

Sub-1 GHz Sensor-to-Cloud Linux® E14 Kit

This guide provides steps to run the out-of-box Sensor-to-Cloud example. This kit allows you to view and control sensors on a Sub-1 GHz network from the cloud. All the devices in the kit are preprogrammed with required software. The kit includes two methods of operation: a cloud-connected gateway and a local gateway. The cloud-connected gateway lets you leverage cloud services such as [Amazon Web Services™](#) (AWS) and [IBM Watson® Internet of Things \(IoT\)](#). The local gateway lets you run a gateway within a local IP network for privately managed networks that do not require external connectivity. It is important to note that the design lets you quickly add *any* desired cloud service.

Kit Contents

- 5-V Power Supply
- [BeagleBone Black](#)
- [BeagleBone Wireless Connectivity Cape](#)
- FTDI Cable
- Preflashed MicroSD
- 2x [TI SimpleLink™ CC1350 LaunchPad™](#)
- 2x Micro-USB Type B Cable

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1 Hardware Setup

The BeagleBone Black (BBB) comes equipped with a BeagleBone Wireless Connectivity Cape and a preinserted microSD card with necessary software. Connect the BBB to the CC1350 LaunchPad labeled **MAC co-processor** as shown in [Figure 1](#). Connect the 5-V power supply to the BBB and an electrical outlet. The CC1350 LaunchPad labeled **Sensor** in [Figure 1](#) should be connected to any USB power source using the provided USB cable.

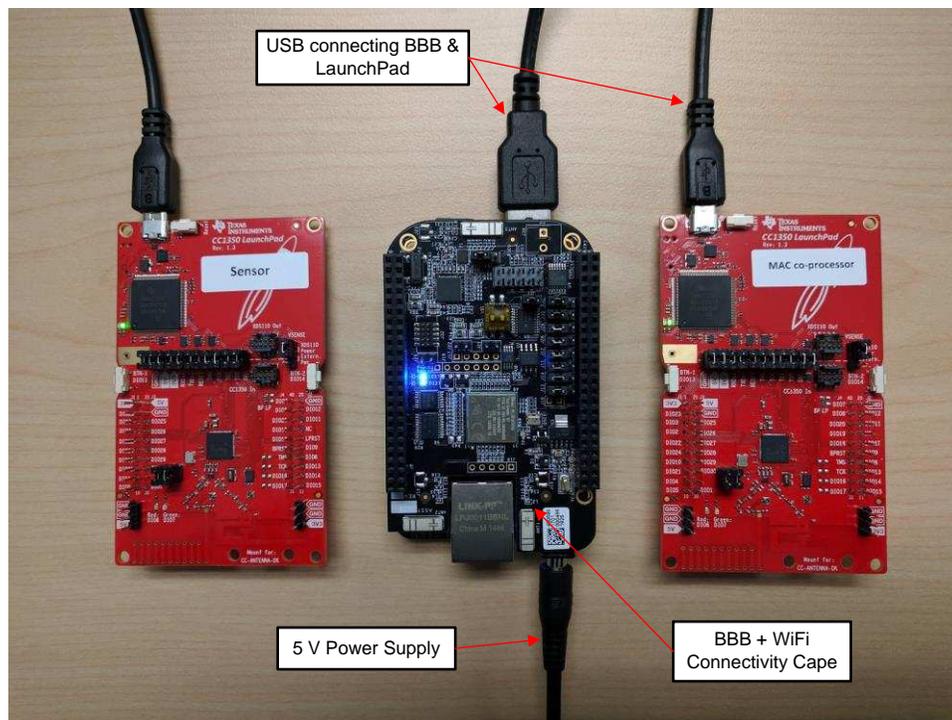


Figure 1. Sensor-to-Cloud Hardware Setup

2 Running the Demo

The BBB operates out of the box as a Wi-Fi® access point with SSID: **SitaraAP**. Connect to the network with a PC by using the password: **sensor-to-cloud**. Once connected, open a browser and type in the address bar: <http://192.168.43.1:1310>. This opens the Sensor-to-Cloud welcome page hosted on the BBB (see [Figure 2](#)).

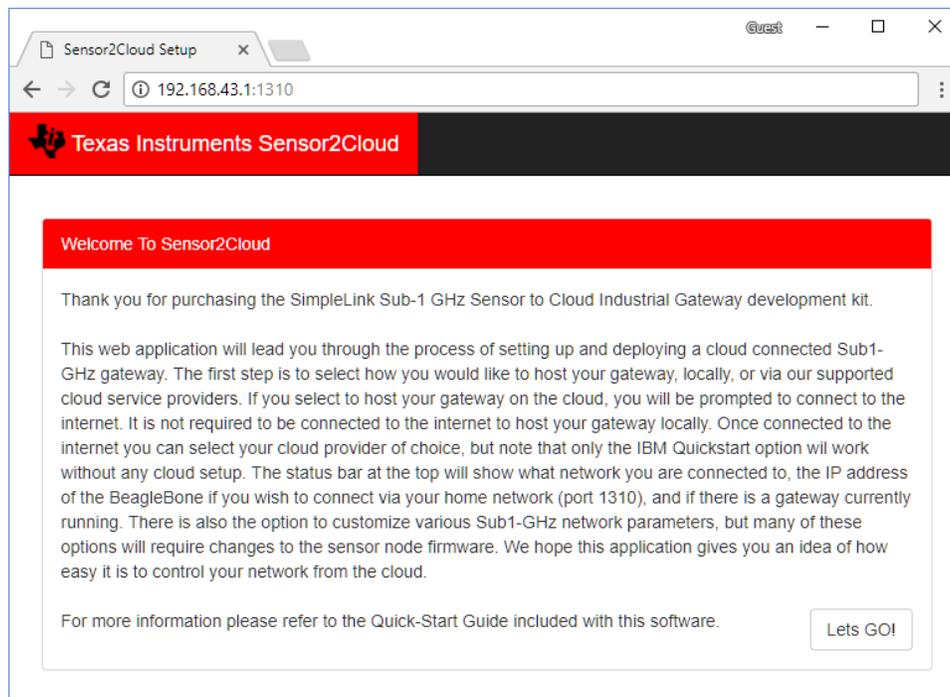


Figure 2. Sensor-to-Cloud Welcome Page

Select the method of operation for the demo:

- Cloud Gateway (see [Section 3](#))
The Cloud Gateway allows you to monitor and control the Sub-1 GHz network using AWS or IBM Cloud Service. The IBM Quickstart method is easy and requires no setup, while other methods require additional steps.
- Local Gateway (see [Section 8](#))
The Local Gateway is the best method to start with. This method allows you to monitor and control the Sub-1 GHz network using a local IP network for privately managed networks that do not need external connectivity.

