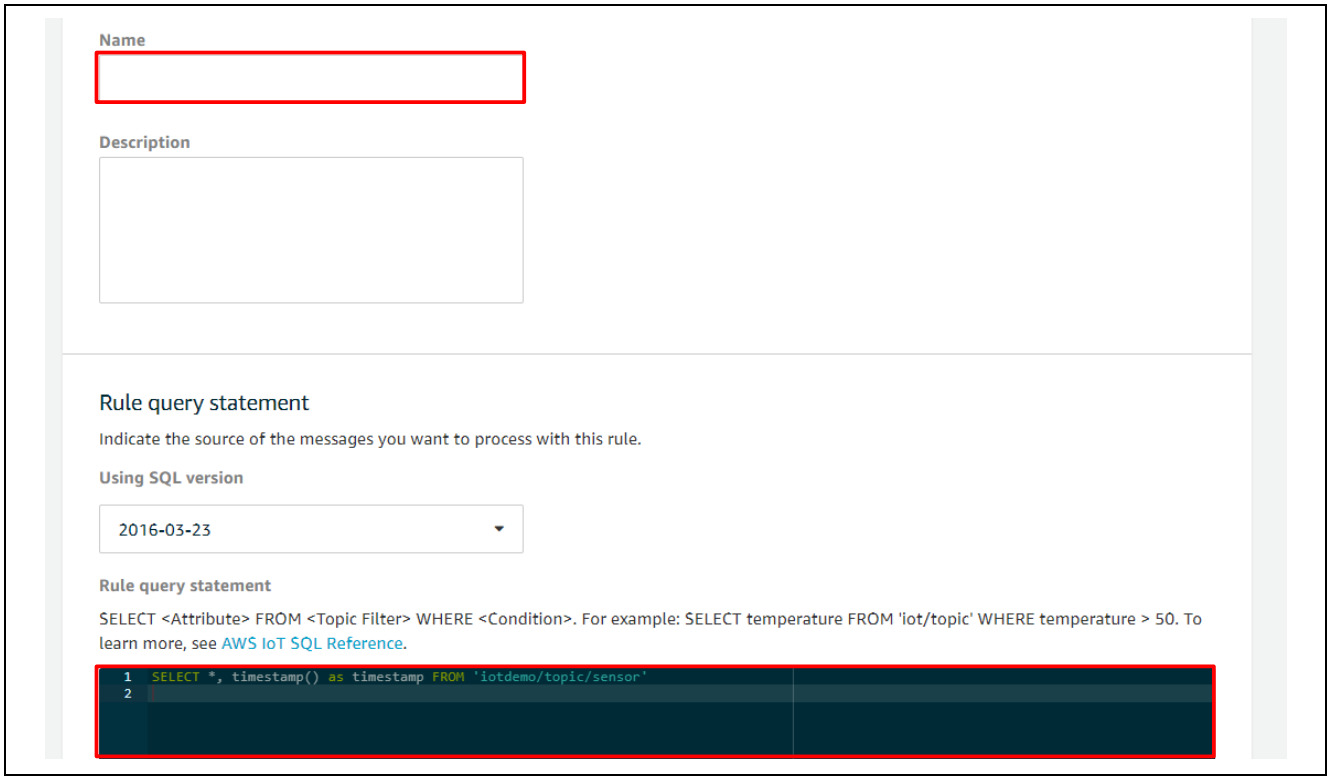

Figure 6.20 Entering Code

3. Click **Add action**.

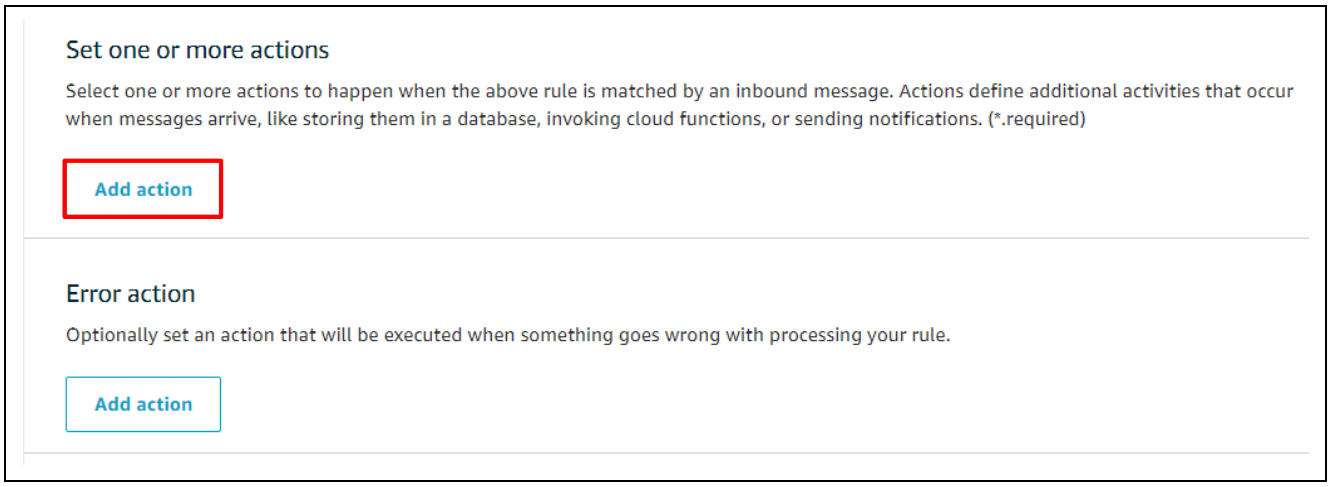

Figure 6.21 Add action

4. Select **Send a message to the Amazon Elasticsearch Service** and click **Configure action**.

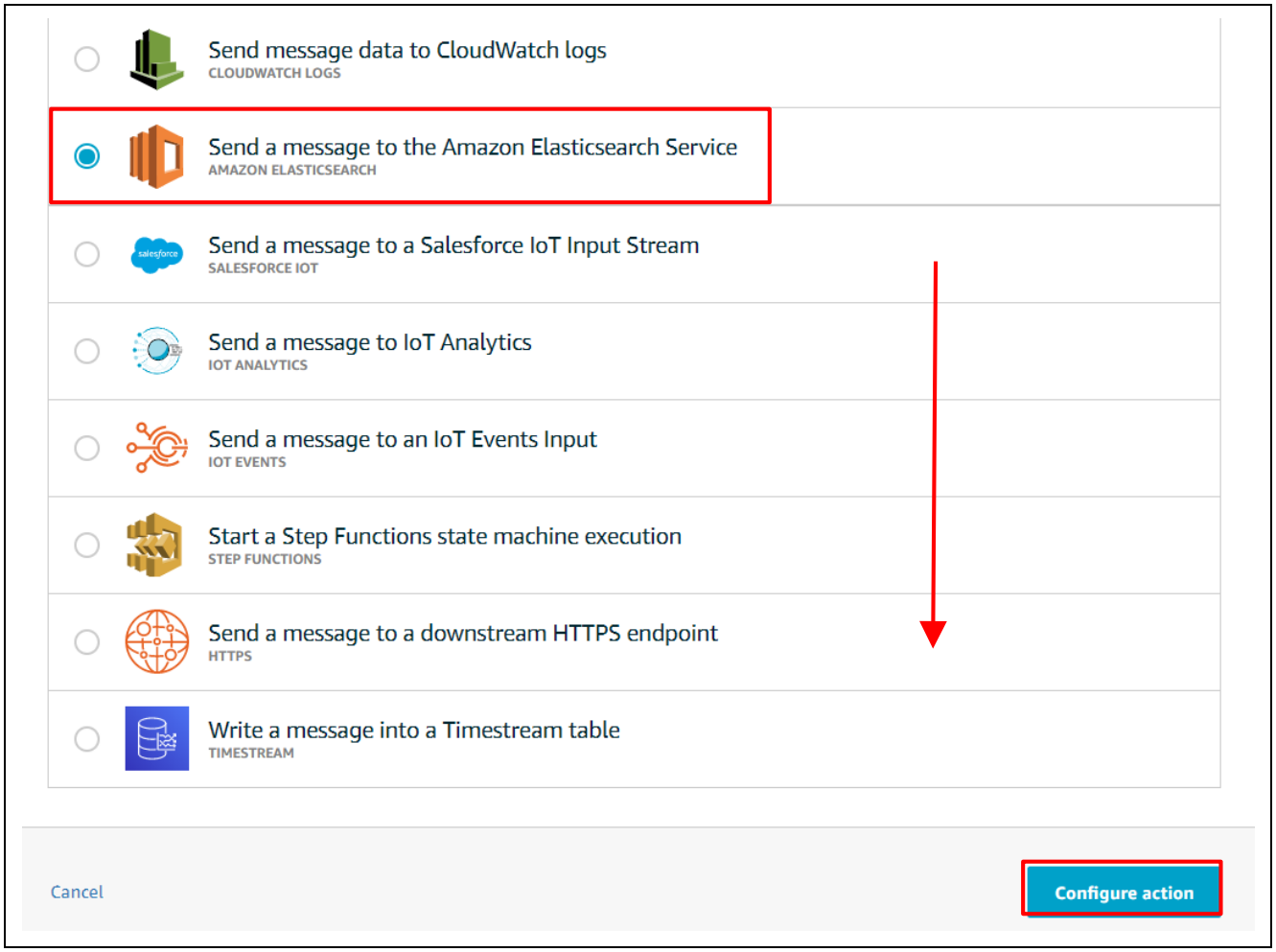

Figure 6.22 Configure action

5. For **Domain name** enter the domain name created as described in 6.1, Elasticsearch Preparation, for **ID** enter **${newuuid()}**, for **Index** enter **sensor**, and for **Type** enter **sensor**.

