

# Chapter 6: Amazon FreeRTOS & Reference Flow

After completing this chapter, you will understand Amazon FreeRTOS and how to build IoT projects using Cypress Wi-Fi, Bluetooth, and PSoC 6.

<b>6.1</b>	<b>AMAZON FREERTOS TOUR .....</b>	<b>3</b>
6.1.1	CONNECTIVITY OVERVIEW .....	3
6.1.2	FIRMWARE OVERVIEW .....	3
6.1.3	AFR WEBSITE.....	4
6.1.4	FREERTOS WEBSITE .....	5
6.1.5	CYPRESS WEBSITE .....	6
6.1.6	CYPRESS GITHUB.....	7
6.1.7	CYPRESS COMMUNITY .....	8
6.1.8	DOCUMENTATION .....	9
<b>6.2</b>	<b>DEMO WALKTHROUGH.....</b>	<b>15</b>
<b>6.3</b>	<b>EXERCISES (PART 1) .....</b>	<b>25</b>
6.3.1	RUN THE MQTT DEMO.....	25
6.3.2	MODIFY THE PROJECT TO PUBLISH TO A DIFFERENT TOPIC .....	25
<b>6.4</b>	<b>AWS FREERTOS DIRECTORY ORGANIZATION .....</b>	<b>26</b>
6.4.1	TOP LEVEL ORGANIZATION.....	26
6.4.2	DEMOS .....	26
6.4.3	VENDORS .....	30
6.4.4	PROJECTS.....	31
<b>6.5</b>	<b>AWS DEMO NETWORK MANAGER.....</b>	<b>32</b>
6.5.1	INTERFACE HEADERS .....	32
6.5.2	CONFIGURATION MACROS .....	33
6.5.3	NETWORK STATES.....	33
6.5.4	FUNCTIONS.....	33
6.5.5	NETWORK MANAGER - CAUTION .....	34
<b>6.6</b>	<b>APPLICATION &amp; DEMO FIRMWARE FLOW (SOURCE CODE).....</b>	<b>35</b>
6.6.1	STARTUP .....	35
6.6.2	DEMO_RUNNER.....	35
6.6.3	MQTT DEMO.....	37
6.6.4	SHADOW DEMO .....	37
6.6.5	YOUR APPLICATION .....	37
<b>6.7</b>	<b>FREERTOS CONFIGURATION .....</b>	<b>37</b>
6.7.1	CONFIGUSE_DAEMON_TASK_STARTUP_HOOK – vAPPLICATIONDAEMONTASKSTARTUPHOOK .....	37
6.7.2	CONFIGUSE_IDLE_HOOK – vAPPLICATIONIDLEHOOK .....	37
6.7.3	CONFIGUSE_TICK_HOOK – vAPPLICATIONTICKHOOK .....	38
6.7.4	CONFIGPRINTF – vLOGGINGPRINTF .....	38
6.7.5	CONFIGUSE_MALLOC_FAILED_HOOK – vAPPLICATIONMALLOCFAILEDHOOK .....	38
6.7.6	CONFIGCHECK_FOR_STACK_OVERFLOW – vAPPLICATIONSTACKOVERFLOWHOOK .....	39
<b>6.8</b>	<b>FREERTOS NAMING CONVENTION(S).....</b>	<b>39</b>
6.8.1	VARIABLES.....	39
6.8.2	FUNCTIONS.....	40
6.8.3	MACROS.....	40
<b>6.9</b>	<b>AMAZON FREERTOS LIBRARIES.....</b>	<b>40</b>
6.9.1	MQTT .....	40
6.9.2	BLUETOOTH .....	41
6.9.3	LOGGING .....	42
6.9.4	AWS DEVICE SHADOW .....	44

---

<b>6.10 USING THE CYPRESS HAL &amp; PDL .....</b>	<b>44</b>
<b>6.11 BUILD SYSTEM .....</b>	<b>45</b>
6.11.1   MAKE .....	45
6.11.2   CMAKE .....	45
<b>6.12 COMING IN FUTURE RELEASES .....</b>	<b>46</b>
<b>6.13 EXERCISES (PART 2) .....</b>	<b>47</b>
6.13.1   AWS IoT SETUP.....	47
6.13.2   AWS COGNITO SETUP.....	48
6.13.3   BUILDING THE iOS APP .....	50
6.13.4   BUILDING THE ANDROID APP .....	54
6.13.5   RUNNING MQTT OVER BLE DEMO.....	57
6.13.6   RUNNING BLE GATT SERVER DEMO .....	67
6.13.7   Wi-Fi SCAN AND CONNECT TO ACCESS POINT .....	72
6.13.8   DISPLAY USING TFT .....	73
6.13.9   MODIFY THE MQTT DEMO WITH DISPLAY .....	74
6.13.10   RETARGET CONFIGPRINTF.....	75
6.13.11   SIMPLE MQTT OVER Wi-Fi.....	76
6.13.12   SIMPLE MQTT OVER BLE.....	77
6.13.13   USE TFT TO DISPLAY MESSAGES RECEIVED VIA MQTT SUBSCRIBE.....	79
6.13.14   RUN THE SHADOW DEMO .....	80
6.13.15   UPDATE SHADOW WITH COUNT OF BUTTON PRESSES .....	83
6.13.16   ADVERTISE WITH BLE.....	85
6.13.17   MAKE THE LOGGING SYSTEM SEND LOG MESSAGES TO AN MQTT TOPIC.....	87
6.13.18   USE HTTPS TO UPDATE A SHADOW STATE .....	88
6.13.19   USE HTTPS TO GET THE SHADOW STATE.....	91
6.13.20   FIX THE LOGGING SYSTEM TO PRINT OUT THE TIME INSTEAD OF [LU] .....	93

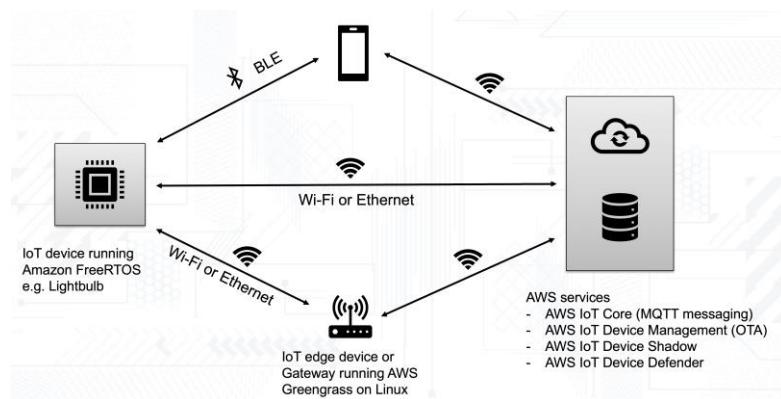
## 6.1 Amazon FreeRTOS Tour

Amazon FreeRTOS (AFR) is a release of FreeRTOS that has been packaged (by Amazon) with a TCP/IP Stack, MBED TLS, and a complete set of IoT Middleware libraries, which can be used to connect to the Amazon Web Services IoT Core. Cypress extended this release by adding the PSoC 6 libraries (HAL, PDL) and the required drivers to use the Cypress PSoC 6 & 43xxx Wi-Fi Bluetooth combo radios.

FreeRTOS continues as a stand-alone open source product sponsored by Amazon, but it is distributed by FreeRTOS.org.

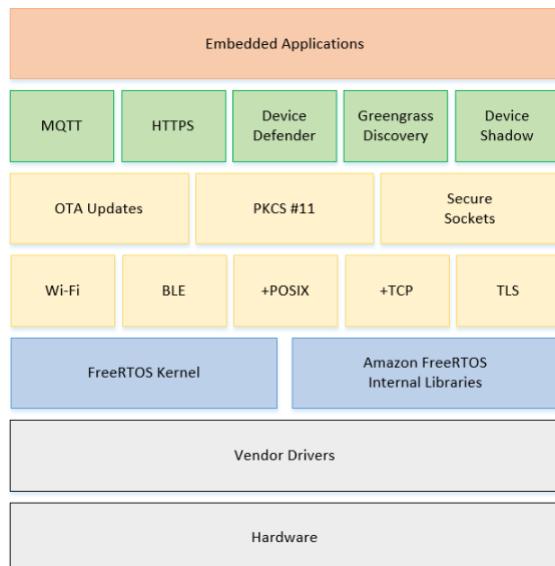
### 6.1.1 Connectivity Overview

AFR is built around the singular objective of implementing IoT systems that connect to the AWS cloud directly or via Greengrass using Wi-Fi or Bluetooth.



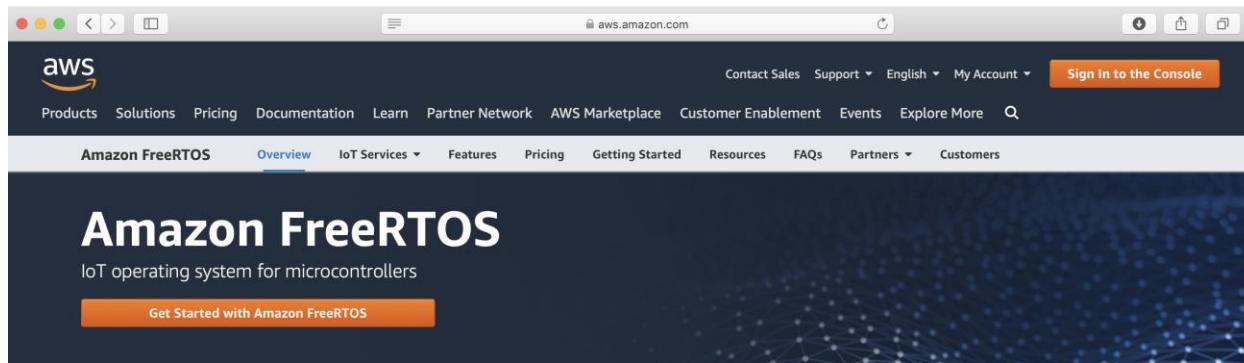
### 6.1.2 Firmware Overview

Amazon FreeRTOS includes a complete version of FreeRTOS, an MCU framework, and an IoT framework.



### 6.1.3 AFR Website

<https://aws.amazon.com/freertos/>



Amazon FreeRTOS (aFreeRTOS) is an open source operating system for microcontrollers that makes small, low-power edge devices easy to program, deploy, secure, connect, and manage. Amazon FreeRTOS extends the FreeRTOS kernel, a popular open source operating system for microcontrollers, with software libraries that make it easy to securely connect your small, low-power devices to AWS cloud services like AWS IoT Core or to more powerful edge devices running AWS IoT Greengrass.

A microcontroller (MCU) is a single chip containing a simple processor that can be found in many devices, including appliances, sensors, fitness trackers, industrial automation, and automobiles. Many of these small devices could benefit from connecting to the cloud or locally to other devices. For example, smart electricity meters need to connect to the cloud to report on usage, and building security systems need to communicate locally so that a door will unlock when you badge in. Microcontrollers have limited compute power and memory capacity and typically perform simple, functional tasks. Microcontrollers frequently run operating systems that do not have built-in functionality to connect to local networks or the cloud, making IoT applications a challenge. Amazon FreeRTOS helps solve this problem by providing both the core operating system (to run the edge device) as well as software libraries that make it easy to securely connect to the cloud (or other edge devices) so you can collect data from them for IoT applications and take action.

To get started, you can select a device from the AWS Partner Device Catalog. Then, you can use the Amazon FreeRTOS console to download Amazon FreeRTOS for your device or download from GitHub. Amazon FreeRTOS is open source and there is no charge to use it. Visit our getting started page to learn more about Amazon FreeRTOS.



What is Amazon FreeRTOS? (1:38)