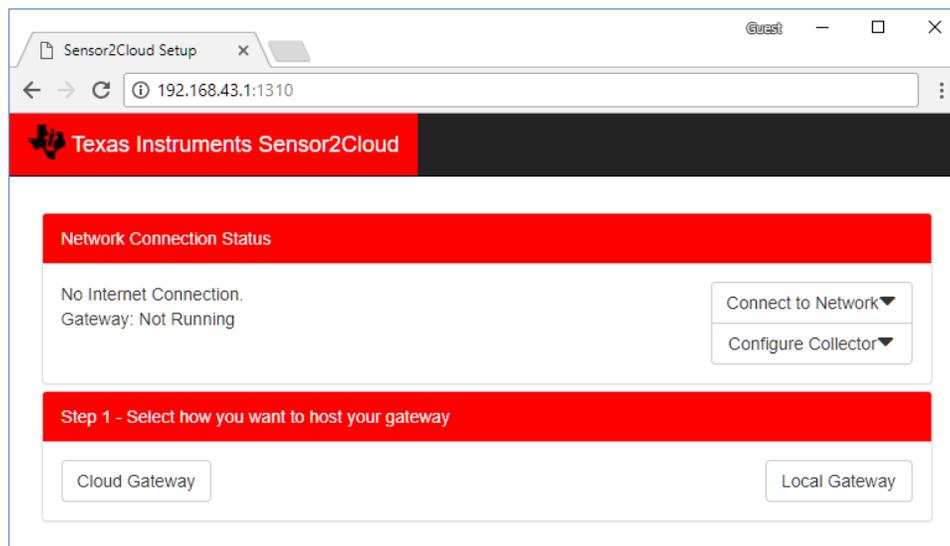


Figure 3. Sensor-to-Cloud Main Portal

3 Running Local Gateway

Clicking **Local Gateway** automatically redirects to the **TI 15.4-Stack Example Application - Collector Application** after a short delay (see [Figure 4](#)).

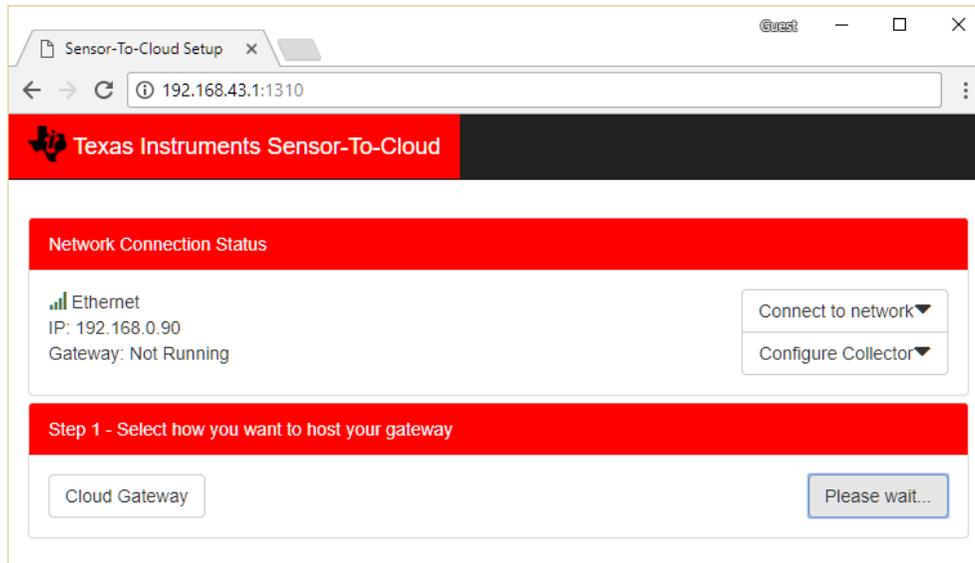


Figure 4. Selecting Local Gateway

1. Select **open** to allow the sensor to join the network.
2. Power on the sensor, if not done so already. The sensor will automatically join the network.

NOTE: If the sensor does not connect automatically, see [Section 8.1](#).

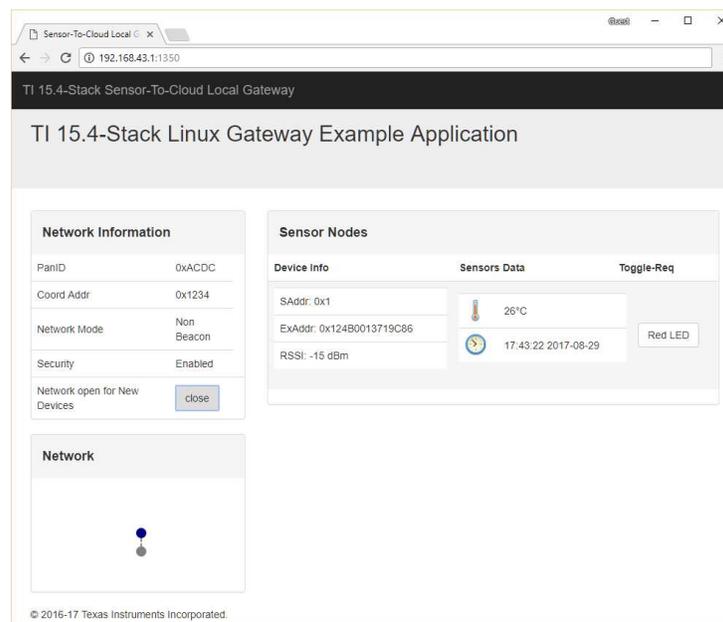


Figure 5. TI 15.4-Stack Linux Gateway Example Application

3. The sensor is now reporting data to the Sub-1 GHz gateway and allows you to control and visualize data on a local cloud platform. Use the **Red LED** option to control the red LED on the CC1350 LaunchPad labeled **Sensor**.

NOTE: There may be a few seconds of delay with the **Toggle** command.

4 Running Cloud Gateway

To run a **Cloud Gateway**, the BBB must be connected to the Internet.

1. Click **Cloud Gateway**.
2. The BBB can be connected through ethernet or Wi-Fi.
 - a. If you are using a Wi-Fi connection, skip to [Step 3](#).
 - b. For ethernet connections, attach an ethernet cable to the ethernet port on the BBB. You should see **Ethernet** in the *Network Connection Status* as seen in [Figure 6](#). Next, skip to [Step 4](#).

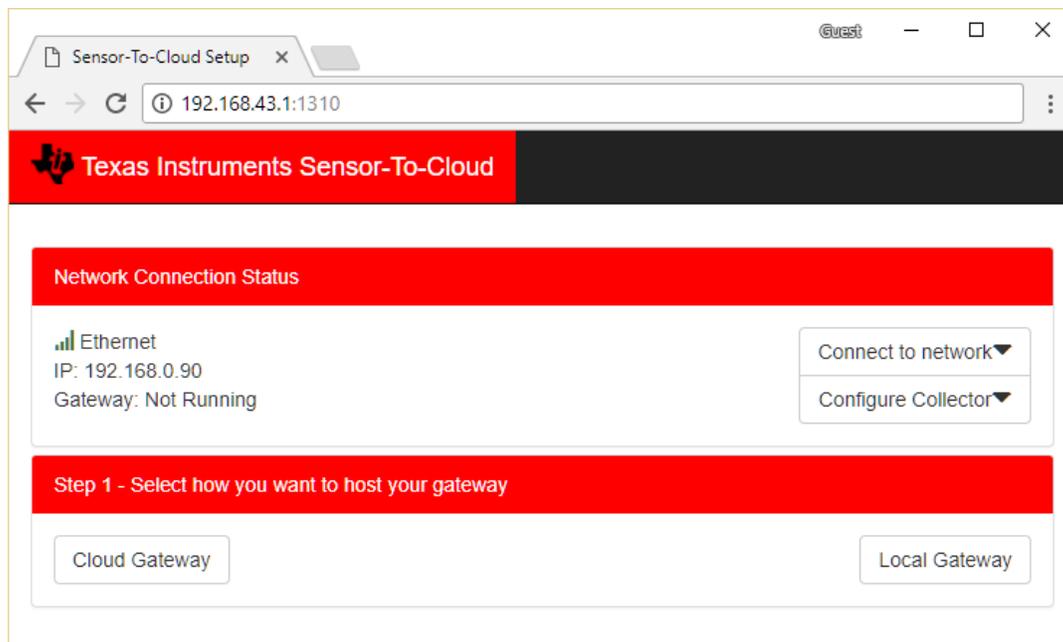


Figure 6. BBB Ethernet Connection

- To begin a 10-second network scan, select the drop-down menu adjacent to the **SSID** labeled **Click here to scan for available networks**. Select from the list of available networks and provide the **Network Key**. Selecting **Remember Network** causes the BBB to automatically connect to the selected network when possible. This is true even after the device has been reset.