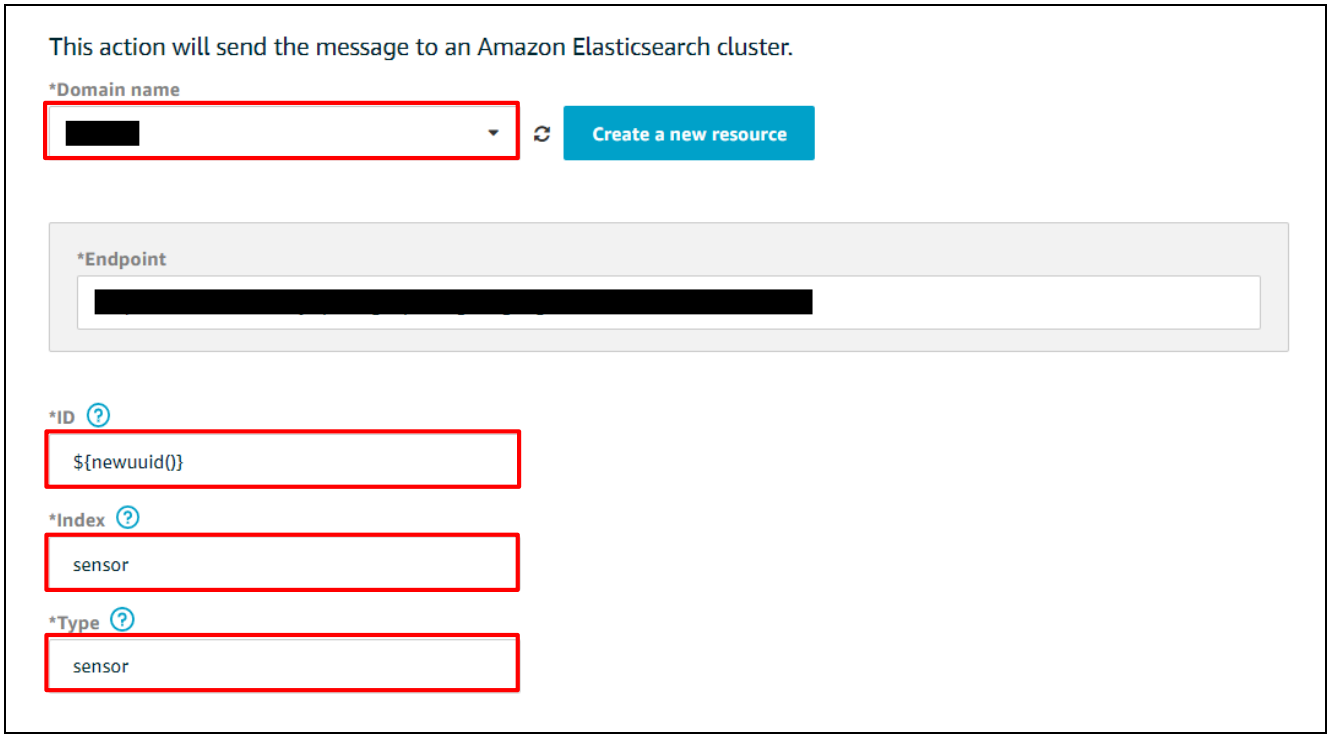

Figure 6.23 Domain name, ID, Index, and Type Settings

6. Click **Create a new role**, then enter the name of the role and click **Create role**.

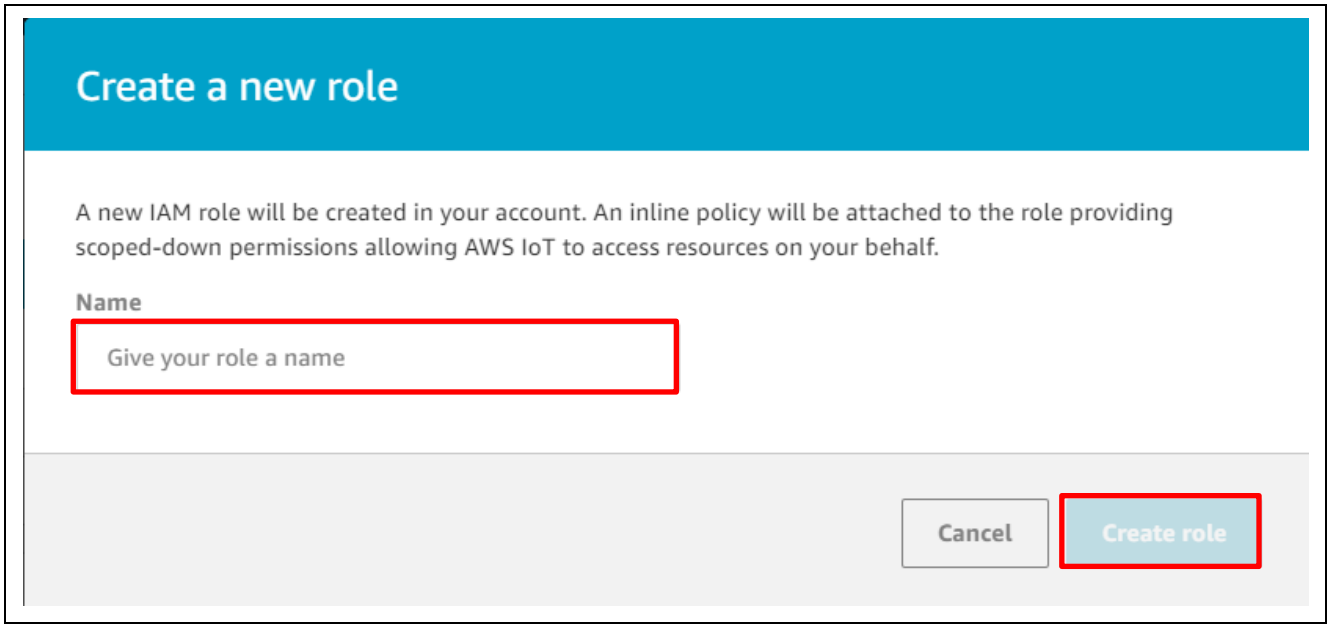

Figure 6.24 Create role

7. Confirm that the role you created is selected, then click **Add action**.

Figure 6.25 Add action

8. Confirm that the action was added, then click **Create rule**.

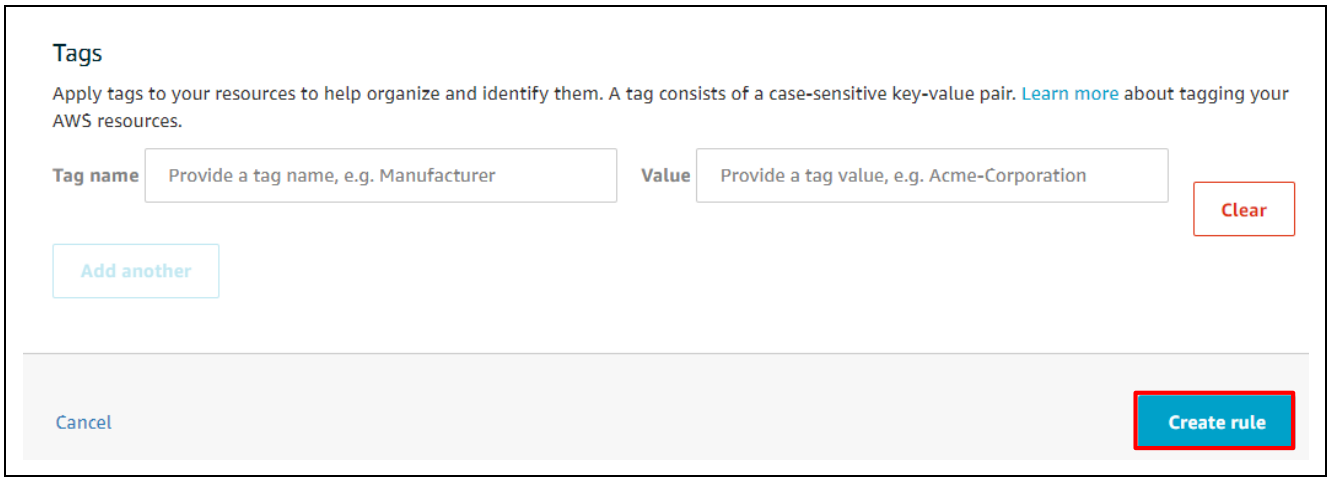

Figure 6.26 Create rule

6.4 Running the Demo Program

Follow the steps below to run the demo program.

1. Click the **Debug** button to connect to RX65N Cloud Kit.

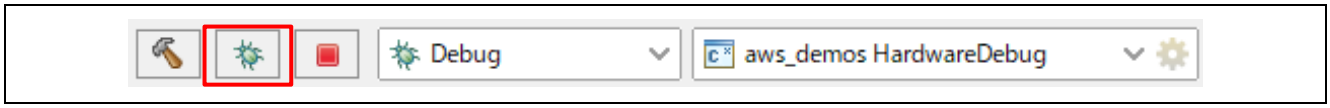

Figure 6.27 Debug

2. Click the **Resume** button. After a short time execution pauses at the main function; click the **Resume** button again.

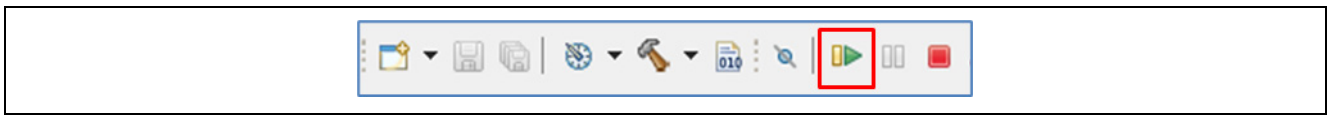

Figure 6.28 Running the Demo Program

6.5 Visualizing Sensor Information with Kibana

Follow the steps below to use Kibana to visualize sensor information.