## 6.1.4 FreeRTOS Website

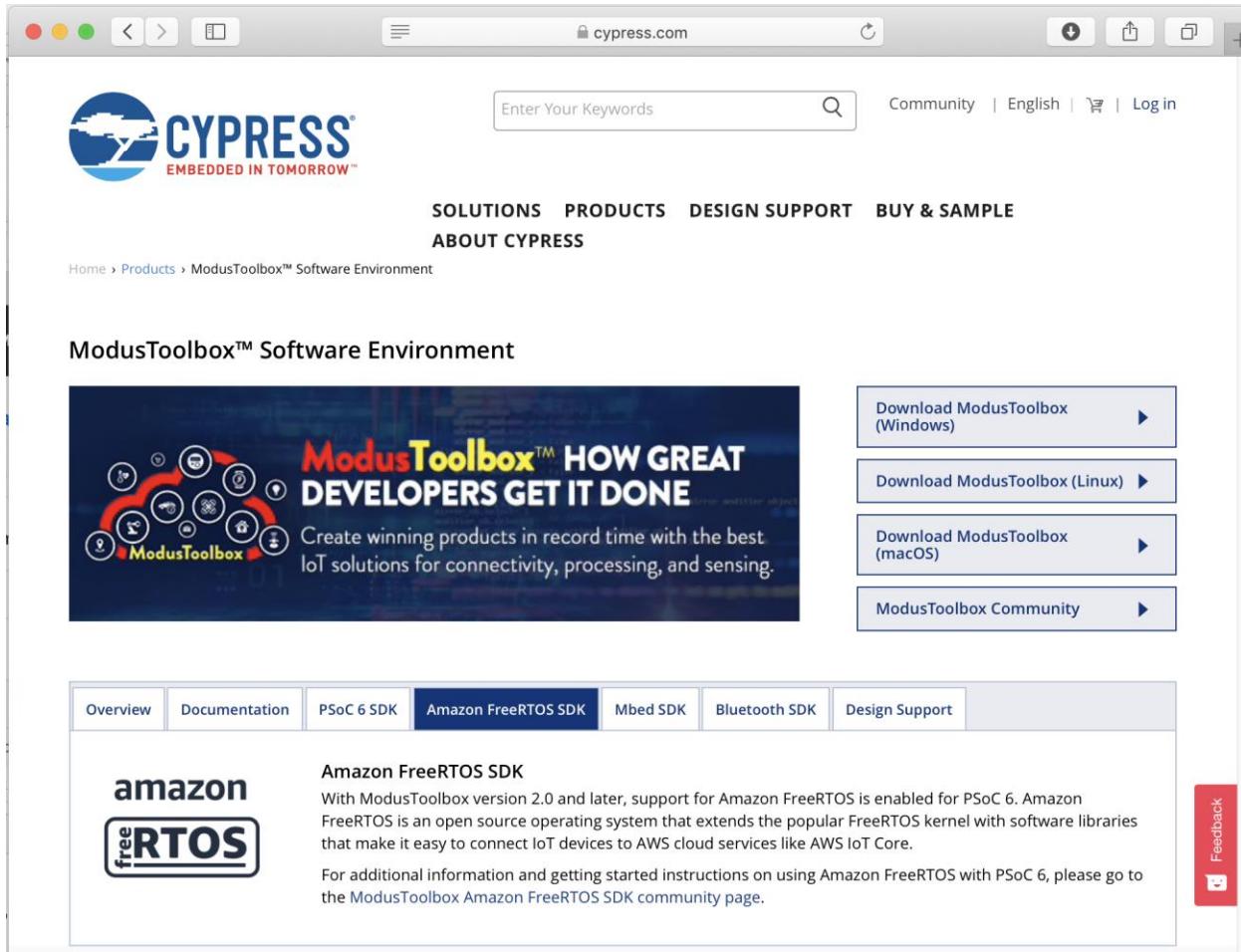
<https://freertos.org>



The screenshot shows the official FreeRTOS website at <https://freertos.org>. The page features a header with the Cypress logo and the text "EMBEDDED IN TOMORROW™". Below the header, a banner states "The FreeRTOS kernel is an MIT licensed AWS open source project." and encourages users to "Take the survey now". The main navigation bar includes links for "Home", "FreeRTOS Books and Manuals", "FreeRTOS", "FreeRTOS Interactive!", "Quick Start", "Supported MCUs", "PDF Books", "Trace Tools", "Ecosystem", and "Email List+". A sidebar on the left contains sections for "FreeRTOS+ TCP", "SafeRTOS", "OpenRTOS", "Fail Safe File System", "FreeRTOS BSPs", "Trace & Visualisation", "CLI", "WolfSSL SSL / TLS", "RTOS Training", "IO", "FreeRTOS+ Lab Projects", "IoT MQTT", "IoT HTTPS", "IoT Task Pool", "FreeRTOS+POSIX", and "FreeRTOS+FAT". The central content area features a large section titled "The FreeRTOS™ Kernel" with the subtitle "Market Leading, De-facto Standard and Cross Platform RTOS kernel." It highlights features like "Immediate Free Download and Use", "Feature Rich", "Tiny Footprint", "Easy To Use Pre-configured Projects", and "Can Be Used In Commercial Applications". Below this, a paragraph discusses the partnership with chip companies and the de-facto standard solution for microcontrollers and small microprocessors. Another section covers deployment in various sectors and the careful management of IP. A "Did you know?" box lists several facts about FreeRTOS, such as its download frequency, market leadership, lower project risks, and support for low power applications. To the right, a "Latest News" box provides updates on v10.2.1, IoT MQTT, and POSIX libraries. Other news items mention an OTA Update Security and Reliability webinar and career opportunities. A "FreeRTOS Partners" section lists logos for ARM, Cadence, Espressif, IAR Systems, Microchip, NXP, MediaTek, Renesas, RISC-V, and SiFive.

## 6.1.5 Cypress Website

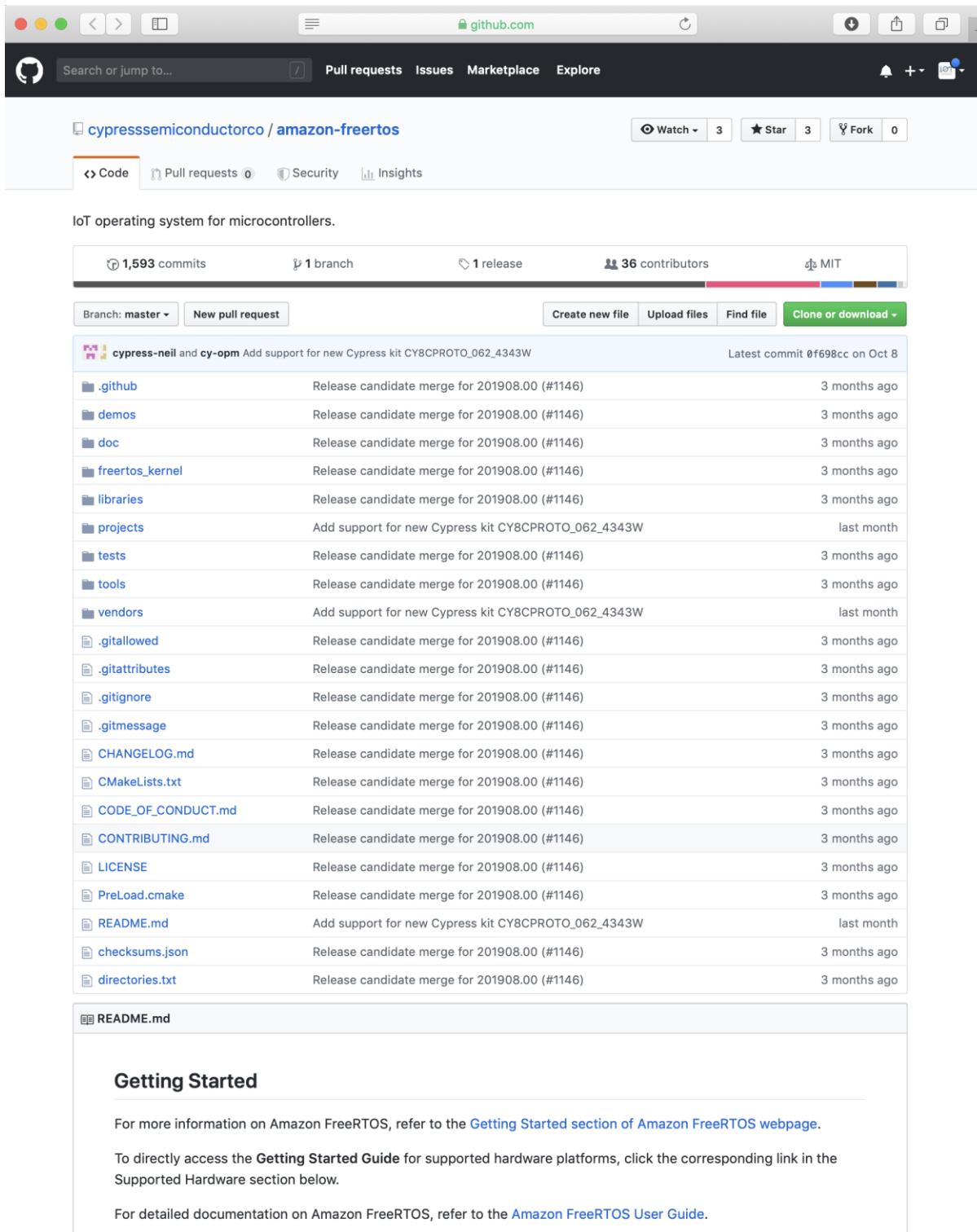
<https://www.cypress.com/products/modustoolbox-software-environment>



The screenshot shows the Cypress website's product page for the ModusToolbox Software Environment. At the top, there's a navigation bar with links for SOLUTIONS, PRODUCTS, DESIGN SUPPORT, BUY & SAMPLE, and ABOUT CYPRESS. Below the navigation is a breadcrumb trail: Home > Products > ModusToolbox™ Software Environment. The main content area features a banner with the text "ModusToolbox™ HOW GREAT DEVELOPERS GET IT DONE" and a subtext "Create winning products in record time with the best IoT solutions for connectivity, processing, and sensing." To the right of the banner are four download links: "Download ModusToolbox (Windows)", "Download ModusToolbox (Linux)", "Download ModusToolbox (macOS)", and "ModusToolbox Community". Below the banner is a navigation bar with tabs for Overview, Documentation, PSoC 6 SDK, Amazon FreeRTOS SDK (which is highlighted in blue), Mbed SDK, Bluetooth SDK, and Design Support. On the left side of the content area, there's a logo for Amazon FreeRTOS. On the right side, there's a red "Feedback" button.

## 6.1.6 Cypress GitHub

<https://github.com/cypresssemiconductorco/amazon-freertos>



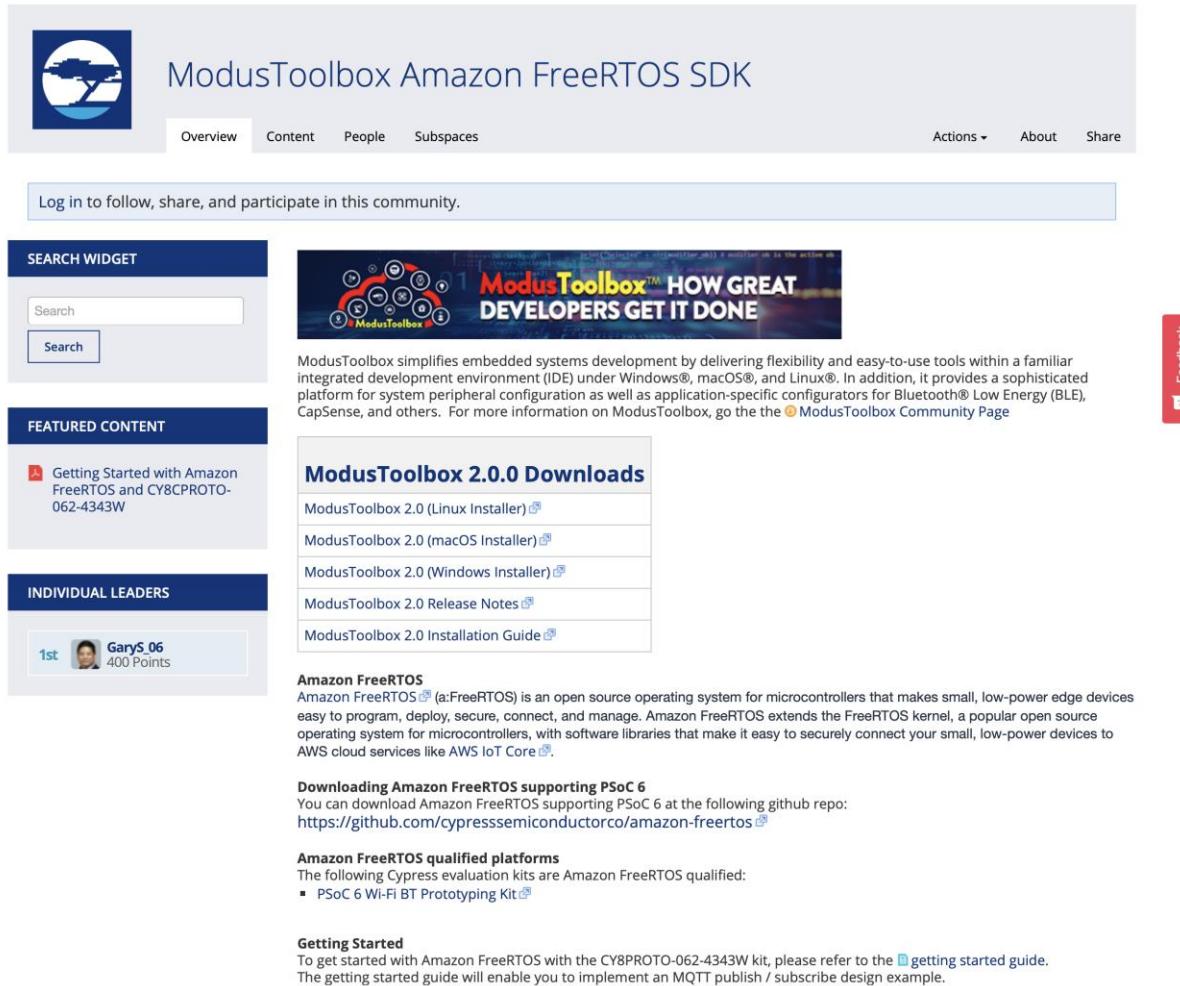
IoT operating system for microcontrollers.

Branch: master		New pull request	Create new file	Upload files	Find file	Clone or download
cypress-neil and cy-opm Add support for new Cypress kit CY8CPROTO_062_4343W      Latest commit 0f698cc on Oct 8						
	.github	Release candidate merge for 201908.00 (#1146)	3 months ago			
	demos	Release candidate merge for 201908.00 (#1146)	3 months ago			
	doc	Release candidate merge for 201908.00 (#1146)	3 months ago			
	freertos_kernel	Release candidate merge for 201908.00 (#1146)	3 months ago			
	libraries	Release candidate merge for 201908.00 (#1146)	3 months ago			
	projects	Add support for new Cypress kit CY8CPROTO_062_4343W	last month			
	tests	Release candidate merge for 201908.00 (#1146)	3 months ago			
	tools	Release candidate merge for 201908.00 (#1146)	3 months ago			
	vendors	Add support for new Cypress kit CY8CPROTO_062_4343W	last month			
	.gitallowed	Release candidate merge for 201908.00 (#1146)	3 months ago			
	.gitattributes	Release candidate merge for 201908.00 (#1146)	3 months ago			
	.gitignore	Release candidate merge for 201908.00 (#1146)	3 months ago			
	.gitmessage	Release candidate merge for 201908.00 (#1146)	3 months ago			
	CHANGELOG.md	Release candidate merge for 201908.00 (#1146)	3 months ago			
	CMakeLists.txt	Release candidate merge for 201908.00 (#1146)	3 months ago			
	CODE_OF_CONDUCT.md	Release candidate merge for 201908.00 (#1146)	3 months ago			
	CONTRIBUTING.md	Release candidate merge for 201908.00 (#1146)	3 months ago			
	LICENSE	Release candidate merge for 201908.00 (#1146)	3 months ago			
	PreLoad.cmake	Release candidate merge for 201908.00 (#1146)	3 months ago			
	README.md	Add support for new Cypress kit CY8CPROTO_062_4343W	last month			
	checksums.json	Release candidate merge for 201908.00 (#1146)	3 months ago			
	directories.txt	Release candidate merge for 201908.00 (#1146)	3 months ago			
<hr/>						
	README.md					
<hr/>						
<h3>Getting Started</h3> <p>For more information on Amazon FreeRTOS, refer to the <a href="#">Getting Started section of Amazon FreeRTOS webpage</a>.</p> <p>To directly access the <b>Getting Started</b> Guide for supported hardware platforms, click the corresponding link in the Supported Hardware section below.</p> <p>For detailed documentation on Amazon FreeRTOS, refer to the <a href="#">Amazon FreeRTOS User Guide</a>.</p>						

## 6.1.7 Cypress Community

<https://community.cypress.com/community/modustoolbox-amazon-freertos-sdk>

Home > All Places >



The screenshot shows the Cypress Community page for the ModusToolbox Amazon FreeRTOS SDK. At the top, there's a navigation bar with links for Overview, Content, People, Subspaces, Actions, About, and Share. A search bar is located at the top left. Below the header, a banner reads "ModusToolbox Amazon FreeRTOS SDK". A call-to-action button says "Log in to follow, share, and participate in this community." On the left, there's a "SEARCH WIDGET" with a search bar and a "FEATURED CONTENT" section containing a link to "Getting Started with Amazon FreeRTOS and CY8CPROTO-062-4343W". Below that is an "INDIVIDUAL LEADERS" section featuring "GaryS\_06" with 400 Points. The main content area has a large image of a circuit board with the text "ModusToolbox HOW GREAT DEVELOPERS GET IT DONE". Below this image is a detailed description of ModusToolbox. To the right of the image is a "ModusToolbox 2.0.0 Downloads" section with links for various installer types. Further down are sections for "Amazon FreeRTOS", "Downloading Amazon FreeRTOS supporting PSoC 6", "Amazon FreeRTOS qualified platforms", and "Getting Started".