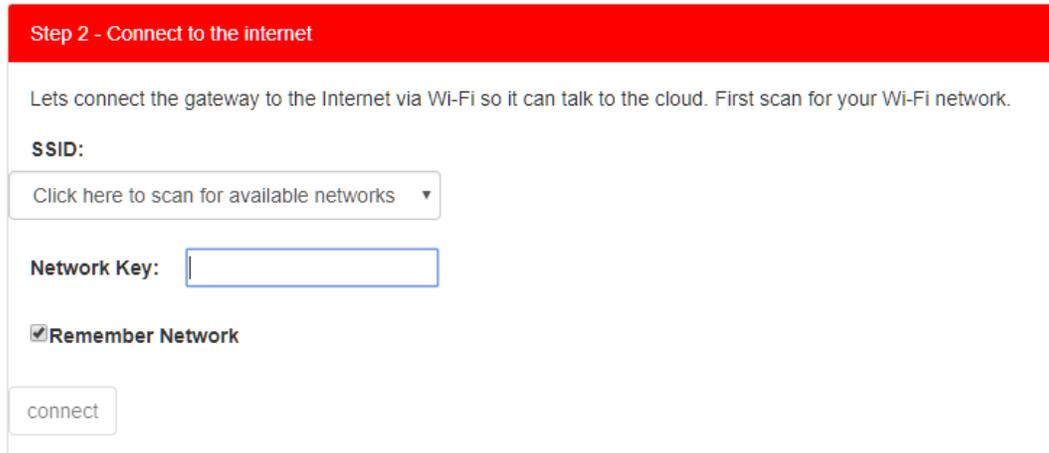


Figure 7. Internet Connection Configuration

- After successfully connecting to the Internet, select the desired cloud service (see [Figure 8](#)). The **Local Gateway** option may be selected even though it does not require an Internet connection. [Amazon Web Services](#) is provided through [stackArmor](#).

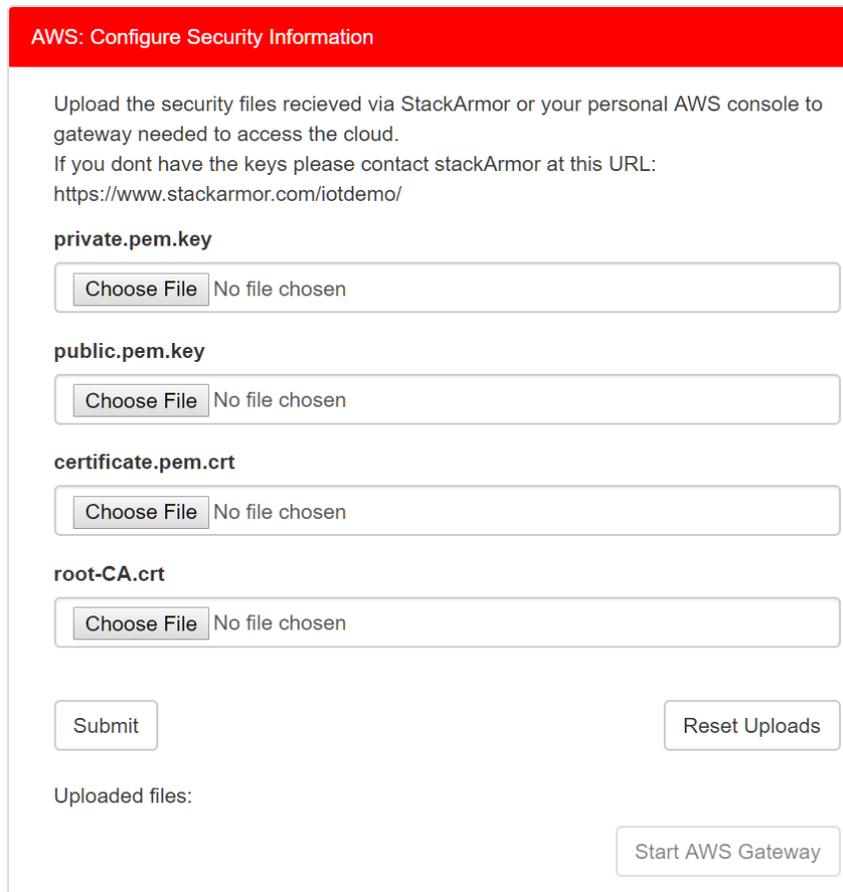


Figure 8. Cloud Service Selections

5 Using Amazon Web Services (AWS)

Use the following steps for Amazon Web Services:

1. [Section 2](#) and [Section 3](#) should be followed before continuing here (see [Section 2](#) and [Section 3](#), respectively).
2. Request credentials from [stackArmor](#).
If approved, stackArmor will provide the security credentials necessary for the steps that follow.
3. Use **Choose File** to select the security credentials received from [stackArmor](#).
4. Click **Submit** to upload the selected files.



AWS: Configure Security Information

Upload the security files recieved via StackArmor or your personal AWS console to gateway needed to access the cloud.
If you dont have the keys please contact stackArmor at this URL:
<https://www.stackarmor.com/iotdemo/>

private.pem.key
Choose File No file chosen

public.pem.key
Choose File No file chosen

certificate.pem.crt
Choose File No file chosen

root-CA.crt
Choose File No file chosen

Submit Reset Uploads

Uploaded files:
Start AWS Gateway

Figure 9. Uploading Security Credentials

5. After uploading the security files, select **Start AWS Gateway**. You will be prompted to enter the username and password provided through email from [stackArmor](#).

- You will automatically be redirected to the AWS IoT Dashboard through stackArmor, as shown in [Figure 10](#).