1. Go to Kibana, and click the **Management** icon in the menu at left.

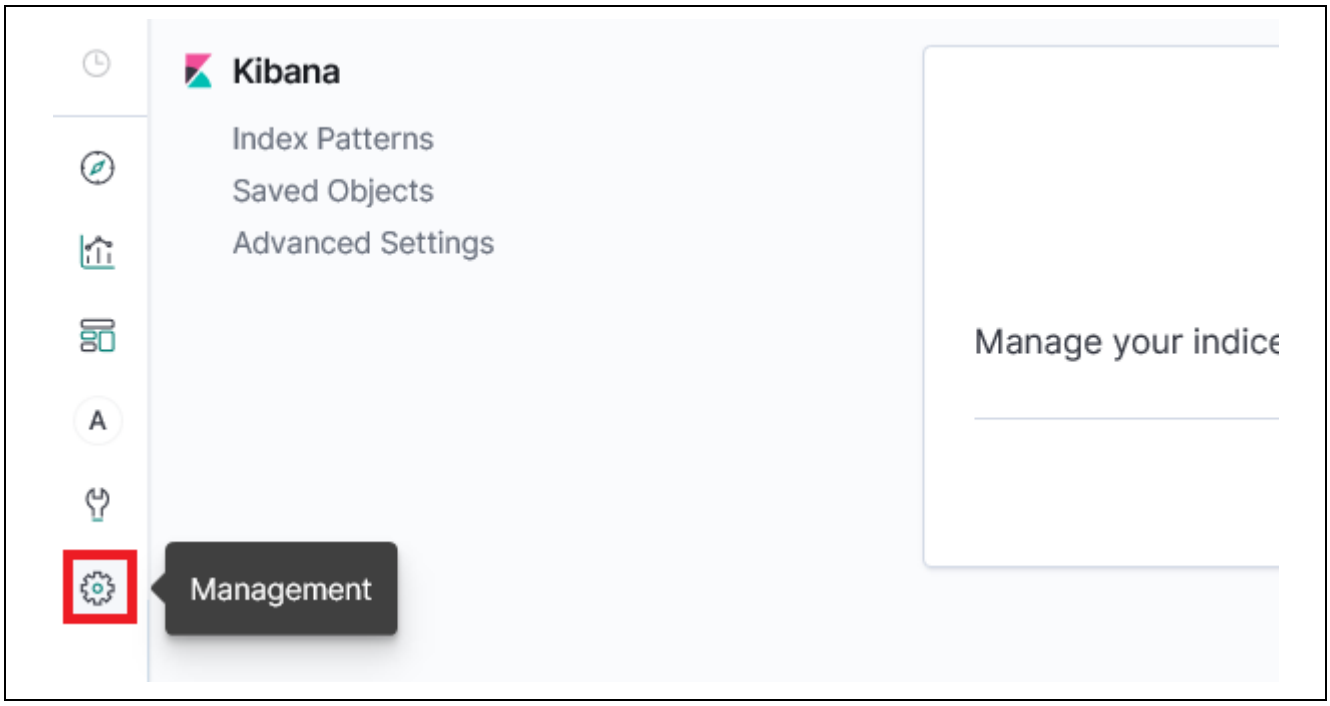

Figure 6.29 Kibana Setup

2. Click **Index Patterns** and for **Index pattern** enter **sensor**, then click **> Next step**.

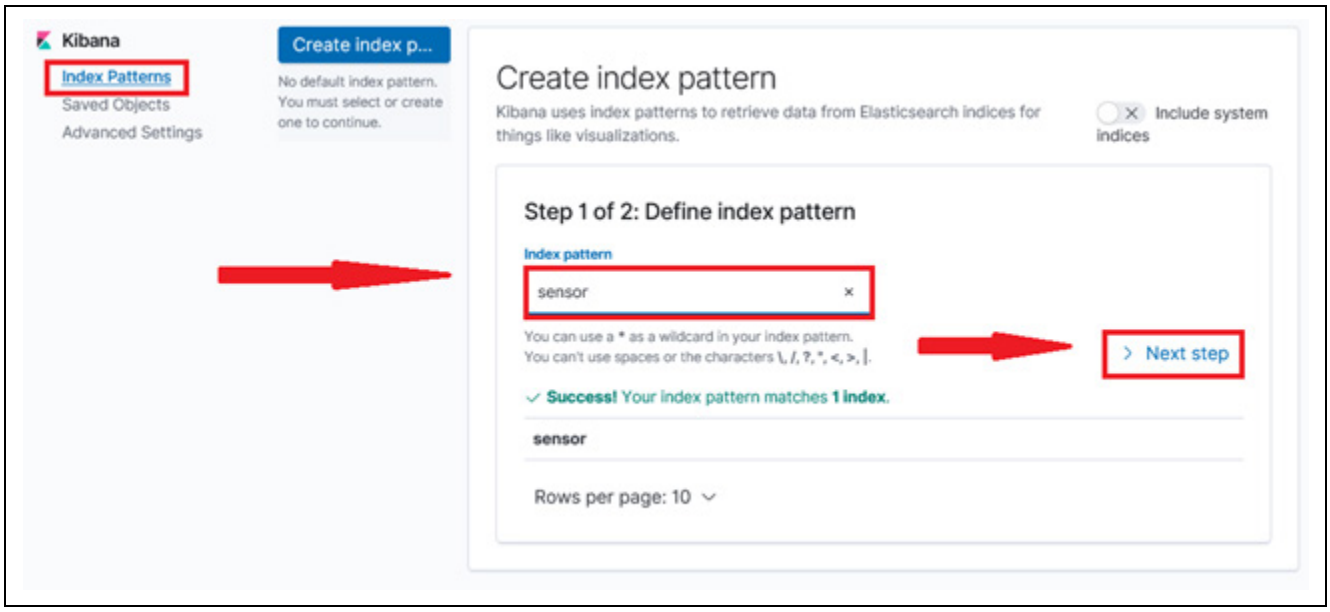