## 6.1.8 Documentation

Cypress Getting Started with Amazon FreeRTOS: <https://community.cypress.com/docs/DOC-18348>

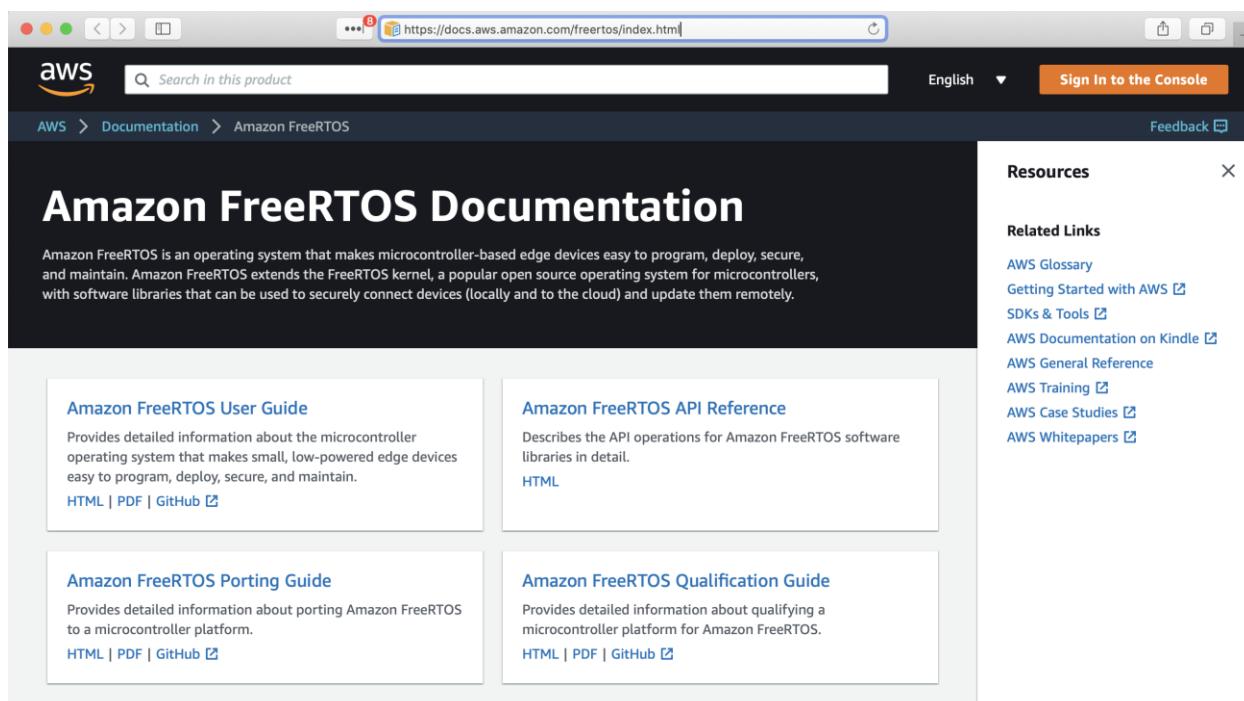
### Getting Started with the CY8CPROTO-062-4343W

This document provides instructions for getting started with the [CY8CPROTO-062-4343W PSoC 6 Wi-Fi BT Prototyping Kit](#). If you do not have the CY8CPROTO-062-4343W Kit, visit the AWS Partner Device Catalog to purchase one from our [partner](#).

Before you begin, you must configure AWS IoT and your Amazon FreeRTOS download to connect your device to the AWS Cloud. See [First Steps](#) for instructions. In this tutorial, the path to the Amazon FreeRTOS download directory is referred to as `<amazon-freertos>`.

**Note:** On Windows OS, the root directory cannot have more than 98 characters. Please see [Downloading Amazon FreeRTOS](#) for details.

AWS Amazon FreeRTOS Documentation: <https://docs.aws.amazon.com/freertos/index.html>



The screenshot shows the AWS Amazon FreeRTOS Documentation page. The top navigation bar includes the AWS logo, a search bar, language selection (English), and a 'Sign In to the Console' button. The main content area has a dark header with the title 'Amazon FreeRTOS Documentation'. Below the header, a paragraph describes Amazon FreeRTOS as an operating system for microcontrollers. The page features four main content boxes: 'Amazon FreeRTOS User Guide' (Provides detailed information about the microcontroller operating system), 'Amazon FreeRTOS API Reference' (Describes the API operations for Amazon FreeRTOS software libraries), 'Amazon FreeRTOS Porting Guide' (Provides detailed information about porting Amazon FreeRTOS to a microcontroller platform), and 'Amazon FreeRTOS Qualification Guide' (Provides detailed information about qualifying a microcontroller platform for Amazon FreeRTOS). To the right of these boxes is a 'Resources' sidebar with links to 'Related Links' such as AWS Glossary, Getting Started with AWS, SDKs & Tools, AWS Documentation on Kindle, AWS General Reference, AWS Training, AWS Case Studies, and AWS Whitepapers.

Freertos.org Reference Manual [https://www.freertos.org/wp-content/uploads/2018/07/FreeRTOS\\_Reference\\_Manual\\_V10.0.0.pdf](https://www.freertos.org/wp-content/uploads/2018/07/FreeRTOS_Reference_Manual_V10.0.0.pdf)

# The FreeRTOS™ Reference Manual

## API Functions and Configuration Options

Amazon Web Services

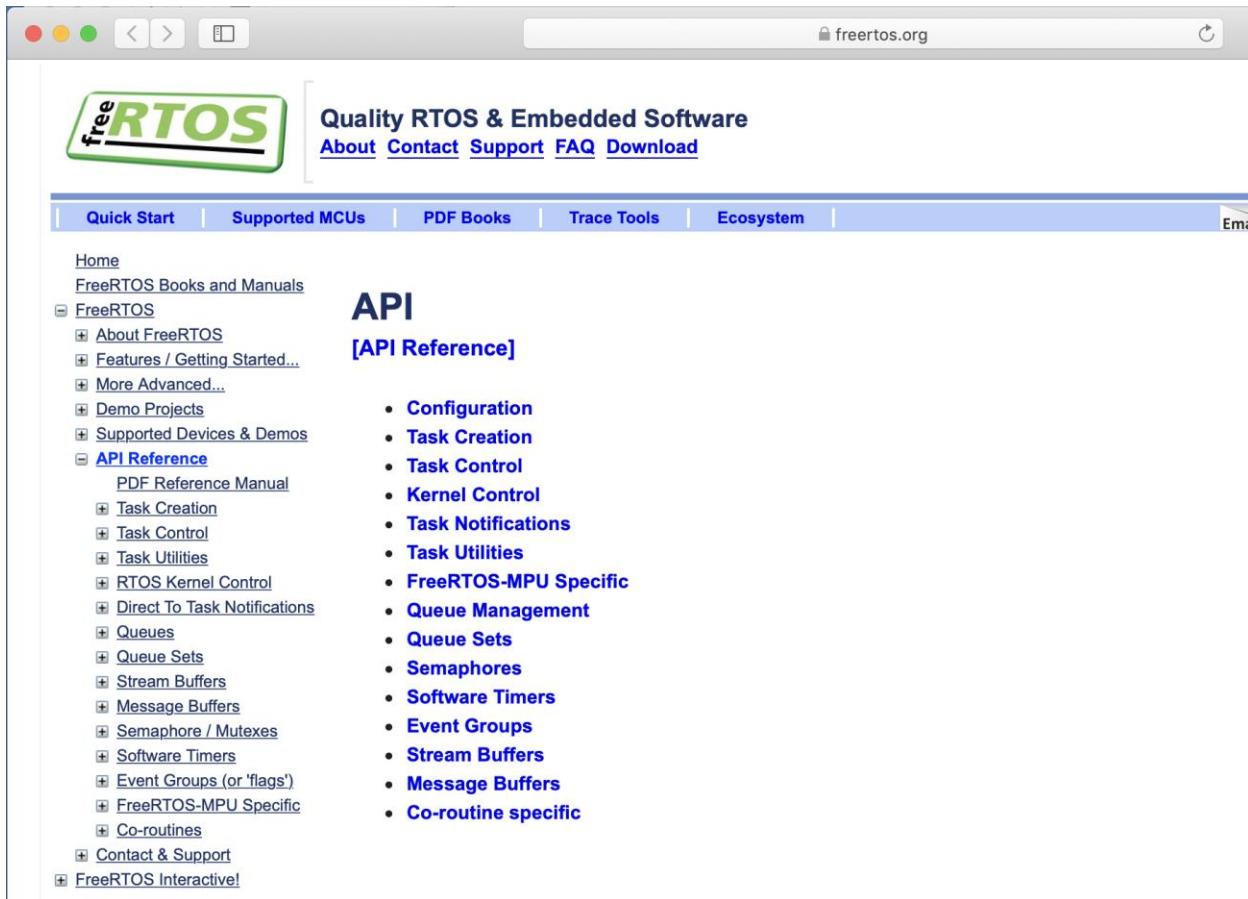
Mastering the FreeRTOS Real Time Kernel [https://www.freertos.org/wp-content/uploads/2018/07/161204\\_Mastering\\_the\\_FreeRTOS\\_Real\\_Time\\_Kernel-A\\_Hands-On\\_Tutorial\\_Guide.pdf](https://www.freertos.org/wp-content/uploads/2018/07/161204_Mastering_the_FreeRTOS_Real_Time_Kernel-A_Hands-On_Tutorial_Guide.pdf)

## Mastering the FreeRTOS™ Real Time Kernel

This is the 161204 copy which does not yet cover FreeRTOS V9.0.0, FreeRTOS V10.0.0, or low power tick-less operation. Check <http://www.FreeRTOS.org> regularly for additional documentation and updates to this book. See <http://www.FreeRTOS.org/FreeRTOS-V9.html> for information on FreeRTOS V9.x.x. See <https://www.freertos.org/FreeRTOS-V10.html> for information on FreeRTOS V10.x.x. Applications created using FreeRTOS V9.x.x onwards can allocate all kernel objects statically at compile time, removing the need to include a heap memory manager.

This text is being provided for free. In return we ask that you use the business contact email link on <http://www.FreeRTOS.org/contact> to provide feedback, comments and corrections. Thank you.

FreeRTOS API Reference <https://www.freertos.org/a00106.html>



The screenshot shows a web browser window displaying the FreeRTOS API Reference. The URL in the address bar is <https://www.freertos.org/a00106.html>. The page header includes the FreeRTOS logo and navigation links for About, Contact, Support, FAQ, and Download. A main navigation bar at the top has links for Quick Start, Supported MCUs, PDF Books, Trace Tools, Ecosystem, and Email. The left sidebar contains a navigation tree for FreeRTOS, including sections for Home, FreeRTOS Books and Manuals, FreeRTOS (with links to About FreeRTOS, Features / Getting Started..., More Advanced..., Demo Projects, Supported Devices & Demos, API Reference, Contact & Support, and FreeRTOS Interactive!). The main content area is titled "API [API Reference]" and lists a comprehensive index of API functions categorized into groups such as Configuration, Task Creation, Task Control, Kernel Control, Task Notifications, Task Utilities, FreeRTOS-MPU Specific, Queue Management, Queue Sets, Semaphores, Software Timers, Event Groups, Stream Buffers, Message Buffers, Semaphore / Mutexes, Software Timers, Event Groups (or 'flags'), FreeRTOS-MPU Specific, and Co-routine specific.

Amazon FreeRTOS API Reference <https://docs.aws.amazon.com/freertos/latest/lib-ref/index.html>

# Amazon FreeRTOS

## Amazon FreeRTOS API Reference

Amazon FreeRTOS is a secure, cloud-native IoT operating system for microcontrollers.