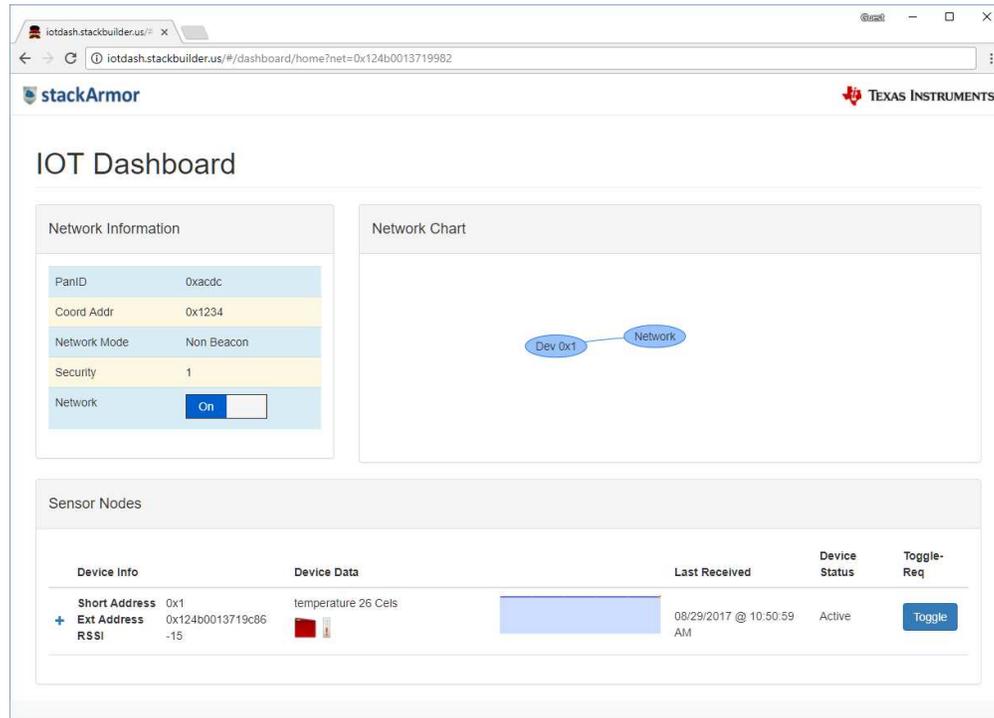


Figure 10. Internet-of-Things (IoT) Dashboard

- Power-on the sensor, if this is not already done. The sensor automatically joins the network and appears in the **Network Chart** and **Sensor Nodes** table, as shown in [Figure 10](#).

NOTE: If sensor does not connect automatically, see [Section 8.1](#).

- The sensor is now reporting data to the Sub-1 GHz gateway and allows you to control and visualize data through AWS. Use the **Toggle** option to control the red LED on the CC1350 LaunchPad labeled **Sensor**.

NOTE: There may be a few seconds of delay with the **Toggle** command.

6 Using IBM Quickstart

Section 2 and Section 3 should be followed before continuing here (see Section 2 and Section 3, respectively).

Selecting **IBM Quickstart** launches the IBM Watson IoT Platform.

NOTE: Currently, IBM Quickstart does not support a way to send commands from the cloud to the Sub-1 GHz gateway.

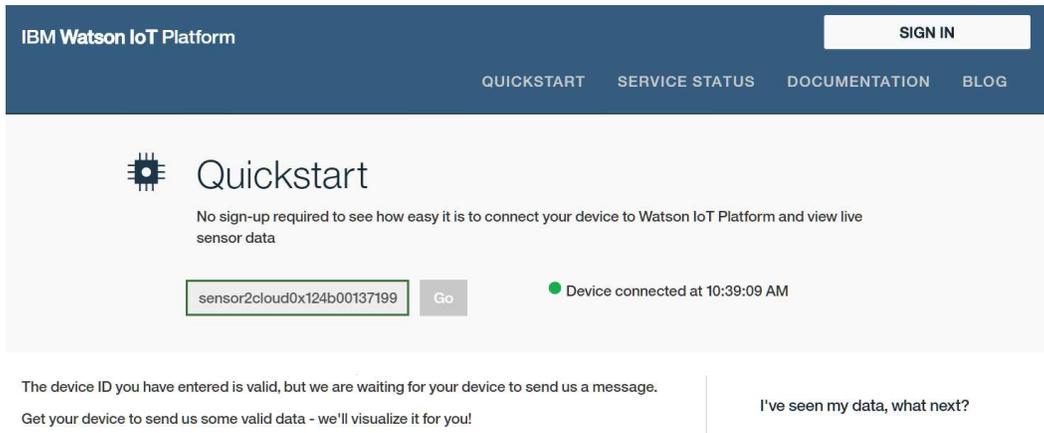


Figure 11. IBM Quickstart

1. Power on the sensor, if not done so already. The platform automatically detects the sensor, and the web page updates with a list of sensor data.

NOTE: If sensor does not connect automatically, see Section 8.1.

2. From the list of sensor data, select a sensor data point to see its value graphed. In Figure 12, `smart_objects.temperature.0.sensorValue` is selected.



Figure 12. IBM Quickstart Graph

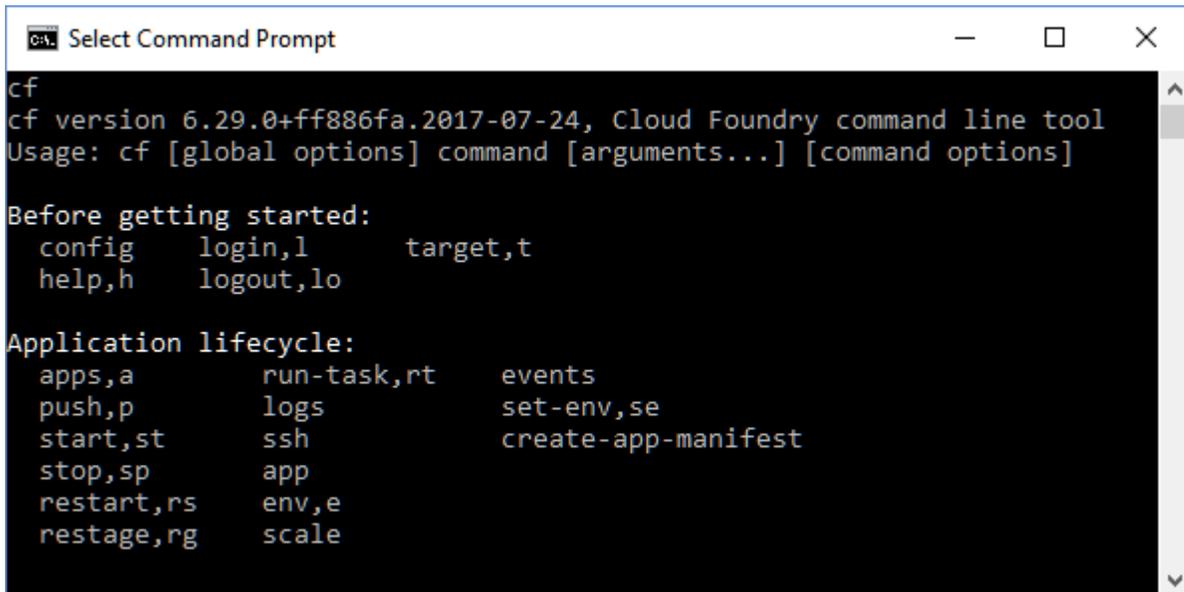
3. The sensor is now reporting data to the Sub-1 GHz gateway and allows you to visualize data through IBM Quickstart.

7 Using IBM Cloud Service

7.1 Download and Install Cloud Foundry CLI

Use the steps that follow to install the Cloud Foundry CLI tool on your PC.

1. On your PC, download and install the program from [Cloud Foundry CLI](#).
2. Verify installation by typing the command `cf` on the command line terminal. You should see output similar to that shown in [Figure 13](#).



```

Select Command Prompt
cf
cf version 6.29.0+ff886fa.2017-07-24, Cloud Foundry command line tool
Usage: cf [global options] command [arguments...] [command options]

Before getting started:
  config login,l target,t
  help,h  logout,lo

Application lifecycle:
  apps,a      run-task,rt  events
  push,p      logs        set-env,se
  start,st    ssh         create-app-manifest
  stop,sp     app
  restart,rs  env,e
  restage,rg  scale
  
```

Figure 13. S2C IBM cfTool

7.2 Open IBM Bluemix Account

If you do not have an IBM Bluemix® account, you must open one and use the steps that follow.