Figure 6.30 Define index pattern

3. For **Time Filter field name** select **datetime**, then click **Create index pattern**.

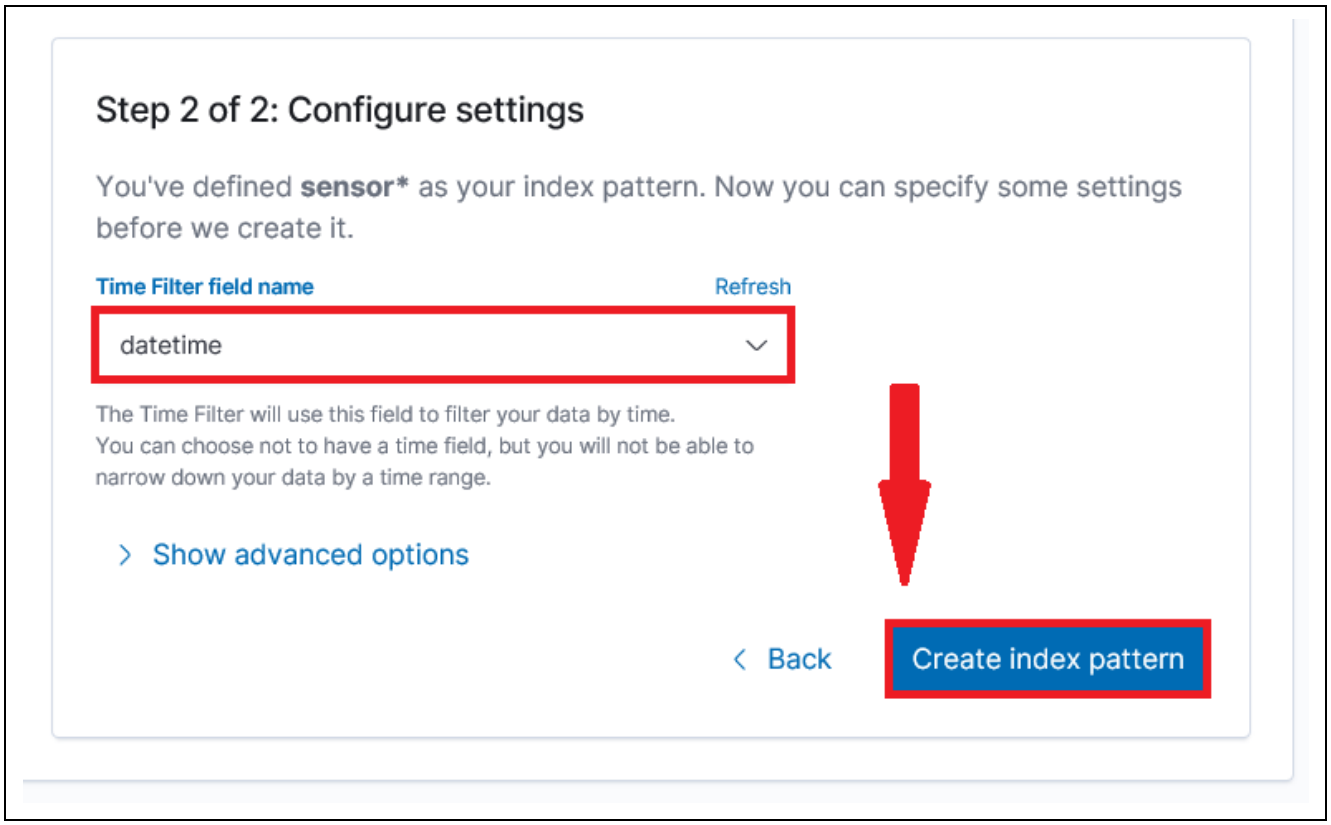

Figure 6.31 Configure settings

4. Click the **Visualize** icon in the menu at left.