The following Amazon FreeRTOS libraries are documented in library-specific API references:

- [Bluetooth Low Energy](#)
- [AWS Greengrass](#)
- [MQTT Core and MQTT Agent Interface \(v1.0.0\)](#)
- [AWS IoT OTA Agent](#)
- [Secure Sockets](#)
- [Wi-Fi](#)
- [HTTPS](#)
- [PKCS #11 API](#)
  - [mbedtls-based PKCS #11 Implementation](#)
  - [PKCS #11 PAL](#)
  - [PKCS #11 Utilities](#)
  - [PKCS #11 Wrappers](#)
- [Provisioning API](#)

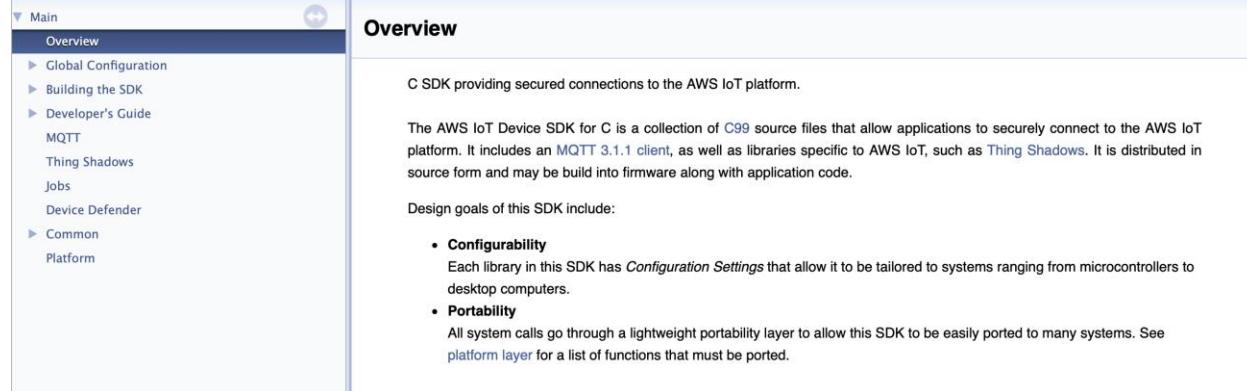
The following Amazon FreeRTOS libraries share APIs with libraries in the [AWS IoT Device SDK for Embedded C](#):

- [Atomic Operations](#)
- [AWS IoT Device Defender](#)
- [Linear Containers](#)
- [Logging](#)
- [MQTT \(v2.0.0\)](#)
- [AWS IoT Device Shadow](#)
- [Static Memory](#)
- [Task Pool](#)

Amazon AWS IoT Device SDK C: Main <https://docs.aws.amazon.com/freertos/latest/lib-ref/c-sdk/main/index.html>

## AWS IoT Device SDK C: Main

[Return to main page ↑](#)



The screenshot shows the "Overview" section of the AWS IoT Device SDK C: Main documentation. On the left, there is a navigation sidebar with a tree view of the documentation structure. The "Overview" node is selected, indicated by a blue bar above it. The main content area contains the following text:

C SDK providing secured connections to the AWS IoT platform.

The AWS IoT Device SDK for C is a collection of C99 source files that allow applications to securely connect to the AWS IoT platform. It includes an MQTT 3.1.1 client, as well as libraries specific to AWS IoT, such as Thing Shadows. It is distributed in source form and may be build into firmware along with application code.

Design goals of this SDK include:

- Configurability**  
Each library in this SDK has *Configuration Settings* that allow it to be tailored to systems ranging from microcontrollers to desktop computers.
- Portability**  
All system calls go through a lightweight portability layer to allow this SDK to be easily ported to many systems. See [platform layer](#) for a list of functions that must be ported.

## 6.2 Demo Walkthrough

Amazon FreeRTOS has built a crazy set of demo projects that are all wound together in one giant demo framework. It can be configured to run one of many tasks including MQTT, BLE, GreenGrass, etc.

You can use Amazon FreeRTOS by cloning the Cypress Amazon-FreeRTOS GitHub site, and then importing the enclosed Eclipse project into the Eclipse IDE. You will be making changes directly in these directories and files (one copy of this repository per project).

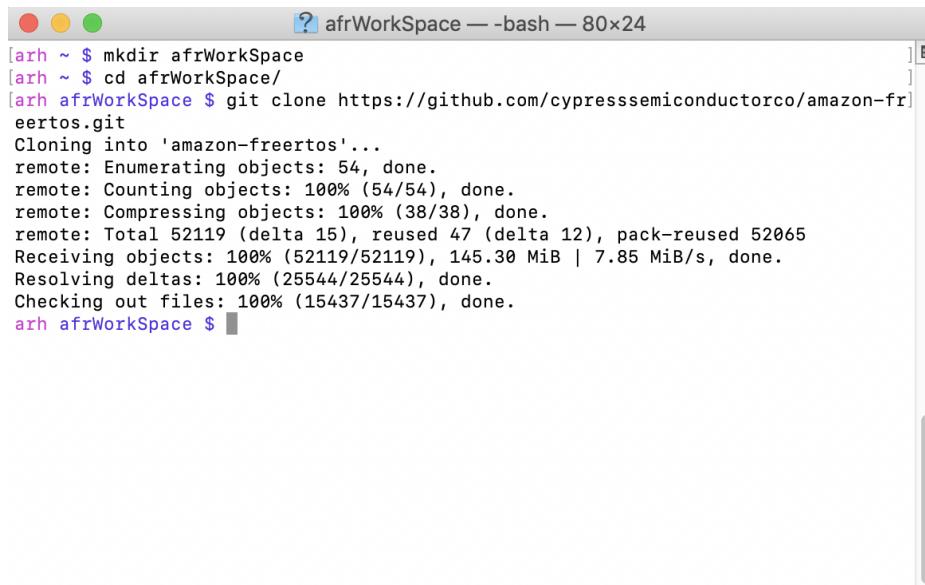
Start by making a new directory (to hold the workspace and Eclipse project):

```
mkdir afrWorkSpace  
cd afrWorkSpace
```

**Note:** The workspace should be as close as possible to the root of a drive (for example, c:\ ).

Then clone the project:

```
git clone https://github.com/cypresssemiconductorco/amazon-freertos.git
```

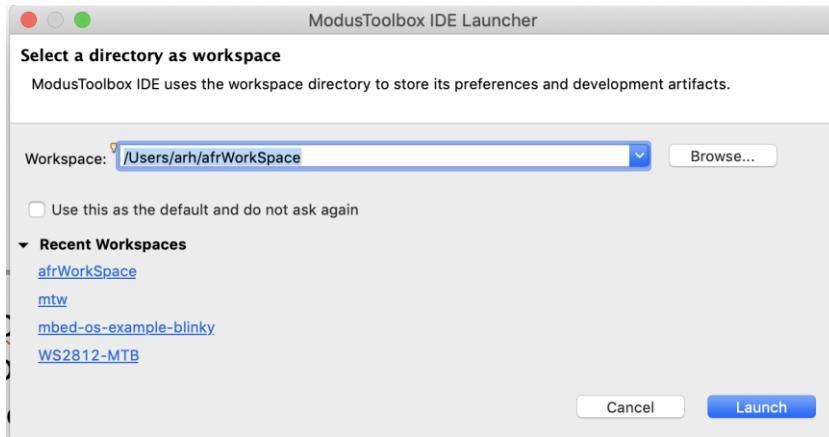


The screenshot shows a terminal window titled 'afrWorkSpace — bash — 80x24'. The user has run the commands 'mkdir afrWorkSpace' and 'cd afrWorkSpace/'. Then, they have run 'git clone https://github.com/cypresssemiconductorco/amazon-freertos.git'. The terminal output shows the progress of the git clone command, including object enumeration, counting, compressing, and receiving objects, followed by resolving deltas and checking out files. The process is completed at 100%.

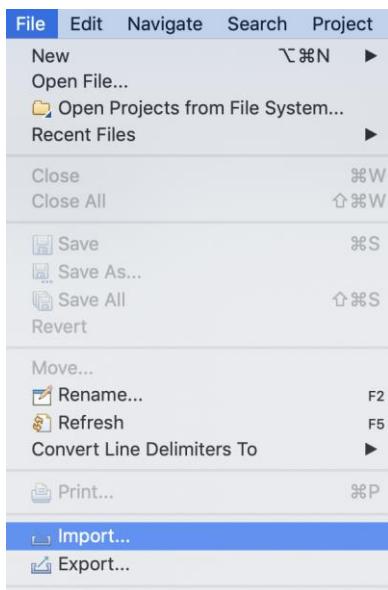
```
[arh ~ $ mkdir afrWorkSpace  
[arh ~ $ cd afrWorkSpace/  
[arh afrWorkSpace $ git clone https://github.com/cypresssemiconductorco/amazon-fr]  
eertos.git  
Cloning into 'amazon-freertos'...  
remote: Enumerating objects: 54, done.  
remote: Counting objects: 100% (54/54), done.  
remote: Compressing objects: 100% (38/38), done.  
remote: Total 52119 (delta 15), reused 47 (delta 12), pack-reused 52065  
Receiving objects: 100% (52119/52119), 145.30 MiB | 7.85 MiB/s, done.  
Resolving deltas: 100% (25544/25544), done.  
Checking out files: 100% (15437/15437), done.  
arh afrWorkSpace $
```

Amazon FreeRTOS is distributed with a Cypress created Eclipse project that works with the Eclipse IDE for ModusToolbox. To use the project, you need to import it into the Eclipse IDE. There can only be one Amazon FreeRTOS project in a workspace at a time (because of name collisions).

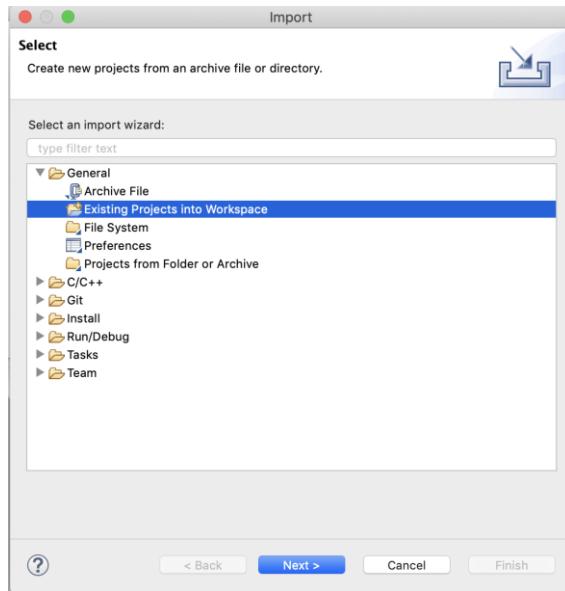
Launch the IDE. Use the **Browse** button to open your new workspace (the one you created with the `mkdir` command.)



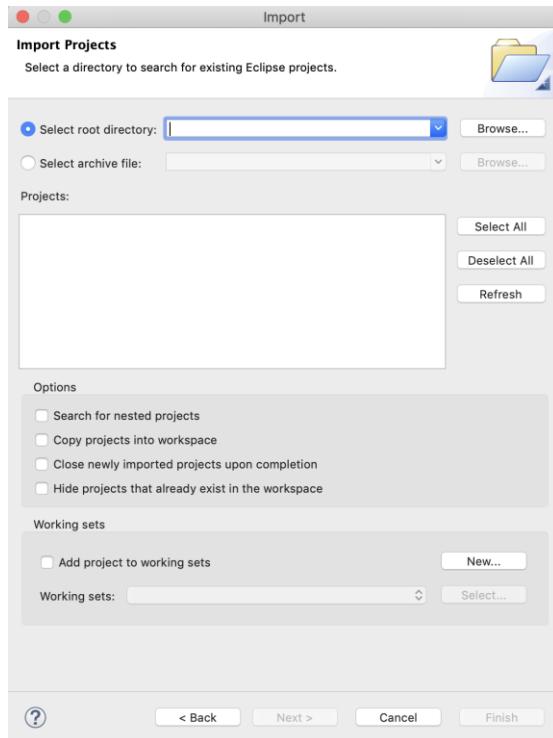
Use **File > Import** to open the Import dialog.



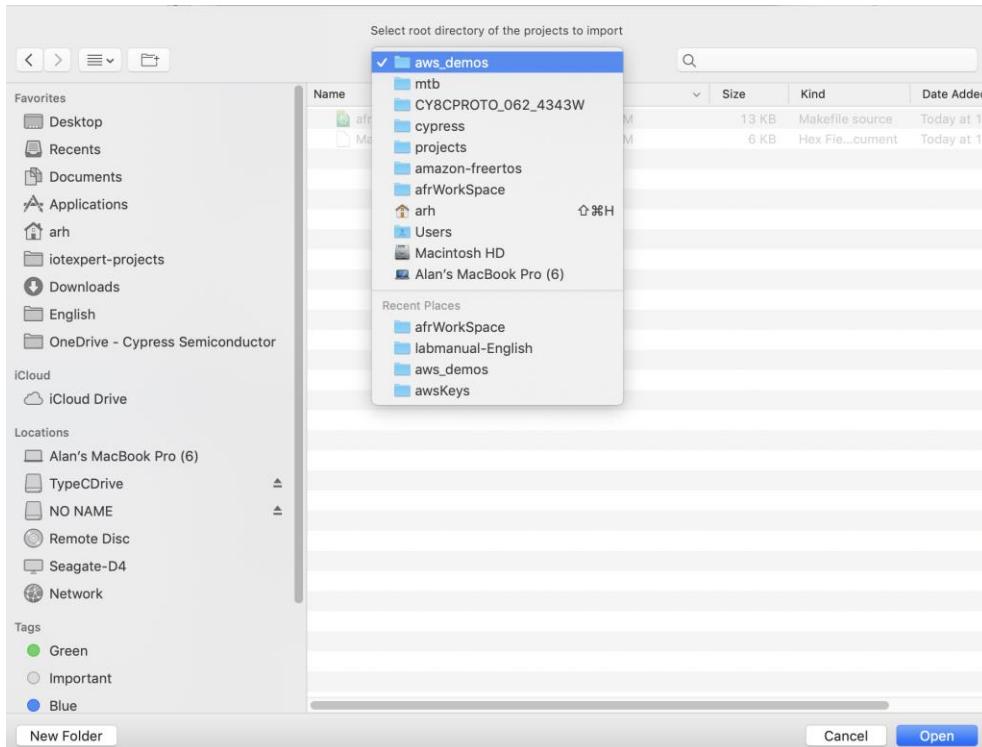
Select **General > Existing Projects into Workspace** and click **Next >**



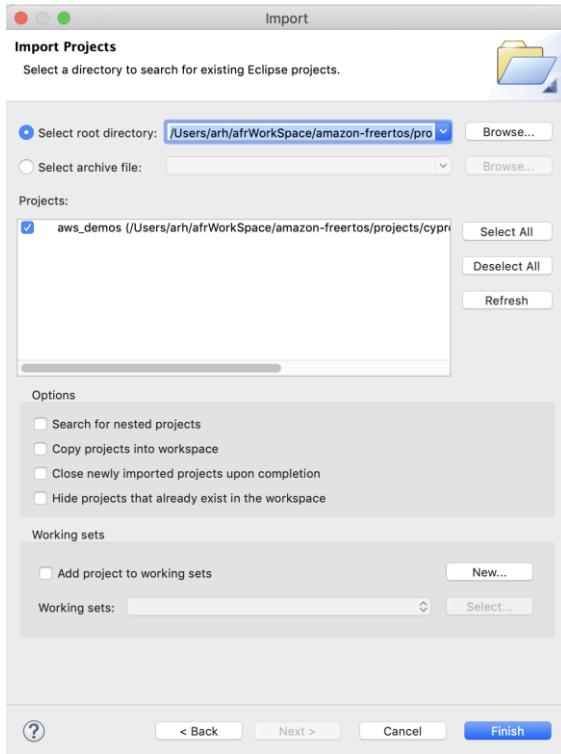
Click **Browse** and navigate to the **aws\_demos** directory.