1. Create an [IBM Bluemix account](#) and register for a 30-day trial account.
2. Confirm the Bluemix account using the link provided by IBM through email.
3. Log into the Bluemix account page that is shown in [Figure 14](#).

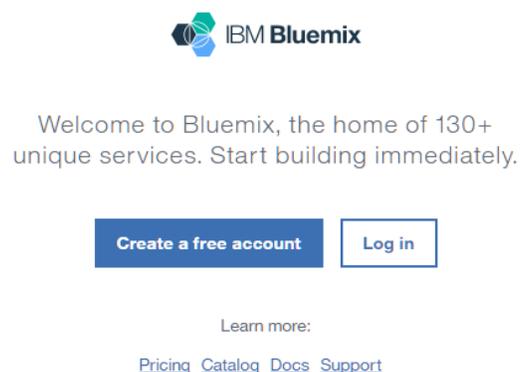


Figure 14. Sensor-to-Cloud IBM Bluemix

7.3 Create a Service

Use the steps that follow to create a service.

1. From the [IBM Bluemix Dashboard](#), select **Catalog** from the upper-right corner.
2. Select **Internet of Things** from the menu on the left, as shown in [Figure 15](#).



Figure 15. IBM Apps Menu

3. Select the **Internet of Things Platform**.

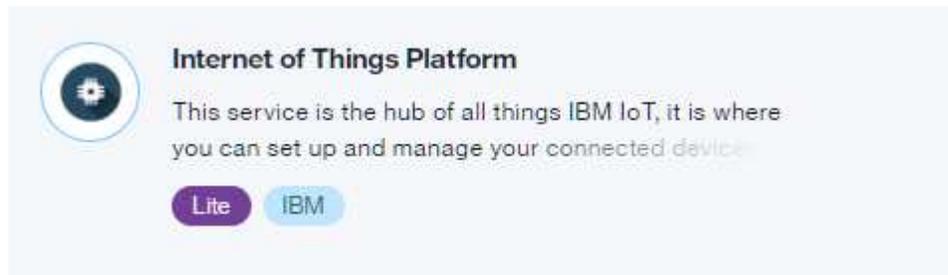


Figure 16. IoT Platform

4. Use **myService** as the **Service name**, though any name may be used. The service name, myService, will be used later in this user's guide. All other options can remain unchanged. Click **Create**. You should now see a screen as shown in [Figure 17](#).

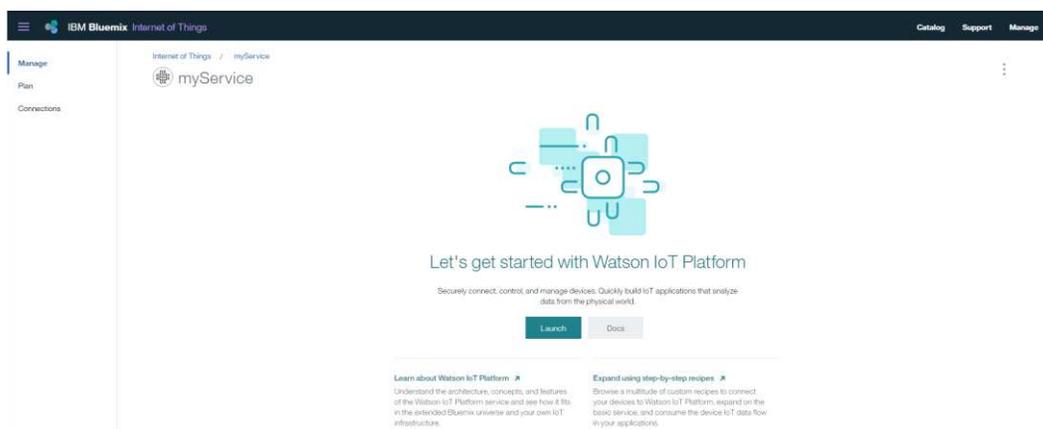


Figure 17. Service Launch

5. Select **Launch**.
6. Hover the mouse over the left side menu and select **Devices**. Click **+ Add Device**, as shown in [Figure 18](#).

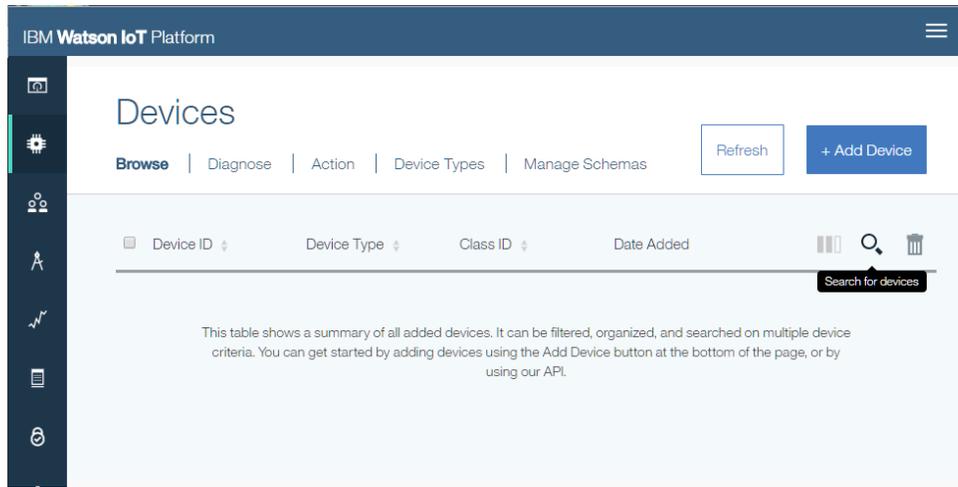


Figure 18. Devices Menu

7. Select **Create device type** (see [Figure 19](#)).

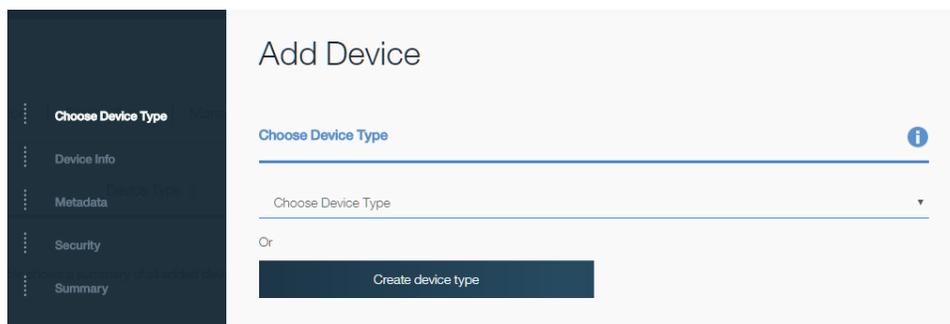


Figure 19. Create Device Type

8. Select **Create gateway type** on the next prompt (see [Figure 20](#)).



Figure 20. Create Gateway Device

9. Enter *gateway* as the **Name**, and add an optional description (see [Figure 21](#)). Click **Next**.



Figure 21. Device Name Gateway

- Click **Next**—ignoring the subsequent options—until reaching the **Add Device** screen that is shown in [Figure 22](#). From the **Choose Device Type** drop-down menu, select *gateway*. Click **Next**.