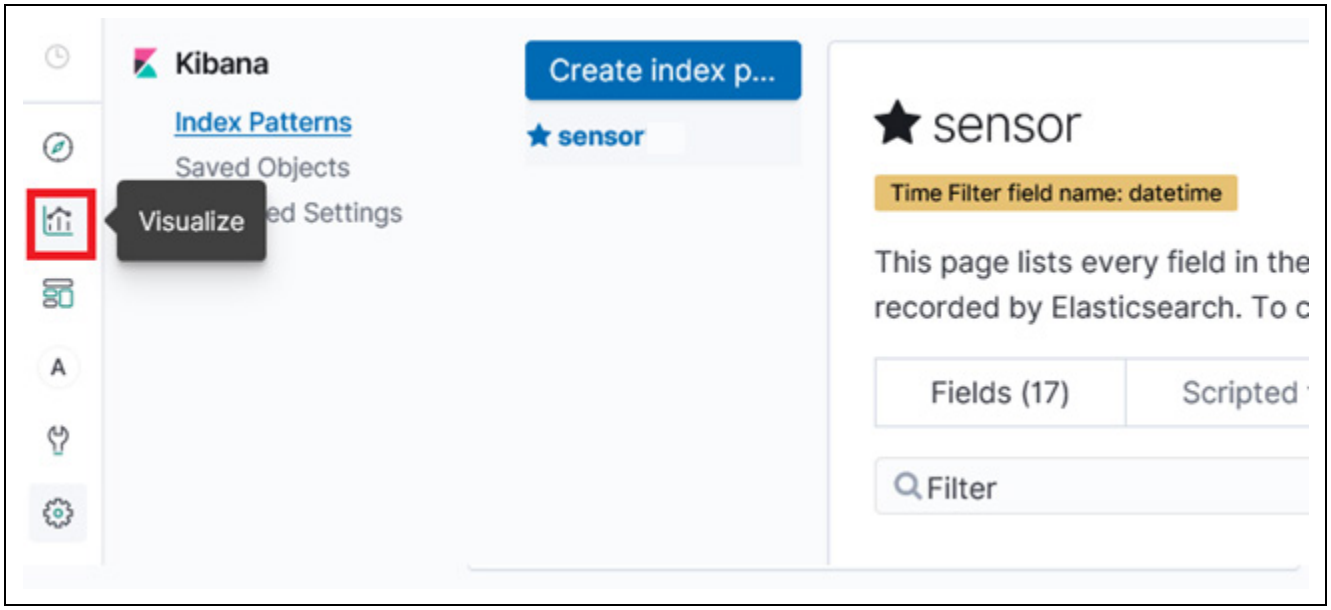

Figure 6.32 Visualize

5. Click **Create a visualization**.

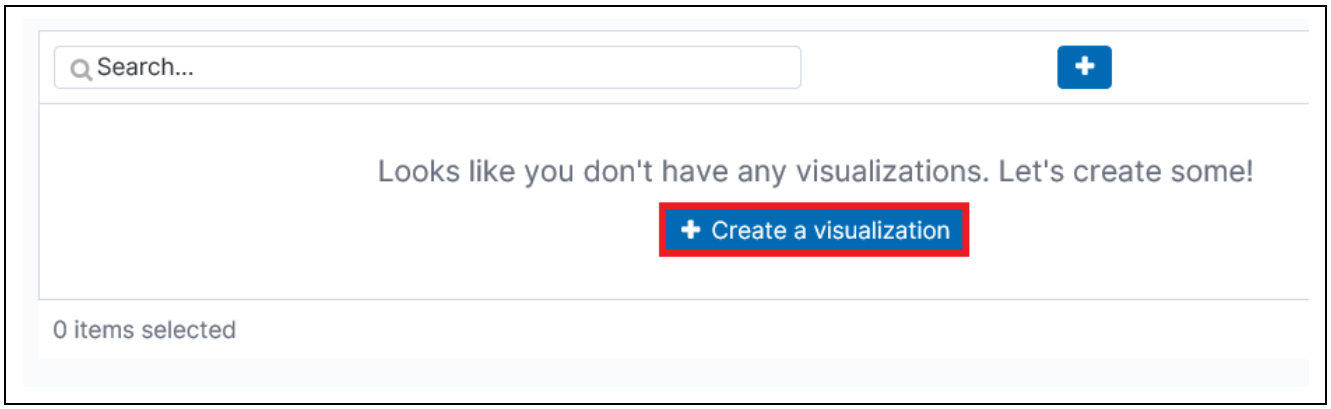

Figure 6.33 Create a visualization

6. Click the **Line** icon.

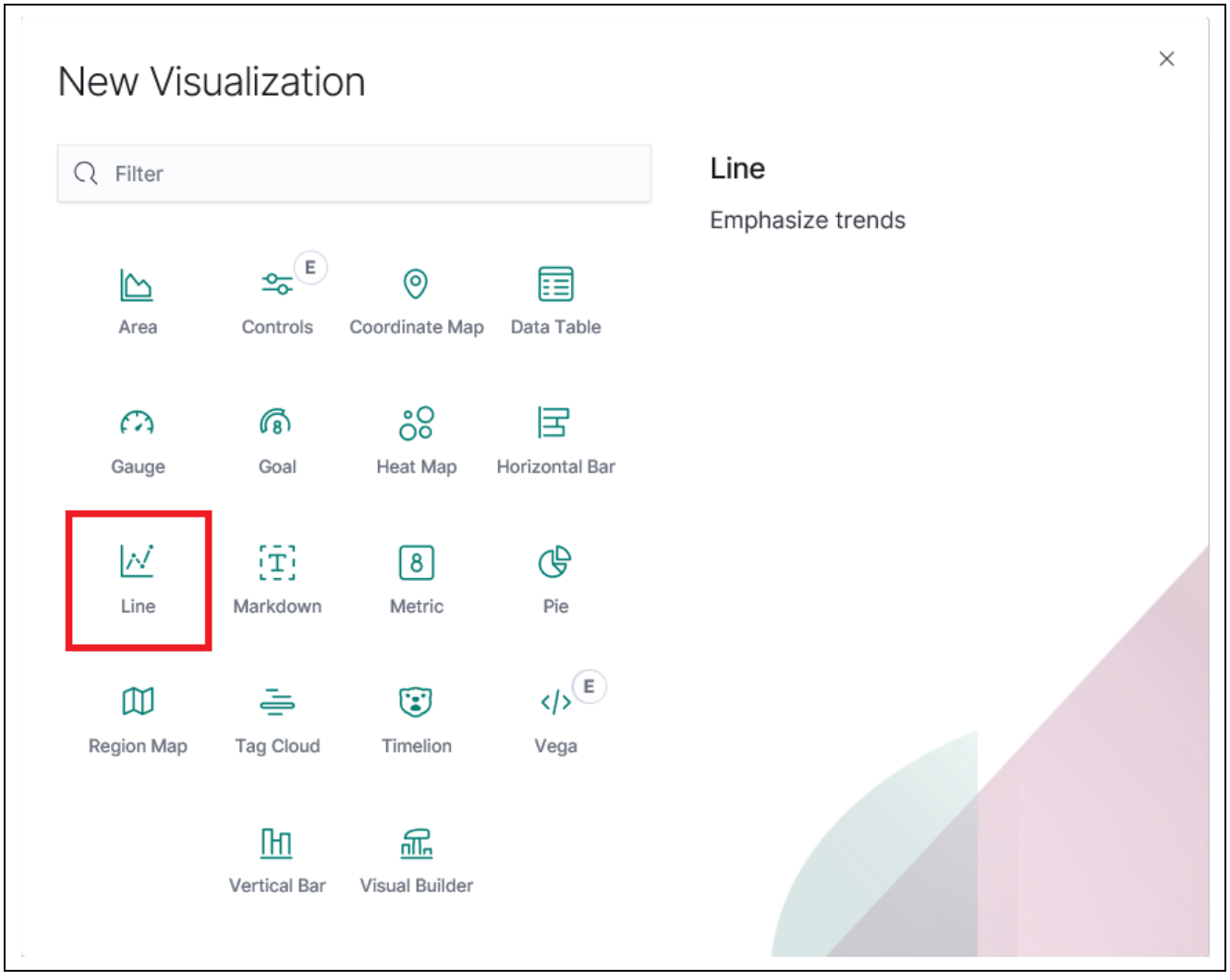

Figure 6.34 Line

7.Click **sensor**.