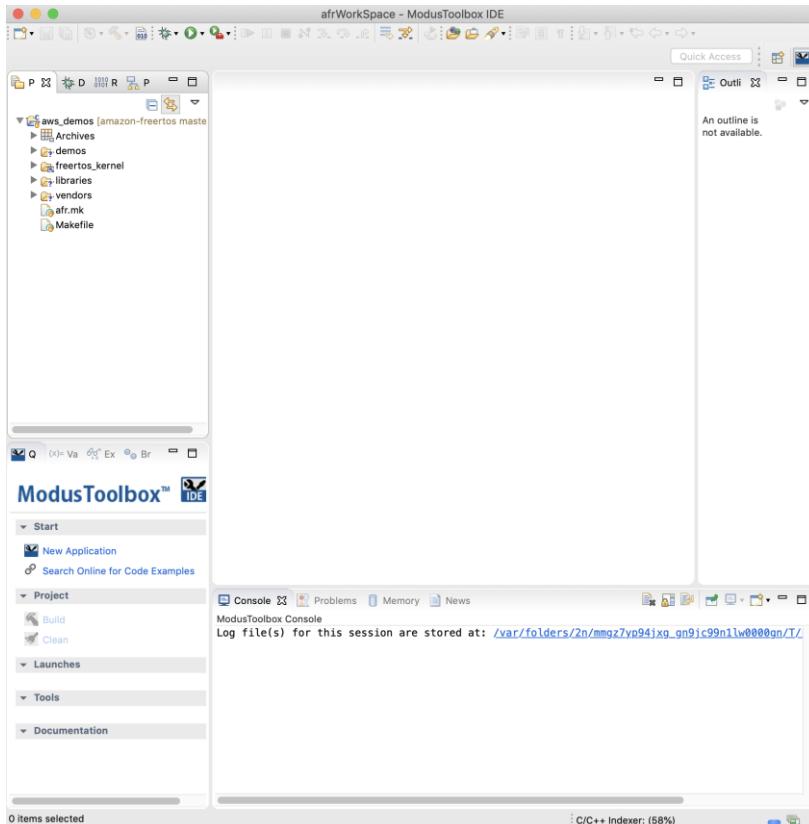
The path in the workspace is amazon-freertos/projects/cypress/CY8CPROTO\_062\_4343W/  
mtb/aws\_demos.



Click **Finish** and view the project in the IDE.

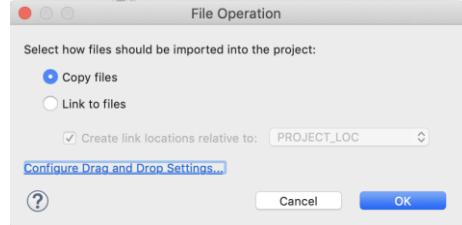
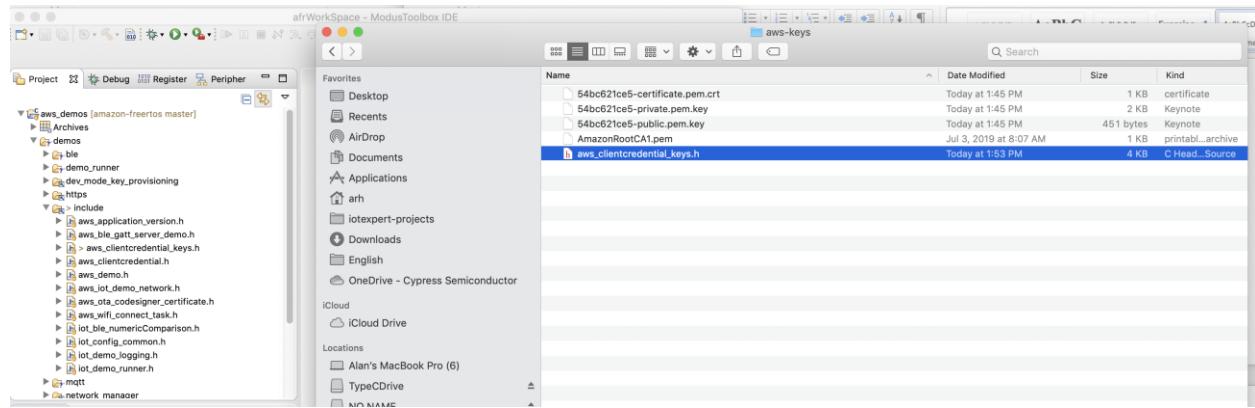


Your workspace should look something like this after you expand `aws_demos`:

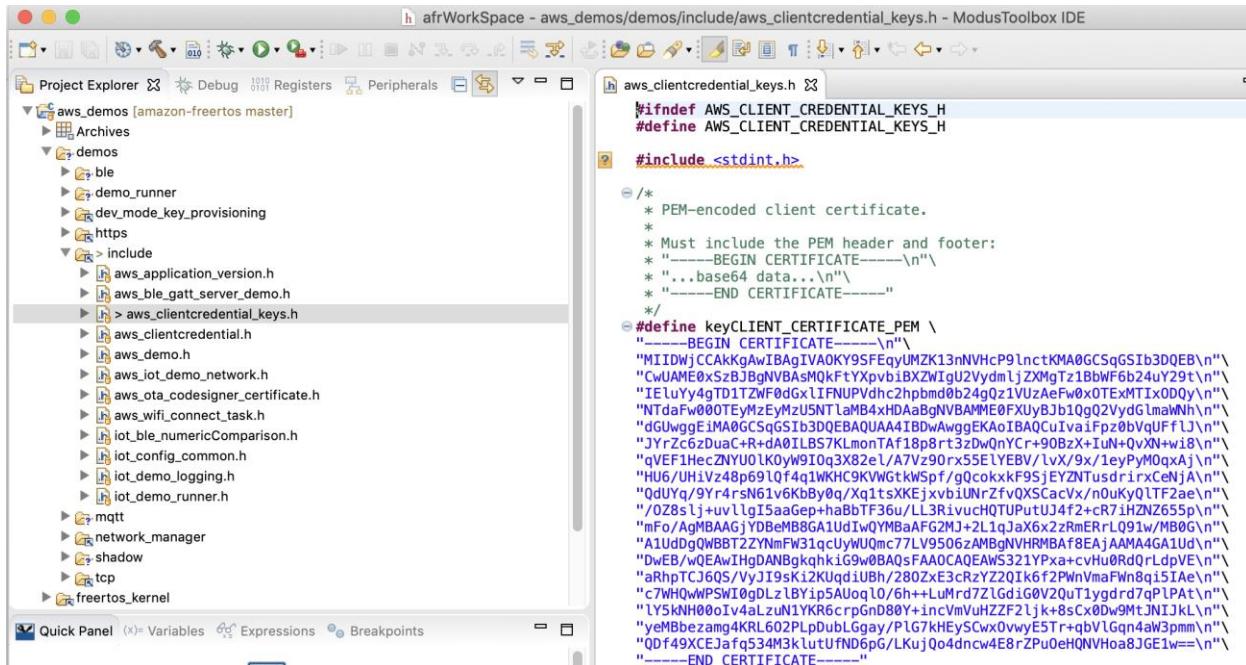


In order to make a TLS connection to the AWS IoT MQTT server, you will need to include the Certificate and Private key for your “Thing”. (See the **AWS IoT Core Chapter** for instructions on making the keys.)

I have created the keys, which I store on my computer in a directory/file called aws-keys/aws\_clientcredential\_keys.h. To use them in a project, I copy the file from the file browser and paste it into the Eclipse project under demos/include. (Just drag and drop.) When you do this yourself, you will want to create your own certificates and keys. This process is described in chapter 3. You will want to overwrite the existing file since it doesn't contain any keys.



Once you have the keys in your project, open the `aws_clientcredential_keys.h` file and make sure that you have them correct.



```

#ifndef AWS_CLIENT_CREDENTIAL_KEYS_H
#define AWS_CLIENT_CREDENTIAL_KEYS_H

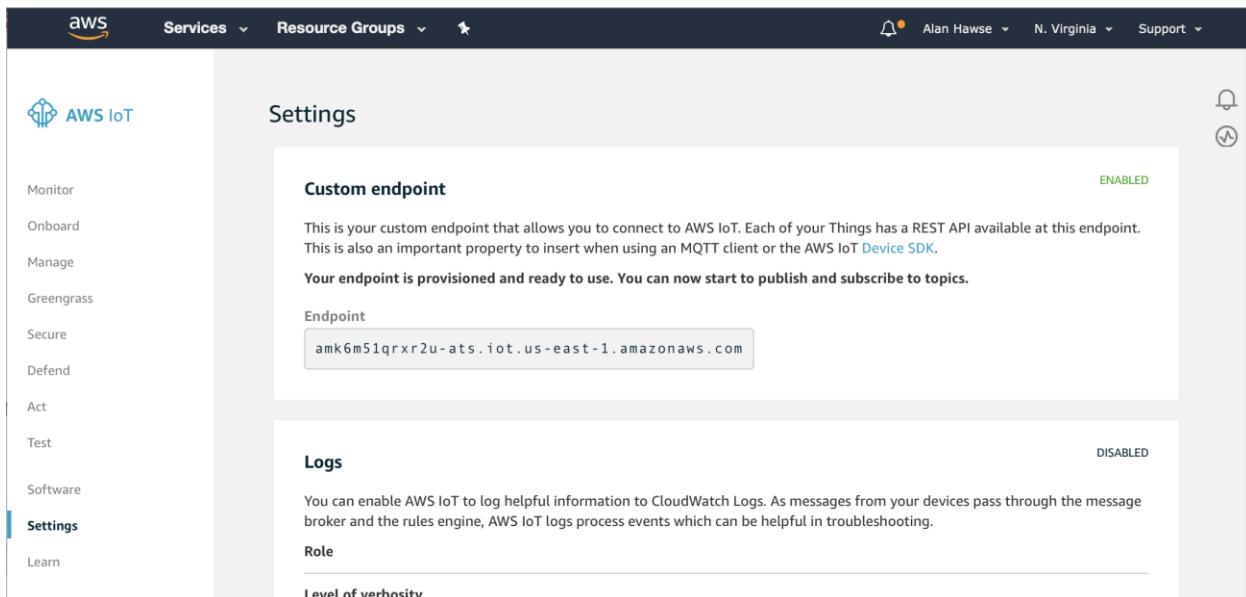
#include <stdint.h>

/*
 * PEM-encoded client certificate.
 *
 * Must include the PEM header and footer:
 * -----BEGIN CERTIFICATE-----\n"
 * ...base64 data...\n"
 * -----END CERTIFICATE-----"
 */

#define keyCLIENT_CERTIFICATE_PEM \
"-----BEGIN CERTIFICATE-----\n" \
"MIIDWjCCAKKgAwIBAgIWA0KY9SFEqyUMZK13nNVHcP9lnctKMA0GCSqGSIb3DQEBAQ\n" \
"CwUAME0xSzBzBjgNVBAsQKftYXpvblBXZWIGU2VydmljZXMGtZ2BWF6b24uY29t\n" \
"IElYr4gTD17P0dgxLlNlUPvdhc2hpbm0b24g0z1VUzAeFw0x0TEMTIxOD0y\n" \
"NTdafw00OTEyMzU5NTLaMB4xHDAabgNVBAMME0FxUyBj10gQ2VydGLmaWhn\n" \
"dgWwgEjMA0GCSgS1b3DQEBAQUA41BDwAsggEKAoIBAOCuIvaiFpz0bVqUfJ\n" \
"JYrZc6zDuaC+R+d0iLBs7KLmonTAf18p8t3zDwQnYCr+90BzX+IuN+QvXN+wI8\n" \
"qVEF1HeCNZYU0lKoy910q3X82e1A7Vz90rx5E1YEBCV/lvX/9x/IeyPM0qxAj\n" \
"HU6/UH1Vz48p691Qf4q1WKHC9KVWGkWSpf/g0coKxF95jEYZNTUsdrirxCeNjA\n" \
"QdUyq/9Y4r4rsN61v6KbbBy0/Xq1tsKKEjxvbiUN7fvQXSacVx/nouky0LTf2ae\n" \
"/O28s1j+uvllgISaaGep+haBbTF36u/LL3riVuChOTUPutU4f2+cr71HNZ655p\n" \
"mFo/AgHBAAgjYDBeMB8GA1udIwQYMBaAFG2MJ+2L1qJaX6x2zRmERrL091w/MB0G\n" \
"A1UdDg0WBTT2ZYNmFW31qcuyUQmc77LV9506zAMBgNVHRMBAf8EAjAAMA4GA1Ud\n" \
"DwEB/wDEwIhgDNBgkqhkiG9w0BAQsFAAOCAQEAWS321YPx+a+cvhU0RdQrLdpVE\n" \
"arRpTcJ6QS/VyJ19sk1zKUqd1UBh/2802xE3crzY20IK6f2PwnVmaFn8q151Ae\n" \
"c7WHQwPSWI9gDLzLYip5Aluoq10/6h++LuMrd7ZLGiG0V2Qut1ygdrd7qPLPAt\n" \
"ly5Knh00oiV4Lzu1YKR6cPrGnD880+incVmVuHZF21jk+8sCx0dw9MtJNJKL\n" \
"yeMBbezang4KRL202PLpDubLGgay/PlG7kHEYSCwx0vwyE5Tr+qbVlgqn4aw3pm\n" \
"QDf49XCEJafq534M3klutUfnD6pG/LKuJ0o4ndcw4E8rZPu0eH0NVhoa8JGE1w==\n" \
"-----END CERTIFICATE-----"

```

For your project to work, you need to tell it which MQTT broker to use. First, go to your Amazon Web Services IoT Core Settings screen and find the endpoint (that is, the DNS name of your server).