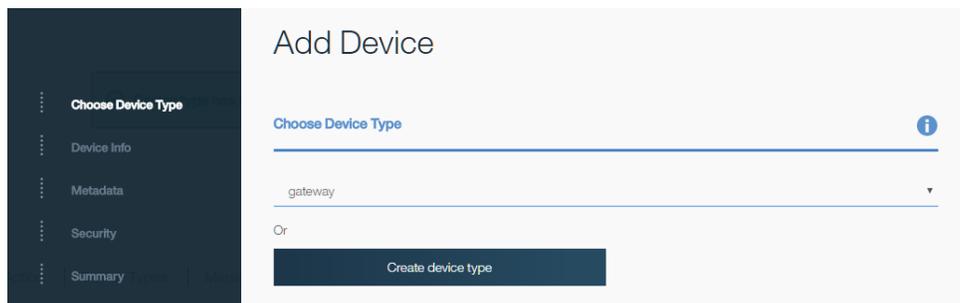


Figure 22. Choose Device Type

- Enter a **Device ID** (see [Figure 23](#)).

NOTE: It is important to remember the Device ID because it will be needed in a later step. This user's guide uses *myGatewayDevice* as the Device ID.

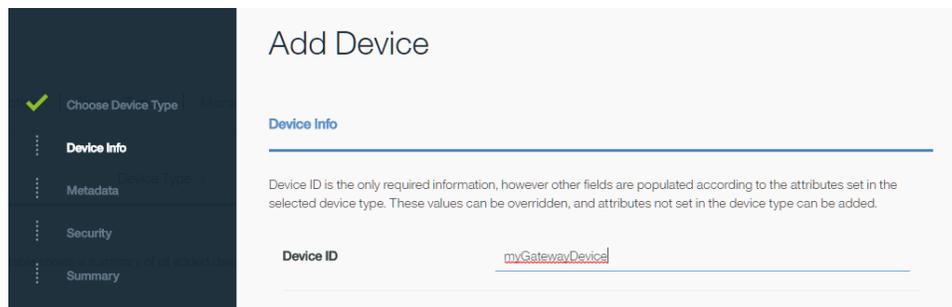


Figure 23. myGatewayDevice

- Click **Next** until reaching the security options screen, as shown in [Figure 24](#). Enter a token. Click **Next**.

NOTE: It is important to remember the token because it will be used in a later step.

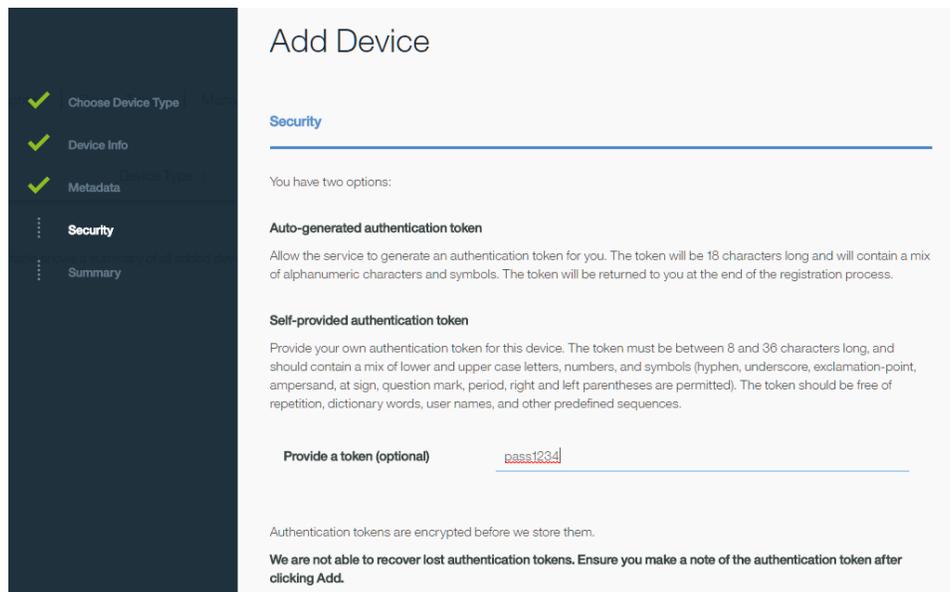


Figure 24. Providing a Token for a New Gateway Device

13. Use the *Summary* view to verify the **Device ID** and **Authentication Token**. Use the **Back** button to edit any items. When you are finished, click **Add**. You should now see your device credentials, as shown in [Figure 25](#).