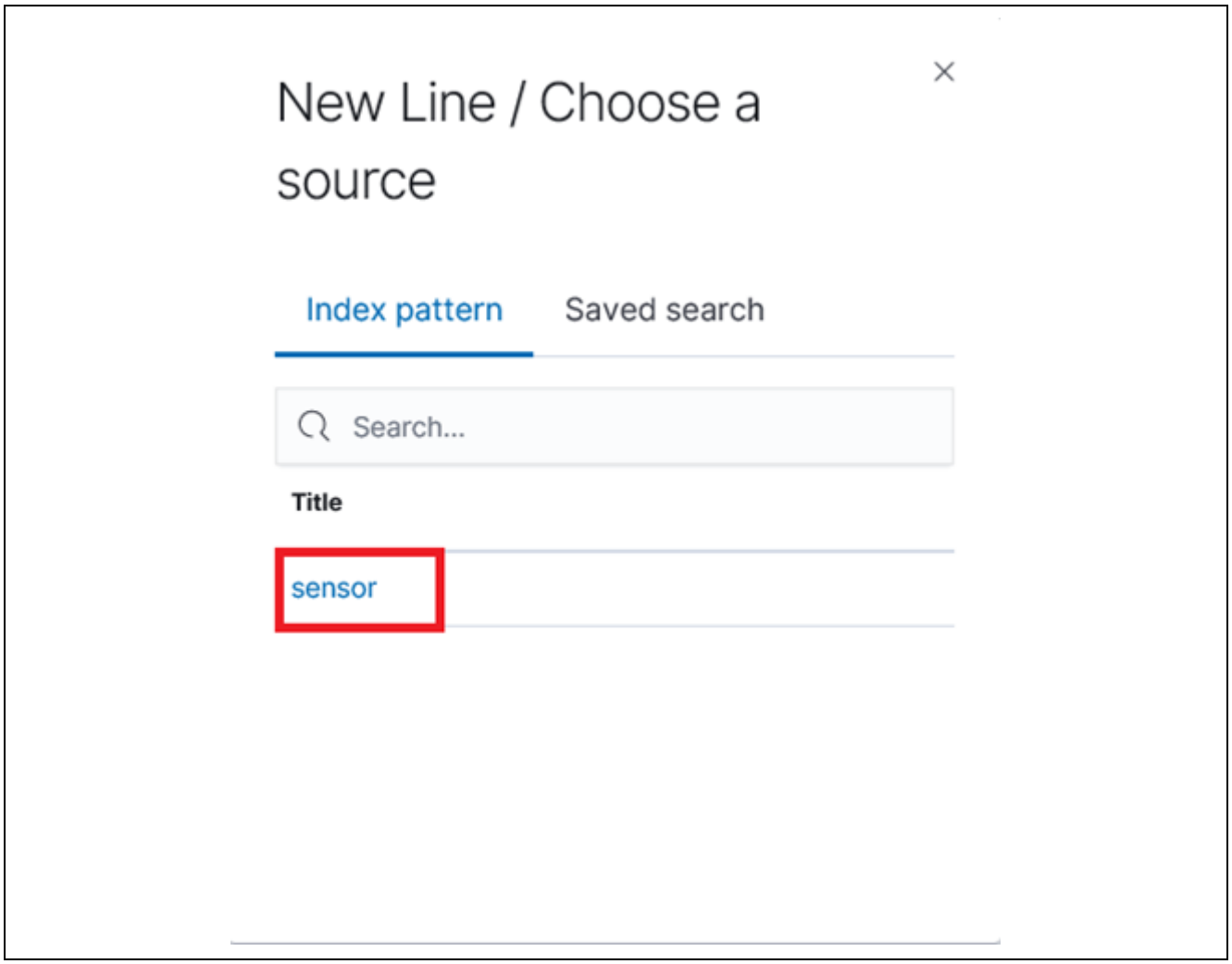

Figure 6.35 New Line / Choose a source

8. Click the calendar icon at the upper right, set **Refresh every** to **5 seconds**, and click **Start**.

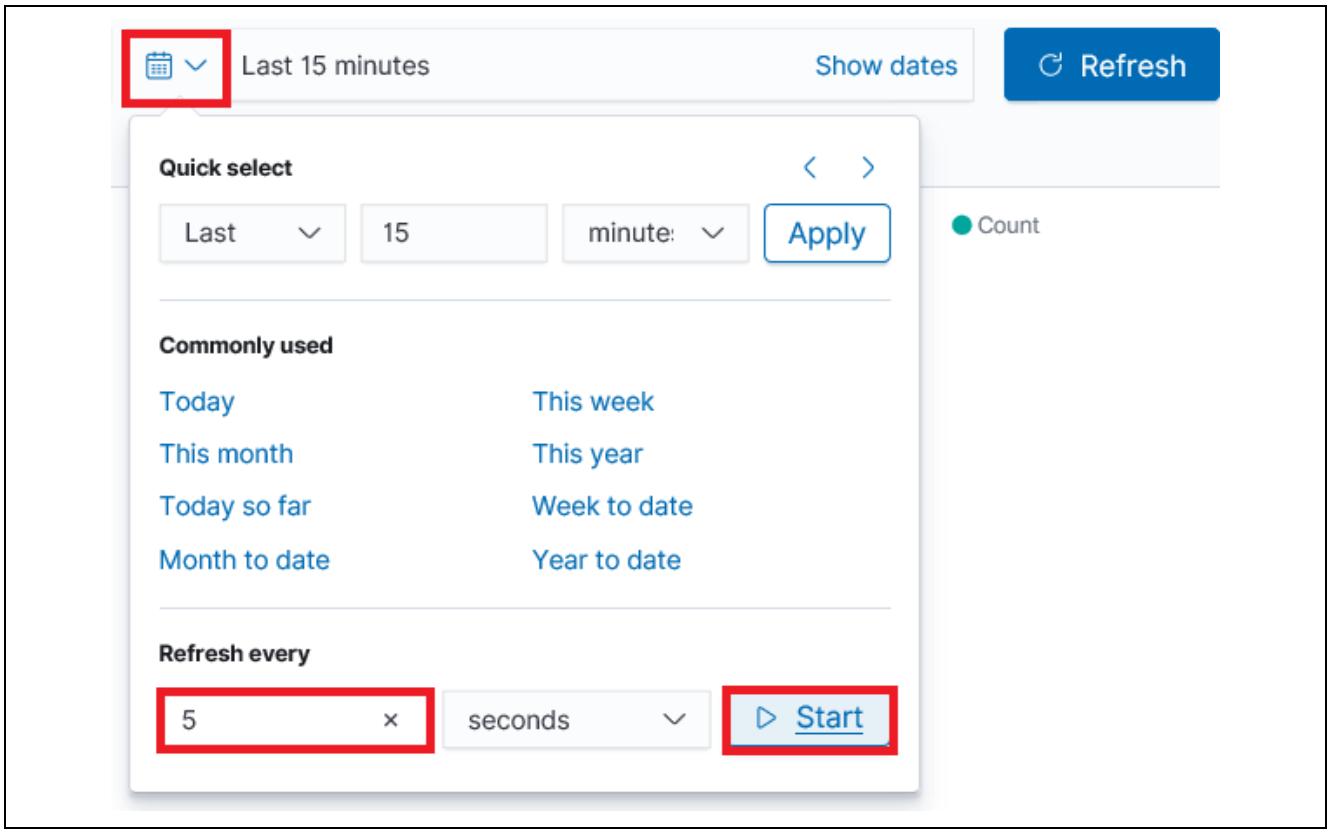

Figure 6.36 Refresh every Setting

9. For **Metrics**, under **Y-Axis** set **Aggregation** to **Average** and **Field** to **light**.

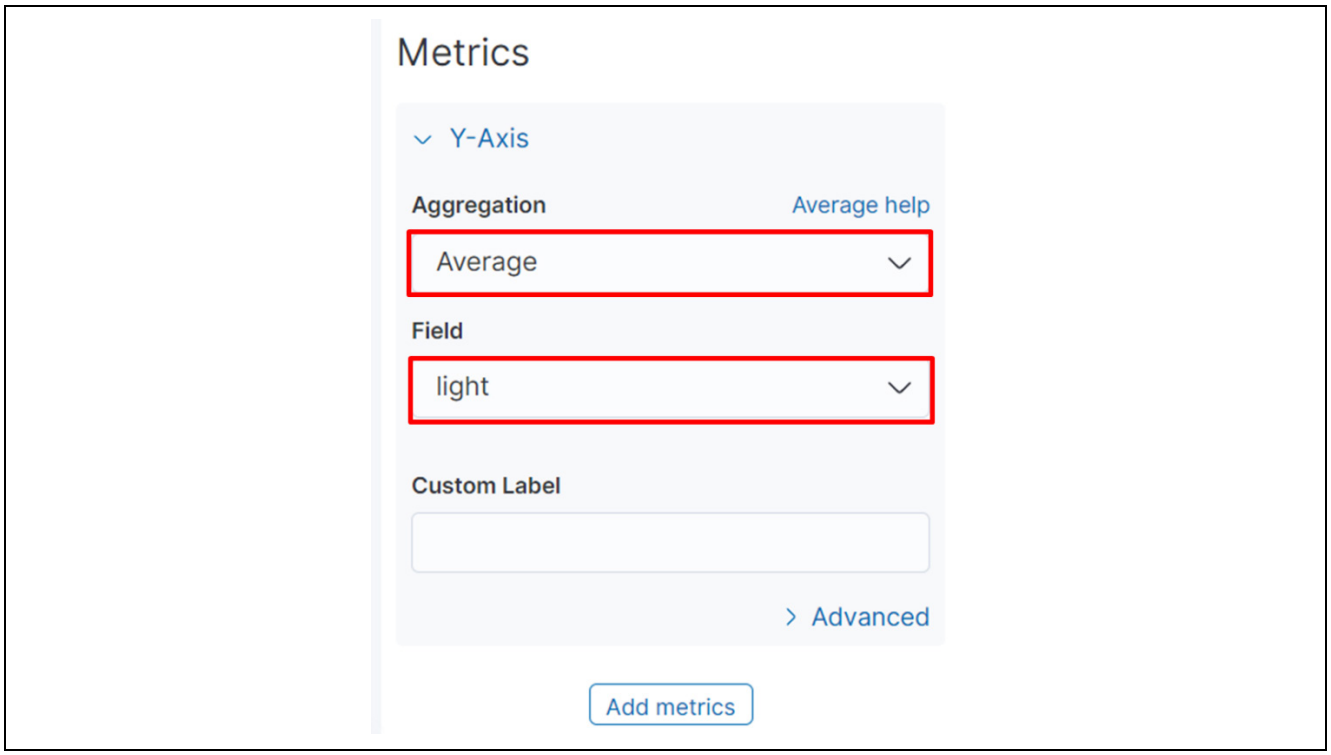

Figure 6.37 Metrics Settings

10. For **Buckets**, under **X-Axis** set **Aggregation** to **Date Histogram**, **Field** to **datetime**, and **Interval** to **Second**.