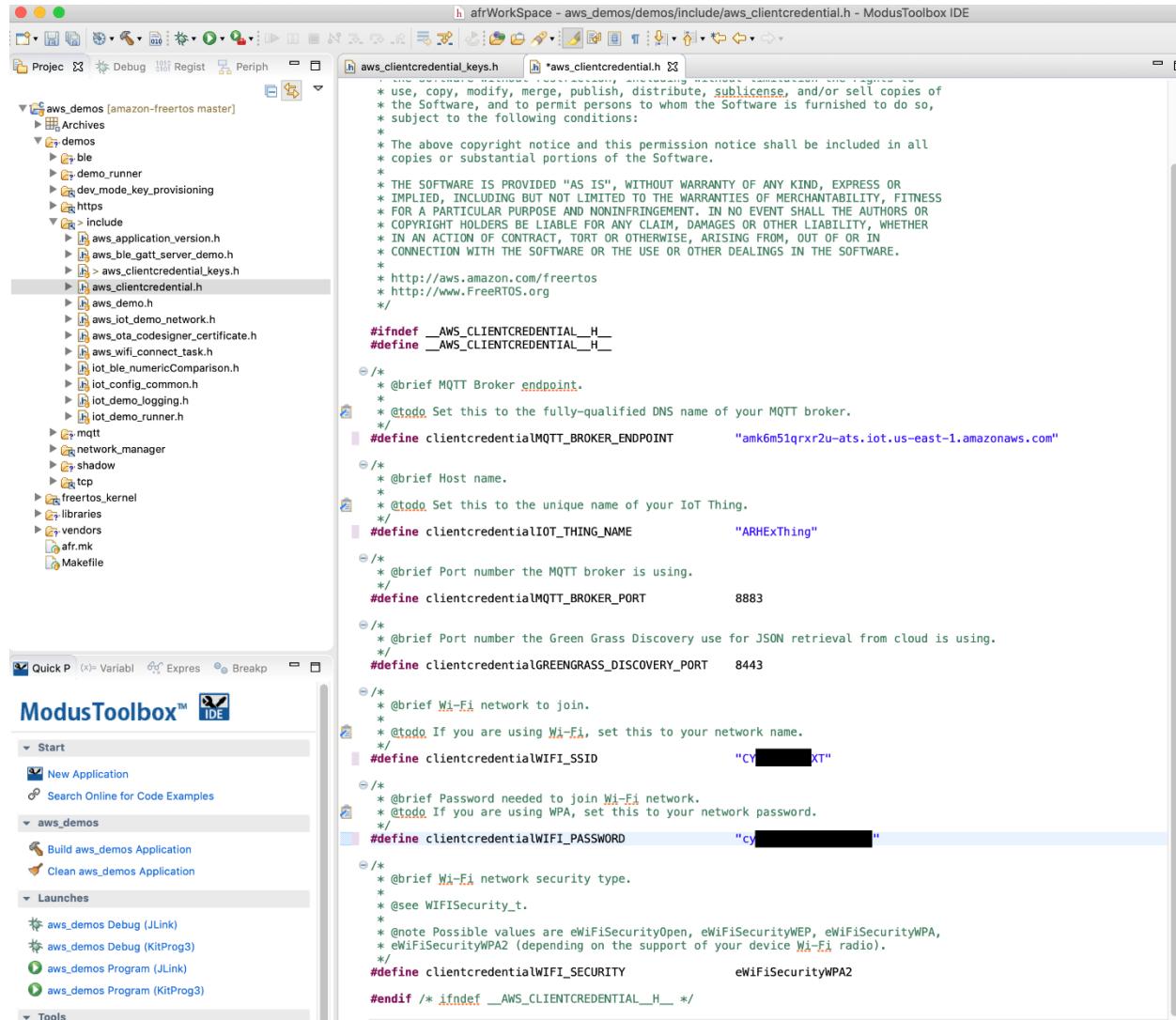


The screenshot shows the AWS IoT Core Settings screen. On the left, there's a sidebar with navigation links: Monitor, Onboard, Manage, Greengrass, Secure, Defend, Act, Test, Software, **Settings**, and Learn. The main area is titled "Settings". Under "Custom endpoint", it says "This is your custom endpoint that allows you to connect to AWS IoT. Each of your Things has a REST API available at this endpoint. This is also an important property to insert when using an MQTT client or the AWS IoT Device SDK." Below this, there's a text input field labeled "Endpoint" containing the value "amk6m51qrxx2u-ats.iot.us-east-1.amazonaws.com". Under "Logs", it says "You can enable AWS IoT to log helpful information to CloudWatch Logs. As messages from your devices pass through the message broker and the rules engine, AWS IoT logs process events which can be helpful in troubleshooting." There are two sections: "Role" (disabled) and "Level of verbosity" (disabled). At the top right, there are user profile and support links.

Next, open the file `aws_clientcredential.h` and paste the name into:

```
#define clientcredentialMQTT_BROKER_ENDPOINT
```

Then configure the name of your Thing, as well as the SSID and password of your Wi-Fi app.



The screenshot shows the ModusToolbox IDE interface. On the left is the Project Explorer with the 'aws\_demos' project selected. The main window displays the contents of the file 'aws\_clientcredential\_keys.h'. The code defines several configuration macros:

```

/*
 * use, copy, modify, merge, publish, distribute, sublicense, and/or sell copies of
 * the Software, and to permit persons to whom the Software is furnished to do so,
 * subject to the following conditions:
 *
 * The above copyright notice and this permission notice shall be included in all
 * copies or substantial portions of the Software.
 *
 * THE SOFTWARE IS PROVIDED "AS IS", WITHOUT WARRANTY OF ANY KIND, EXPRESS OR
 * IMPLIED, INCLUDING BUT NOT LIMITED TO THE WARRANTIES OF MERCHANTABILITY, FITNESS
 * FOR A PARTICULAR PURPOSE AND NONINFRINGEMENT. IN NO EVENT SHALL THE AUTHORS OR
 * COPYRIGHT HOLDERS BE LIABLE FOR ANY CLAIM, DAMAGES OR OTHER LIABILITY, WHETHER
 * IN AN ACTION OF CONTRACT, TORT OR OTHERWISE, ARISING FROM, OUT OF OR IN
 * CONNECTION WITH THE SOFTWARE OR THE USE OR OTHER DEALINGS IN THE SOFTWARE.
 *
 * http://aws.amazon.com/freertos
 * http://www.FreeRTOS.org
 */

#ifndef __AWS_CLIENTCREDENTIAL__H__
#define __AWS_CLIENTCREDENTIAL__H__

/*
 * @brief MQTT Broker endpoint.
 * @todo Set this to the fully-qualified DNS name of your MQTT broker.
 */
#define clientcredentialMQTT_BROKER_ENDPOINT      "amk6m51qrxr2u-ats.iot.us-east-1.amazonaws.com"

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

/*
 * @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                 "CY[REDACTED]XT"

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

#endif /* ifndef __AWS_CLIENTCREDENTIAL__H__ */

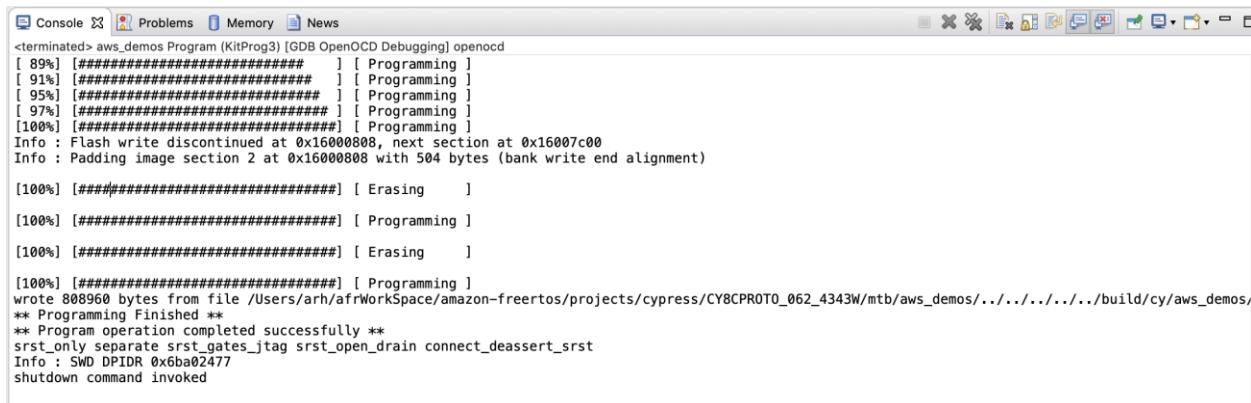
```

The 'Quick P' panel on the left lists various application and tool options, including 'aws\_demos Program (KitProg3)' which is currently selected.

Now build/program the project by clicking "aws\_demos Program (KitProg3)" in the Quick Panel.



You console should look something like this:

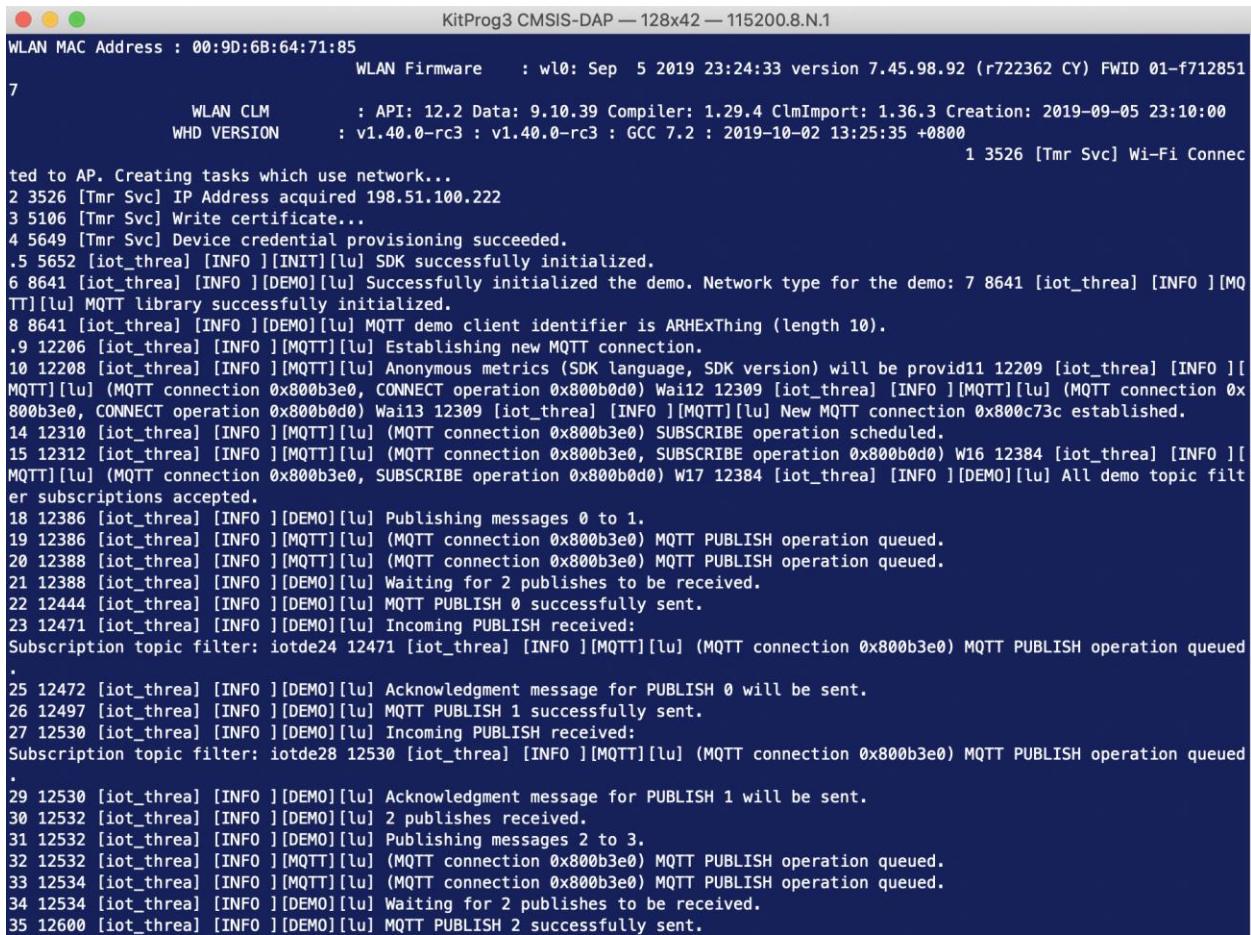


```

Console Problems Memory News
<terminated> aws_demos Program (KitProg3) [GDB OpenOCD Debugging] openocd
[ 89%] [#####
[ 91%] [#####
[ 95%] [#####
[ 97%] [#####
[100%] [#####
Info : Flash write discontinued at 0x16000808, next section at 0x16007c00
Info : Padding image section 2 at 0x16000808 with 504 bytes (bank write end alignment)
[100%] [#####
[100%] [#####
[100%] [#####
[100%] [#####
wrote 808960 bytes from file /Users/arh/afrWorkSpace/amazon-freeRTOS/projects/cypress/CY8CPROTO_062_4343W/mtb/aws_demos/../../../../build/cy/aws_demos
** Programming Finished **
** Program operation completed successfully **
srst_only separate srst_gates_jtag srst_open_drain connect_deassert_srst
Info : SWD DPIDR 0x6ba02477
shutdown command invoked

```

And when you attach a serial terminal you should see something like this:

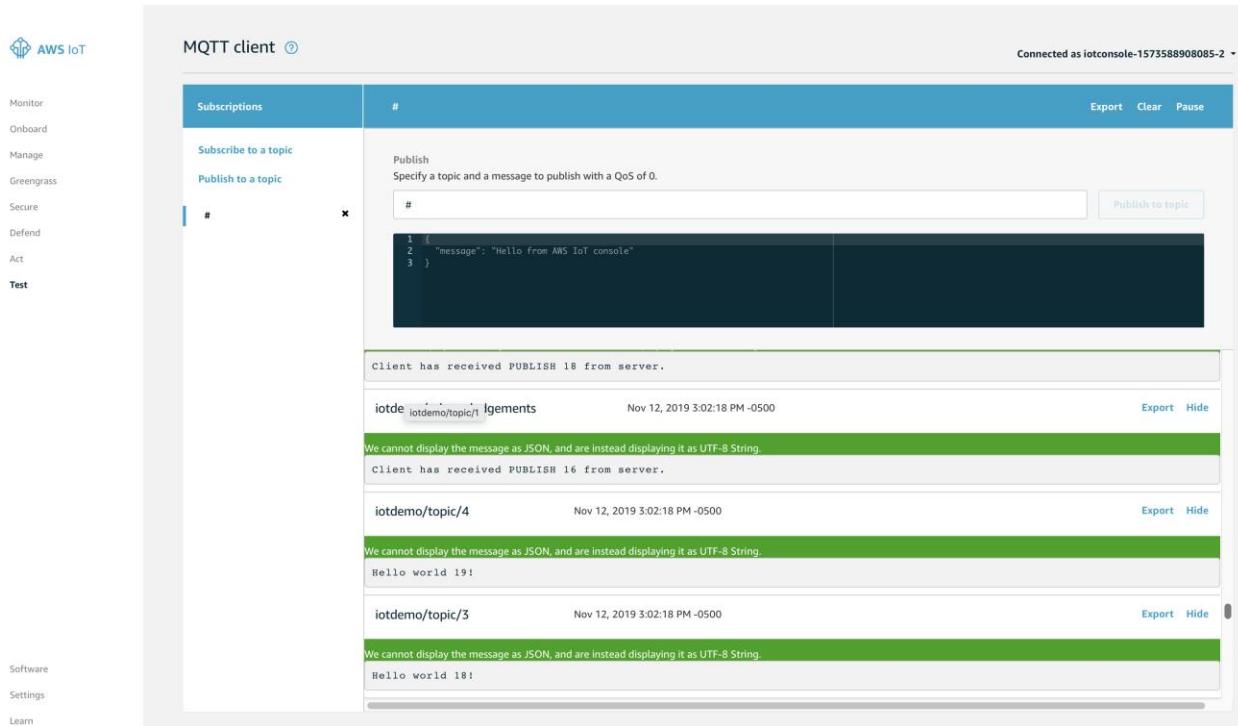


```

WLAN MAC Address : 00:9D:6B:64:71:85
WLAN Firmware      : wl0: Sep  5 2019 23:24:33 version 7.45.98.92 (r722362 CY) FWID 01-f712851
7
WLAN CLM          : API: 12.2 Data: 9.10.39 Compiler: 1.29.4 ClmImport: 1.36.3 Creation: 2019-09-05 23:10:00
WHD VERSION       : v1.40.0-rc3 : v1.40.0-rc3 : GCC 7.2 : 2019-10-02 13:25:35 +0800
1 3526 [Tmr Svc] Wi-Fi Connec
ted to AP. Creating tasks which use network...
2 3526 [Tmr Svc] IP Address acquired 198.51.100.222
3 5106 [Tmr Svc] Write certificate...
4 5649 [Tmr Svc] Device credential provisioning succeeded.
.5 5652 [iot_threa] [INFO ][INIT][lu] SDK successfully initialized.
6 8641 [iot_threa] [INFO ][DEMO][lu] Successfully initialized the demo. Network type for the demo: 7 8641 [iot_threa] [INFO ][MQ
TT][lu] MQTT library successfully initialized.
8 8641 [iot_threa] [INFO ][DEMO][lu] MQTT demo client identifier is ARHEXThing (length 10).
.9 12206 [iot_threa] [INFO ][MQTT][lu] Establishing new MQTT connection.
10 12208 [iot_threa] [INFO ][MQTT][lu] Anonymous metrics (SDK language, SDK version) will be provided 12209 [iot_threa] [INFO ][
MQTT][lu] (MQTT connection 0x800b3e0, CONNECT operation 0x800b0d0) Wai12 12309 [iot_threa] [INFO ][MQTT][lu] (MQTT connection 0x
800b3e0, CONNECT operation 0x800b0d0) Wai13 12309 [iot_threa] [INFO ][MQTT][lu] New MQTT connection 0x800c73c established.
14 12310 [iot_threa] [INFO ][MQTT][lu] (MQTT connection 0x800b3e0) SUBSCRIBE operation scheduled.
15 12312 [iot_threa] [INFO ][MQTT][lu] (MQTT connection 0x800b3e0, SUBSCRIBE operation 0x800b0d0) W16 12384 [iot_threa] [INFO ][
MQTT][lu] (MQTT connection 0x800b3e0, SUBSCRIBE operation 0x800b0d0) W17 12384 [iot_threa] [INFO ][DEMO][lu] All demo topic filt
er subscriptions accepted.
18 12386 [iot_threa] [INFO ][DEMO][lu] Publishing messages 0 to 1.
19 12386 [iot_threa] [INFO ][MQTT][lu] (MQTT connection 0x800b3e0) MQTT PUBLISH operation queued.
20 12388 [iot_threa] [INFO ][MQTT][lu] (MQTT connection 0x800b3e0) MQTT PUBLISH operation queued.
21 12388 [iot_threa] [INFO ][DEMO][lu] Waiting for 2 publishes to be received.
22 12444 [iot_threa] [INFO ][DEMO][lu] MQTT PUBLISH 0 successfully sent.
23 12471 [iot_threa] [INFO ][DEMO][lu] Incoming PUBLISH received:
Subscription topic filter: iotde24 12471 [iot_threa] [INFO ][MQTT][lu] (MQTT connection 0x800b3e0) MQTT PUBLISH operation queued
.
25 12472 [iot_threa] [INFO ][DEMO][lu] Acknowledgment message for PUBLISH 0 will be sent.
26 12497 [iot_threa] [INFO ][DEMO][lu] MQTT PUBLISH 1 successfully sent.
27 12530 [iot_threa] [INFO ][DEMO][lu] Incoming PUBLISH received:
Subscription topic filter: iotde28 12530 [iot_threa] [INFO ][MQTT][lu] (MQTT connection 0x800b3e0) MQTT PUBLISH operation queued
.
29 12530 [iot_threa] [INFO ][DEMO][lu] Acknowledgment message for PUBLISH 1 will be sent.
30 12532 [iot_threa] [INFO ][DEMO][lu] 2 publishes received.
31 12532 [iot_threa] [INFO ][DEMO][lu] Publishing messages 2 to 3.
32 12532 [iot_threa] [INFO ][MQTT][lu] (MQTT connection 0x800b3e0) MQTT PUBLISH operation queued.
33 12534 [iot_threa] [INFO ][MQTT][lu] (MQTT connection 0x800b3e0) MQTT PUBLISH operation queued.
34 12534 [iot_threa] [INFO ][DEMO][lu] Waiting for 2 publishes to be received.
35 12600 [iot_threa] [INFO ][DEMO][lu] MQTT PUBLISH 2 successfully sent.

```

This demo does a series of publish/subscribes to an MQTT topic called "iotdemo/topic/#". You can see these messages being transmitted by subscribing via the MQTT test client on AWS IoT Core.



The screenshot shows the AWS IoT MQTT client interface. On the left, a sidebar lists various services: Monitor, Onboard, Manage, Greengrass, Secure, Defend, Act, and Test. The Test option is selected. The main area is titled "MQTT client" and shows a "Subscriptions" table with one entry: "#". Below this, there are two sections: "Publish" and "Subscribe to a topic". In the "Publish" section, a message is being composed with the topic "#":

```
1  {
2     "message": "Hello from AWS IoT console"
3 }
```

A "Publish to topic" button is present. The "Subscribe to a topic" section shows a list of received messages:

- Client has received PUBLISH 18 from server.  
iotde...otdemo/topic/1 19 messages Nov 12, 2019 3:02:18 PM -0500 Export Hide
- We cannot display the message as JSON, and are instead displaying it as UTF-8 String.  
Client has received PUBLISH 16 from server.
- iotdemo/topic/4 Nov 12, 2019 3:02:18 PM -0500 Export Hide
- We cannot display the message as JSON, and are instead displaying it as UTF-8 String.  
Hello world 19!
- iotdemo/topic/3 Nov 12, 2019 3:02:18 PM -0500 Export Hide
- We cannot display the message as JSON, and are instead displaying it as UTF-8 String.  
Hello world 18!

## 6.3 Exercises (Part 1)

### 6.3.1 Run the MQTT Demo



1. Build and run the demo following the steps in the [Demo Walkthrough](#) section.

### 6.3.2 Modify the project to publish to a different topic

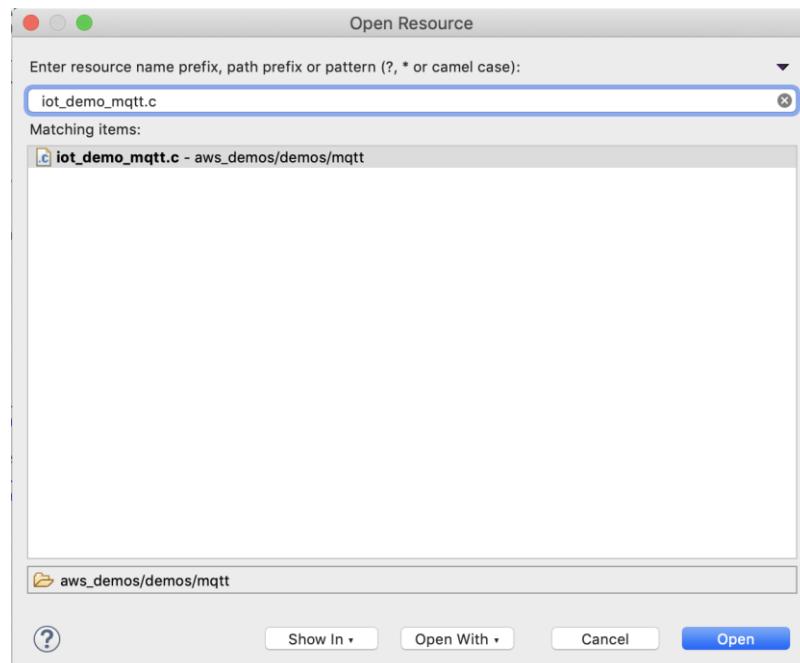
Everyone in the class is publishing to the same topics, which will cause a significant amount of confusion.



1. Modify your project to publish to a new topic; for example, your name.

**Hint:** Modify `iot_demo_mqtt.c`. The `#define` for the topic prefix is `"IOT_DEMO_MQTT_TOPIC_PREFIX"`.

**Hint:** A very useful Eclipse command is “Open Resource” which is Cmd+Shift+R (on a Mac) or Ctrl+Shift+R (on a PC).



## 6.4 AWS FreeRTOS Directory Organization

To use Amazon FreeRTOS you must import the entire repository from GitHub. You then make modifications to source files in that repository to create and configure your project. Each of your projects requires a complete copy of this repository.

Start with:

```
git clone https://github.com/cypresssemiconductorco/amazon-freertos.git
```

### 6.4.1 Top Level Organization

Directory	Comments
demos	Source code for the AWS released demos. Including MQTT, BLE, GreenGrass etc. – your project can be built with 0 files from this directory if you want
build	Intermediate files created by the compilation process including .o's .elf etc. Can be removed
doc	Doxygen files (currently broken) – use online documentation at <a href="https://docs.aws.amazon.com/freertos/index.html">https://docs.aws.amazon.com/freertos/index.html</a>
freertos_kernel	Source code for FreeRTOS
libraries	Amazon's IoT Middleware libraries including MQTT, HTTP etc.
projects	A directory containing IDE files which can be imported into Eclipse
tools	Support tools to help you build and test projects
vendors	Contains all the Cypress driver libraries including the HAL, PDL, Bluetooth, WHD etc.

### 6.4.2 demos

The demos directory contains all the Amazon FreeRTOS Demo projects. Each of the projects are documented on the AFR website <https://docs.aws.amazon.com/freertos/latest/userguide/freertos-next-steps.html>

To configure the demos you need to edit “aws\_demo\_config.h” and add the #define for the demo you want to build. The legal values are:

- CONFIG\_MQTT\_DEMO\_ENABLED
- CONFIG\_SHADOW\_DEMO\_ENABLED
- CONFIG\_GREENGRASS\_DISCOVERY\_DEMO\_ENABLED (requires a GreenGrass Server)
- CONFIG\_TCP\_ECHO\_CLIENT\_DEMO\_ENABLED (Requires a TCP Echo Server)
- CONFIG\_DEFENDER\_DEMO\_ENABLED (Cypress doesn't deliver this demo)
- CONFIG\_POSIX\_DEMO\_ENABLED (Cypress doesn't deliver this demo)
- CONFIG\_OTA\_UPDATE\_DEMO\_ENABLED (Cypress doesn't deliver this demo)
- CONFIG\_BLE\_GATT\_SERVER\_DEMO\_ENABLED (requires MQTT bridge)
- CONFIG\_HTTPS\_SYNC\_DOWNLOAD\_DEMO\_ENABLED (download from S3 bucket)
- CONFIG\_HTTPS\_ASYNC\_DOWNLOAD\_DEMO\_ENABLED (download from S3 bucket)

These #defines will turn on configuration information in `iot_demo_runner.h` including the name of the function for the demo runner to run.

[AWS Documentation](#) » [Amazon FreeRTOS](#) » [User Guide](#) » [Amazon FreeRTOS Demos](#)

## Amazon FreeRTOS Demos

Amazon FreeRTOS includes some demo applications in the `demos` folder, under the main Amazon FreeRTOS directory. All of the examples that can be executed by Amazon FreeRTOS appear in the `common` folder, under `demos`. There is also a folder for each Amazon FreeRTOS-qualified platform under the `demos` folder. If you use the [Amazon FreeRTOS console](#), only the target platform you choose has a subdirectory under `demos`.

Before you try the demo applications, we recommend that you complete the tutorial in [Getting Started with Amazon FreeRTOS](#). It shows you how to set up and run the Hello World MQTT demo.

### Running the Amazon FreeRTOS Demos

The following topics show you how to set up and run the Amazon FreeRTOS demos:

- [Bluetooth Low Energy Demo Applications](#)
- [Demo Bootloader for the Microchip Curiosity PIC32MZEF](#)
- [AWS IoT Device Defender Demo](#)
- [AWS IoT Greengrass Discovery Demo Application](#)
- [Over-the-Air Updates Demo Application](#)
- [Secure Sockets Echo Client Demo](#)
- [AWS IoT Device Shadow Demo Application](#)

The `DEMO_RUNNER_RunDemos()` function, located in `<amazon-freertos>/demos/demo_runner/iot_demo_runner.c`, initializes a detached thread on which a single demo application runs. By default, `DEMO_RUNNER_RunDemos()` only calls the starts the Hello World MQTT demo. Depending on the configuration you selected when you downloaded Amazon FreeRTOS, and depending on where you downloaded Amazon FreeRTOS, the other example runner functions might start by default. To enable a demo application, open `<amazon-freertos>/vendors/<vendor>/boards/<board>/aws_demos/config_files/aws_demo_config.h`, and define the demo that you want to run.