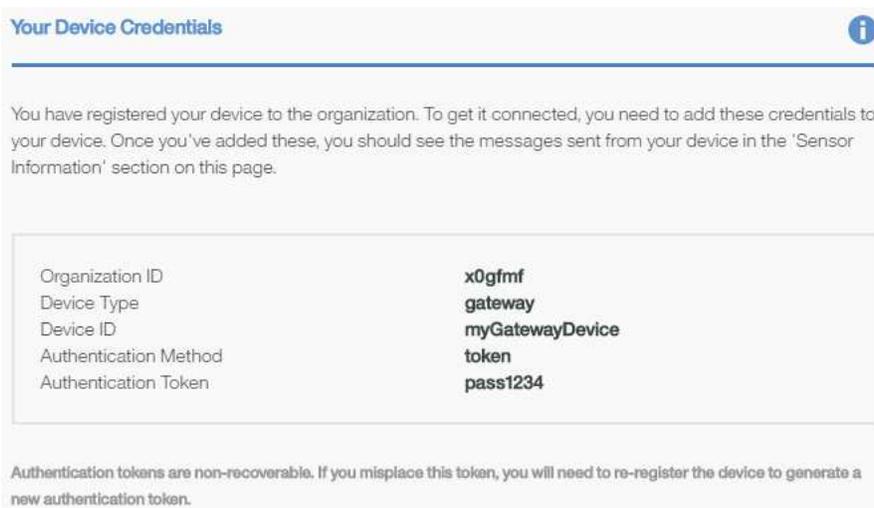


Figure 25. Gateway Device Credentials

14. Keep this web page open for later use.

7.4 Upload the Provided Cloud Foundry Application

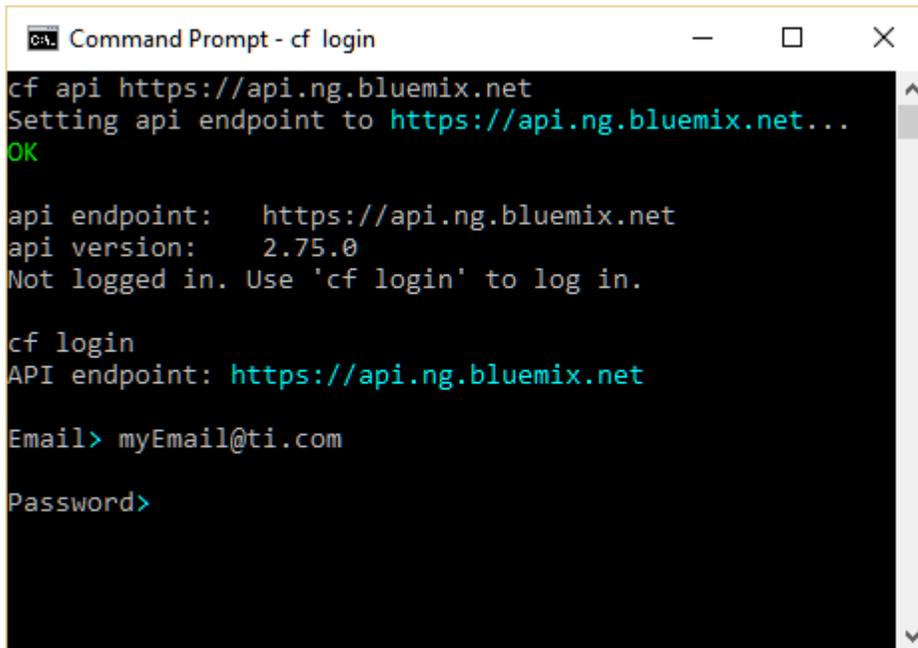
1. Go to [Gitortious](#). Click **Download master as tar.gz** to download the application source file.
2. Unzip the *master.gz* and *master* file. You will then have a directory called *~master*.
3. Navigate to the *master~/apps-tidep0084/examples/ibm-frontend* folder, and use a text editor to modify the **manifest.yml** file shown in [Figure 26](#). Select a name and unique hostname (**host**). The **host** will be used to generate a unique link to your cloud application. You will be able to tell if your selected hostname is already used in [Step 4](#). Add your service name to **services** using the service name from [Step 4](#) in the previous subsection.

```

1  applications:
2  - path: .
3    memory: 256M
4    instances: 1
5    domain: mybluemix.net
6    name: mys2capp
7    host: myS2Capp
8    disk_quota: 1024M
9    services:
10   - myService
    
```

Figure 26. S2C manifest.yml

4. Open a command line terminal and navigate to the *master~/apps-tidep0084/examples/ibm-frontend* directory. Enter the command **cf api https://api.ng.bluemix.net**. Then use the **cf login** command and log in with your account credentials created in [Step 2](#).



```

Command Prompt - cf login
cf api https://api.ng.bluemix.net
Setting api endpoint to https://api.ng.bluemix.net...
OK

api endpoint:  https://api.ng.bluemix.net
api version:   2.75.0
Not logged in. Use 'cf login' to log in.

cf login
API endpoint:  https://api.ng.bluemix.net

Email> myEmail@ti.com

Password>
    
```

Figure 27. Logging In Using the Cloud Foundry Tool

- After successful login, use **cf push** to upload the application (this may take a few minutes). If a unique hostname is not used, an error message will be generated. In that case, return to the **manifest.yml**, modify the host, and try again.
- Open the **IBM Bluemix Dashboard**. As shown in **Figure 28**, the application will now be visible under **Cloud Foundry Apps** with the name used in the **manifest.yml** file from **Step 3**. The **ROUTE** column displays a unique URL for the application. Select the application by clicking the row.

NOTE: Do not click the URL in the **ROUTE** column—doing so will open the application overview.



Figure 28. IBM Bluemix Dashboard Displaying Cloud Foundry Apps

- Click **Connections** in the menu to the left. The service created in **Section 7.3** should be visible. If not, use the **Connect existing** button to add the service.
- Click **View credentials** (see **Figure 29**). This displays all the information necessary to launch your BBB gateway.

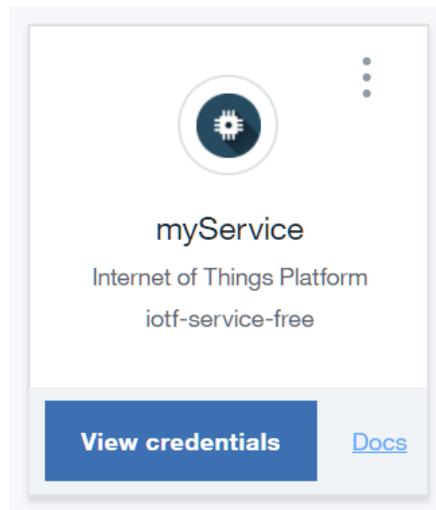


Figure 29. Click *View credentials* to Display Credentials for the Service Created in **Section 7.3**

7.5 Launching the Demo

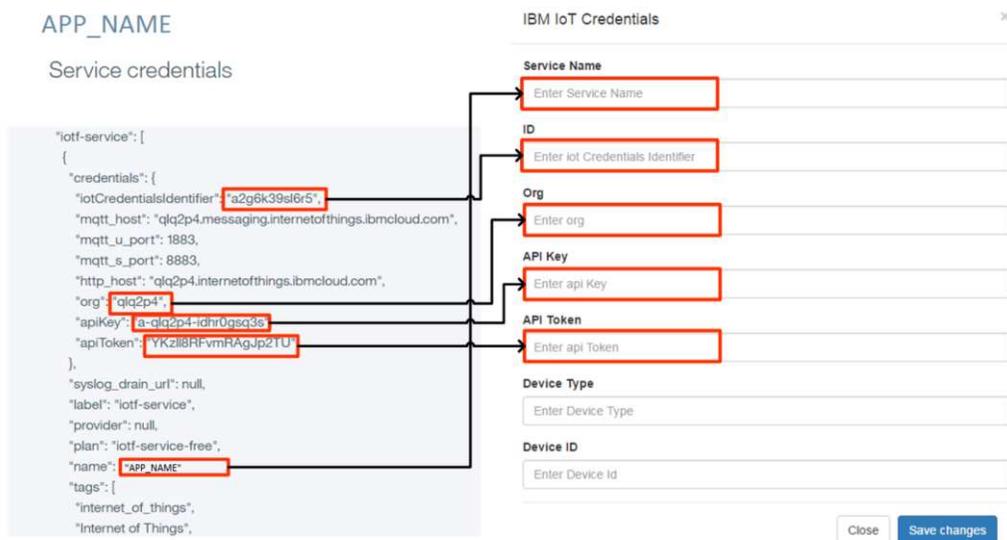
Use the following steps to launch the demo.

1. In a new web browser window, open the [IBM Bluemix Dashboard](#). Click the application URL in the **ROUTE** column that is highlighted in [Figure 30](#). This action launches the TI 15.4-Stack Linux Gateway Example Application web page.



Figure 30. Use the URL of the Cloud Foundry App to Access the TI 15.4-Stack Linux Gateway Example Application

2. Click the gear icon located in the title header of the web page. Using the credentials from [Step 5](#), enter the following information. For **Device Type**, use *gateway*. Use the same **Device ID** used in [Step 6](#). Click **Save changes**. See [Figure 31](#).



- (1) Service credentials from [Step 5](#) appear on the left.
- (2) Use these service credentials to populate fields in the IBM IoT Credentials.

Figure 31. Service Credentials

3. In another web browser window, access the BBB Sensor-to-Cloud portal and select *IBM* as the gateway type.

NOTE: Ensure your PC is connected to the SitaraAP wireless network. Access the BBB Sensor-to-Cloud portal by entering <http://192.168.43.1:1310> into your web browser. Select **Cloud Gateway** and then **IBM**. See [Section 2](#) and [Section 4](#) if necessary.

4. Use the **Org** listed in the service credentials from [Step 7](#). For **Type** use *gateway*, and for **ID** use the device ID from [Step 11](#) of [Section 7.3](#). Lastly, use the token created in [Step 12](#) of [Section 7.3](#). Click **Start IBM Gateway**.

Org
Type
ID
Token

- (1) Service credentials from [Step 5](#) appear on the left.
- (2) Use these service credentials to populate fields in Sensor-to-Cloud application settings.