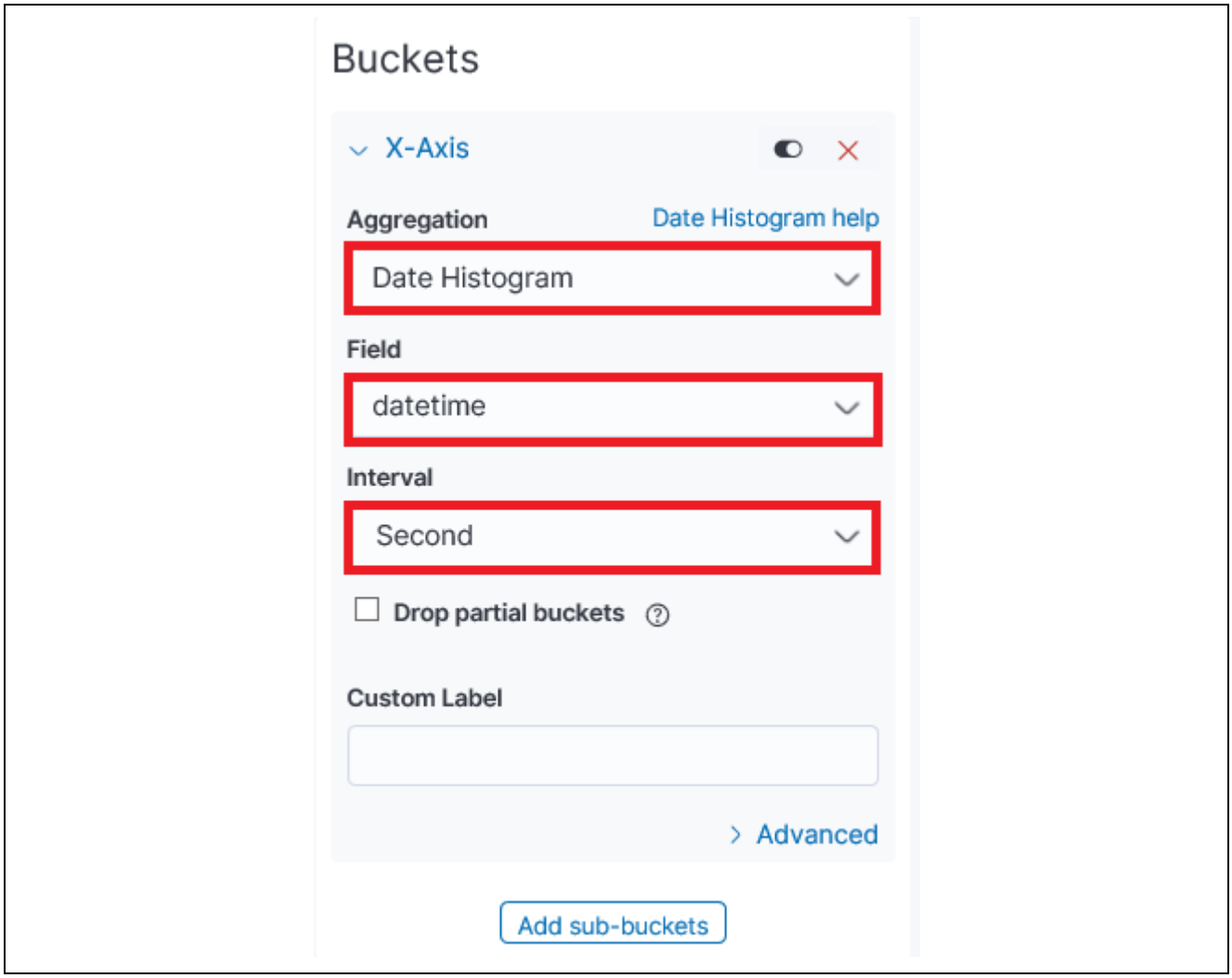

Figure 6.38 X-Axis Settings

11. Click the **Apply changes** icon.

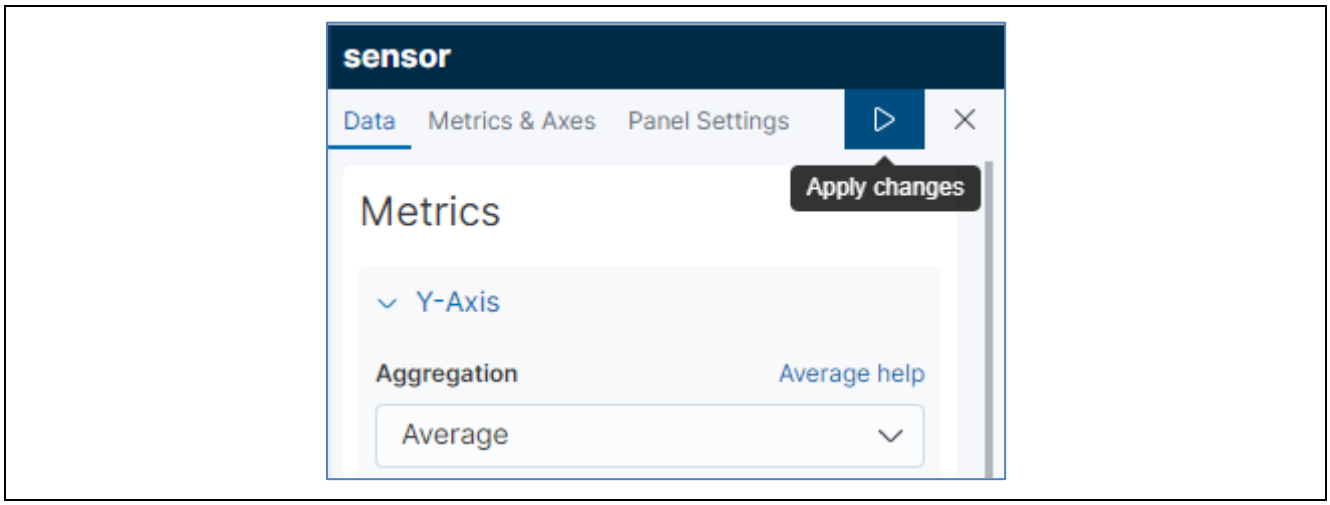

Figure 6.39 Apply changes

12. On the graph of sensor data, confirm that the values change when the brightness changes.
    (The line on the graph should move downward when you cover the board with your hand and move upward when more light strikes the board.)
    A visualization of light sensor information is shown below.

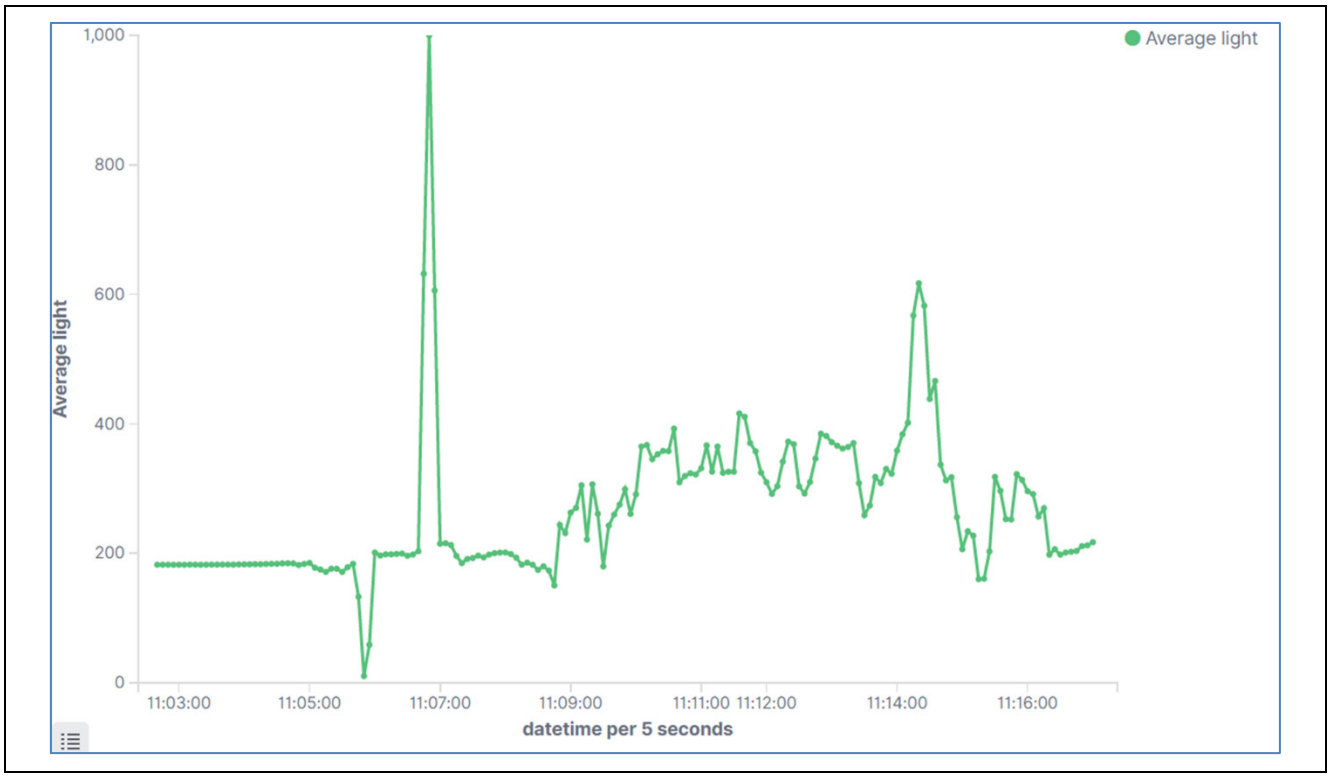

Figure 6.40 Visualization of Light Sensor Information

6.6 Important Note after Running Demo Program

Fees are incurred when are using the Amazon Elasticsearch Service.

Make sure to delete your Elasticsearch domain after you finish using the demo program.

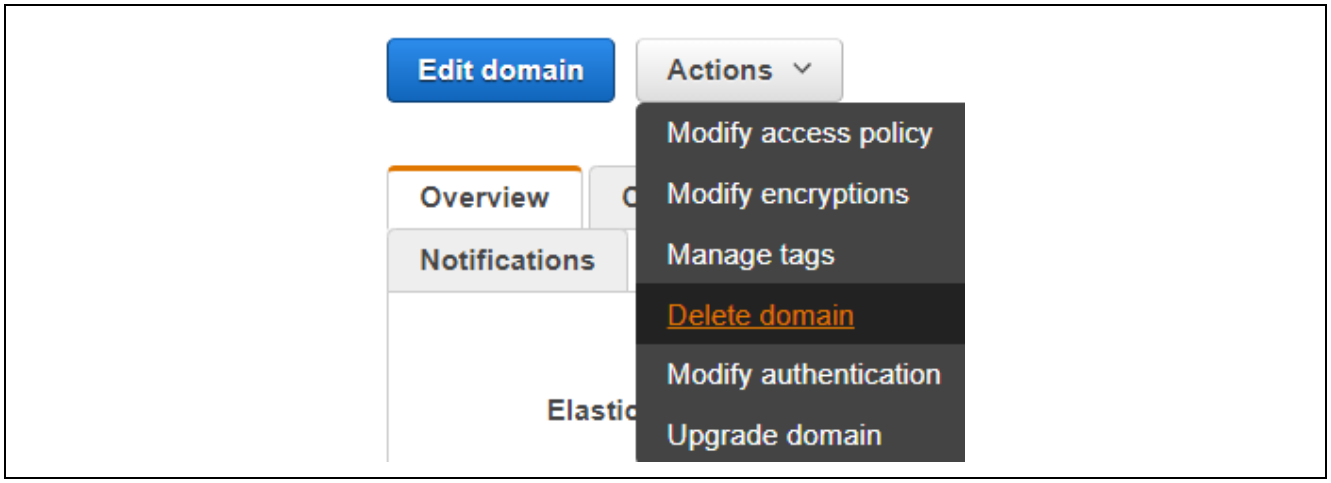

Figure 6.41 Don’t Forget to Delete Your Elasticsearch Domain!

7. Websites and Support

AWS Amazon FreeRTOS forum: http://forums.aws.amazon.com
Renesas Amazon FreeRTOS GitHub: https://github.com/renesas/amazon-freertos

Revision History

Rev.	Date	Description	
		Page	Summary
1.00	Jun. 23, 2021	—	First edition issued

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

The following usage notes are applicable to all Microprocessing unit and Microcontroller unit products from Renesas. For detailed usage notes on the products covered by this document, refer to the relevant sections of the document as well as any technical updates that have been issued for the products.

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

   Before changing from one product to another, for example to a product with a different part number, confirm that the change will not lead to problems. The characteristics of a microprocessing unit or microcontroller unit products in the same group but having a different part number might differ in terms of internal memory capacity, layout pattern, and other factors, which can affect the ranges of electrical characteristics, such as characteristic values, operating margins, immunity to noise, and amount of radiated noise. When changing to a product with a different part number, implement a system-evaluation test for the given product.

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