Figure 32. Start IBM Gateway

5. Return to the TI 15.4-Stack Linux Gateway Example Application.
6. The web page should automatically update, as shown in [Figure 33](#).

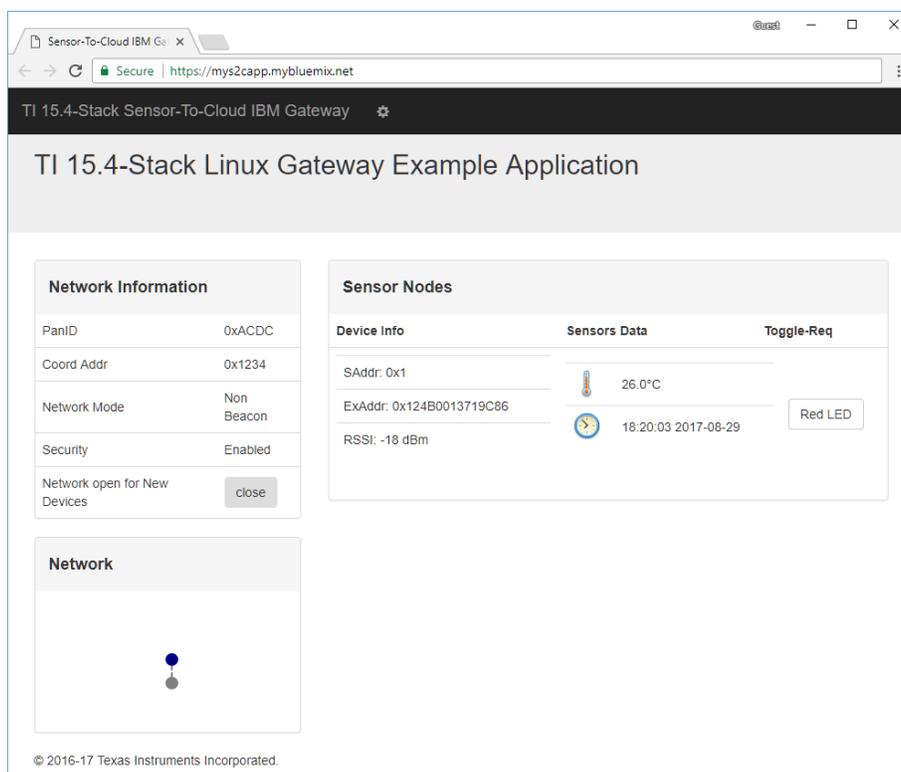


Figure 33. TI 15.4-Stack Linux Gateway Example Application

7. Select **open** to allow the sensors to join the network.
8. Power on the sensors, if not done so already. The sensors will automatically join the network.

NOTE: If the sensor does not connect automatically, see [Section 8.1](#).

8 Troubleshooting

8.1 Sensor Will Not Join the Network

1. To ensure the network is open, toggle the Network **Open/Close** or **On/Off** option.
2. Sensors use nonvolatile storage to remember previous networks. Press and hold the **BTN-2/DIO014** button, and toggle the **Reset** button (see [Figure 34](#)). This action clears the nonvolatile storage and causes the sensor to search for new networks.



Figure 34. The Reset and BTN-2/DIO014 Buttons are Outlined

3. If the sensor still does not join the network, restart the gateway and apply the previous step.

8.2 *How to Determine if the Sensor is Connected to a Network*

If the sensor does not have a saved network in nonvolatile storage after a reset, the LEDs labeled **Red:DIO06** and **Green:DIO07** on the CC1350 LaunchPad **Sensor** will both be off. Both LEDs will remain off until the sensor connects to a network. When the sensor joins a network, the red LED will turn on and the green LED will periodically blink.

If the sensor has a saved network in nonvolatile storage after a reset, the red LED will be on. The green LED will periodically blink.

NOTE: In some instances, the red LED may be toggled from the cloud user interface.

8.3 *BeagleBone Black Will Not Connect to a Cloud Service*

Ensure that the BBB is connected to the Internet. While your PC is connected to the **SitaraAP** access point, you should be able to access the Internet. If not, the BBB is not connected to the Internet. In this case, verify that the connection source for the BBB has Internet access.

8.4 *Local Gateway Fails to Start*

The Local Gateway fails to start if the CC1350 LaunchPad **Co-Processor** is not properly connected to the BBB.

9 Next Steps

You have seen a sensor-to-cloud network in action and you are ready to proceed. TI provides a complete portfolio to accelerate your product from the drawing board to your consumers. Review the software design to get a comprehensive understanding of the system design. Then use a TI Design reference as a template to develop your own custom home or industrial automation network. How quickly can you connect?

9.1 Get More Details on the Software Design

For a detailed description of the design and software, download the [Sub-1 GHz Sensor to Cloud Industrial IoT Gateway Reference Design](#) (TIDEP0084). The TIDEP0084 reference design demonstrates how to connect sensors to the cloud over a long-range Sub-1 GHz wireless network, suitable for industrial settings such as building control and asset tracking. The reference design is powered by a [TI Sitara™ AM335x](#) processor and the SimpleLink™ Sub-1 GHz CC1310/CC1350 devices. The reference design pre-integrates the TI 15.4-Stack Software Development Kit (SDK) for Sub-1 GHz star network connectivity and the [AM335x Sitara™ Processors SDK](#). TI Design Network partner stackArmor supports the cloud application services for cloud connectivity and visualization of the sensor node data.

9.1.1 Get Software Updates

To get software updates, visit the [TIDEP0084 git repository](#).

9.2 Sensor Examples

9.2.1 Develop Your Custom Sensor Application

To develop your own custom sensor application, download the [CC13x0 SimpleLink™ Sub-1 GHz Software Development Kit](#). This SDK provides a comprehensive Sub-1 GHz software package for the [CC1310 SimpleLink™ Sub-1 GHz Wireless Microcontroller \(MCU\) LaunchPad™ Development Kit](#) and the [CC1350 SimpleLink™ Sub-1 GHz and Bluetooth® low energy Wireless Microcontroller LaunchPad™ Development Kit](#) and includes the TI 15.4-Stack sensor example applications, which may be used as a framework for your custom application.

9.2.1.1 Adding New Sensors

To add support for new sensors, visit the [Adding New Sensor Support](#) wiki page.

9.2.2 Get Sensor TI Designs

See these sensor-to-cloud-enabled TI Designs that let you quickly create home automation or industrial automation networks.

- [TIDA-01476 Low Power Wireless PIR Motion Detector](#)
 - [Get the software here](#).

9.3 SimpleLink™ Sub-1 GHz Embedded Sensor-to-Cloud Gateway

For a low-cost embedded sensor-to-cloud gateway, download the [SimpleLink™ Sub-1 GHz Embedded Sensor-to-Cloud Reference Design](#) (TIDC-01002). The TIDC-01002 gateway solution is based on the low-power, [CC3220SF SimpleLink™ Wi-Fi® Wireless Microcontroller LaunchPad™](#), which hosts the gateway application and the [CC1310 SimpleLink™ Sub-1 GHz Wireless Microcontroller \(MCU\) LaunchPad™ Development Kit](#) as the MAC-CO Processor. This reference design also includes sensor node example applications running on the [CC1350 SimpleLink™ Sub-1 GHz and Bluetooth® low energy Wireless Microcontroller LaunchPad™ Development Kit](#).

9.4 Support

For questions and support, visit TI's [E2E™ community forum](#).

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