#### Note

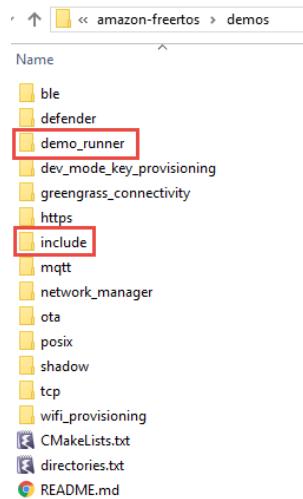
Be aware that not all combinations of examples work together. Depending on the combination, the software might fail to execute on the selected target due to memory constraints. We recommend that you run one demo at a time.

### Configuring the Demos

The demos have been configured to get you started quickly. You might want to change some of the configurations for your project to create a version that runs on your platform. You can find configuration files at `vendors/<vendor>/boards/<board>/aws_demos/config_files`.

The demos directory contains the following:

- Configuration for the demo – in the include directory
- Demo source code in the demos/demo\_runner directory
- 1 directory per example (ble, defender, etc.)



The include directory has these files:

demos/include	
aws_clientcredential.h	SSID Password MQTT_BROKER_ENDPOINT Thing Name
aws_clientcredential_keys.h	Contains the private key and certificate that are downloaded from AWS IoT core and converted into C strings.
aws_demo.h	Defines the generic interface for the demo function signature, e.g. the network connected/disconnected callbacks used by demos. This interface can be modified to add custom applications.
iot_demo_runner.h	Configures demo task function, stack size and priority for the selected demo in aws_demo_config.h. This file only needs to be modified when creating a custom demo.
iot_demo_logging.h	Configures default logging level used by the log library for the demo functions. These defines can be overridden in the iot_config.h file under board config files. Three logging levels are available IOT_LOG_LEVEL_DEMO, IOT_LOG_LEVEL_GLOBAL, IOT_LOG_LEVEL_NONE .
aws_application_version.h	Contains application firmware version. This is used to compare firmware version on the device during OTA operations. This can also be used by applications to track or print firmware version.
aws_ble_gatt_server_demo.h	Defines the GATT database for the aws_ble_gatt_server_demo.
aws_iot_demo_network.h	Defines the interface that allows demos to create a MQTT connection with underlying connection (WIFI/BLE) abstracted.

demos/include	
aws_ota_codesigner_certificate.h	Defines the certificate required for verifying digitally signed firmware. This certificate comes from the AWS manager when creating a digitally signed firmware image and must be converted to c string.
aws_wifi_connect_task.h	Defines the interface to create a task to connect to Wi-Fi. This is used by the network manager module.
iot_ble_numericComparison.h	
iot_config_common.h	Contains default configuration for several libraries and demos. Most of the default configurations in this file can be overridden by defining them in user configuration files. E.g. configuring the asserts, use of malloc vs pvPortMalloc in libraries, etc.

The demo runner directory has these files:

demos/demo_runner	
aws_demo.c	Contains support functions IFF you are using static memory allocation.
aws_demo_network_addr.c	Contains the network configuration definition for the FreeRTOS TCP stack. This file is not applicable Cypress devices, which use the LWIP stack.
aws_demo_version.c	Contains struct definition for the application firmware version.
iot_demo_freertos.c	Contains the implementation for the demo runner interface in aws_demo.h and default implementation for hooks ( <a href="#">vApplicationStackOverflowHook</a> / <a href="#">vApplicationMallocFailedHook</a> ).
iot_demo_runner.c	Contains implementation for demo runner interface in aws_demo.h.

The individual demo directories include:

Demo Directories	
ble	This directory holds three BLE example project, MQTT over BLE, WiFi Provisioning and Generic Attributes Server Demo. For these demos to work you must install the Amazon iOS/Android SDK for BLE to create a bridge to Amazon Web Services.
https	This directory holds an HTTPS demo that will download a file over a secure sockets HTTP(s) connection.
mqtt	This is the default application. It shows an MQTT connection to the AWS IoT Core with publishes and subscribes.
shadow	This demonstrates updating a device shadow via MQTT.
tcp	This project demonstrates using a secure TLS echo server. You run a “go” program which sits on the same network as your device and echo’s back on a secure socket.
wifi_provisioning	This module creates a task for Wi-Fi provisioning that task maintains connection to the provisioned networks and gets triggered on every disconnection. This is used by the network manager.
dev_mode_key_provisioning	This module is a reference implementation for storing and restoring keys and certificates used by the AWS connectivity library. Amazon suggests you use this as a reference to implement your own key provisioning.

network_manager	This module is used by demo applications to handle different types of network connections and their connection/disconnection events.
-----------------	--

### 6.4.3 vendors

The vendors directory contains files for the kits supported by AFR. The only folder of interest to us in that directory hierarchy (for now) is cypress/boards/CY8CPROTO\_062\_4343W/aws\_demos. It contains:

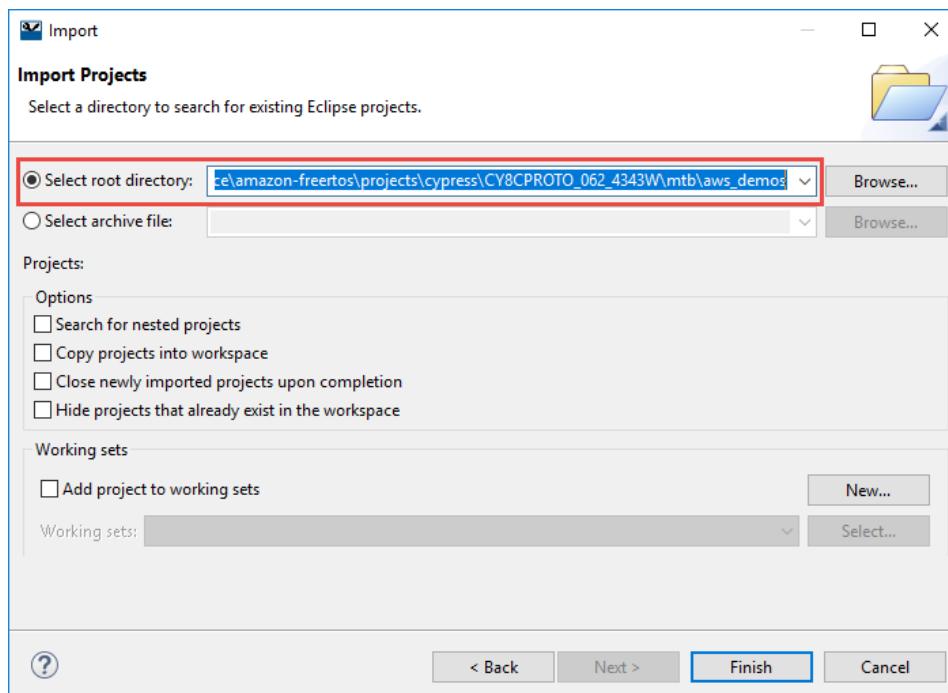
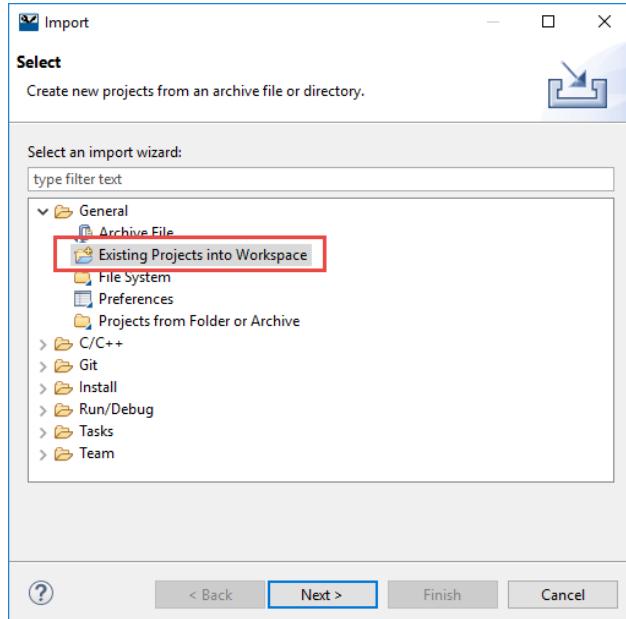
<b>cypress/boards/CY8CPROTO_062_4343W/aws_demos/config_files</b>	
FreeRTOSConfig.h	Configuration of FreeRTOS e.g. heap, semaphores, memory management, etc.
aws_demo_config.h	This file contains #defines that turn on the different demo projects. E.g. #define CONFIG_MQTT_DEMO_ENABLED.
aws_iot_network_config.h	Configure types of network interfaces supported/enabled by the board (Wi-Fi/BLE).
aws_ggd_config.h	Configuration for AWS GreenGrass library. Eg. Max JSON tokens, logging.
aws_mqtt_config.h	Configuration for the MQTT library. E.g. Max Subscriptions, Max Topic length, Enable debug logs etc.
aws_ota_agent_config.h	Configuration for the user configurable setting in the OTA library like ota task priority, selftest timeout etc.
aws_secure_sockets_config.h	Configuration for secure sockets. E.g. receive/send timeouts, max sockets, byte order etc.
aws_shadow_config.h	Configuration for the shadow library. E.g. Max clients, enable debug,
aws_wifi_config.h	Configuration for the Wi-Fi port. E.g. Max network profile storage, SSID and password for AP mode.
FreeRTOSIPConfig.h	Configuration for the FreeRTOS TCP stack. Not applicable to Cypress devices.
lot_ble_config.h	Configuration for the BLE library. E.g. device name etc.
lot_config.h	Common demo configuration. E.g. Logging level, Shadow update count etc.
lot_mqtt_agent_config.h	Configuration specifically for the MQTT agent in the MQTT library.
lot_pkcs11_config.h	Configuration for the PKCS11 library. E.g. labels/key for the different keys and certificates for lookup. OTA code signing verification support.
lwipopts.h	This file configures the LWIP stack library. This is used by any application that requires WiFi connectivity. E.g. Buffer pool size, enable features like IPv6 etc.
trcConfig.h & trcSnapshotConfig.h	Percepio Tracelyzer configuration.

<b>cypress/boards/CY8CPROTO_062_4343W/aws_demos/application_code</b>	
main.c	Generic demo application code described in detail in the <a href="#">Application &amp; Demo Firmware flow (source code)</a> section.
cy_code	design.modus, generated source, and BSP.

#### 6.4.4 projects

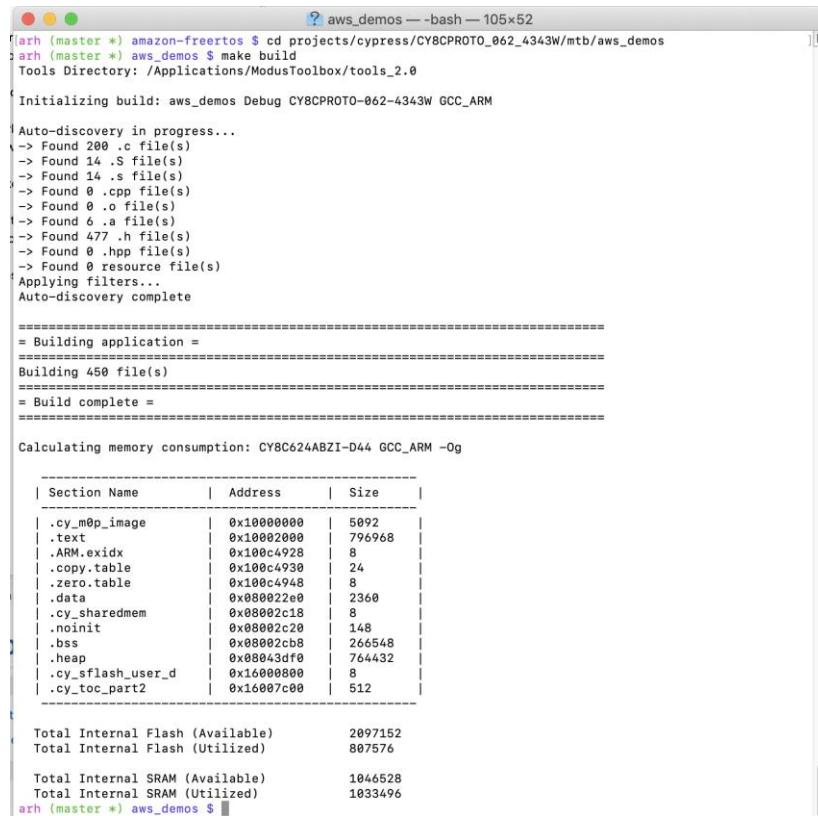
The projects directory contains the IDE configuration files, which includes the .cproject, afr.mk, and Makefile required use the demo projects in the Eclipse IDE and with the ModusToolbox command line.

To import the demo projects into Eclipse IDE, select **Import > General > Existing Projects into Workspace** and select the “projects/cypress/CY8CPROTO\_062\_4343W/mtb/aws\_demos” directory.



To use the ModusToolbox command line:

```
cd projects/cypress/CY8CPROTO_062_4343W/mtb/aws_demos
make build
```



```
aws_demos --bash — 105x52
[arh (master *) amazon-freertos $ cd projects/cypress/CY8CPROTO_062_4343W/mtb/aws_demos
[arh (master *) aws_demos $ make build
Tools Directory: /Applications/ModusToolbox/tools_2.0

Initializing build: aws_demos Debug CY8CPROTO-062-4343W GCC_ARM

Auto-discovery in progress...
-> Found 200 .c file(s)
-> Found 14 .S file(s)
-> Found 14 .s file(s)
-> Found 0 .cpp file(s)
-> Found 0 .o file(s)
-> Found 6 .a file(s)
-> Found 477 .h file(s)
-> Found 0 .hpp file(s)
-> Found 0 resource file(s)
Applying filters...
Auto-discovery complete

=====
= Building application =
=====
Building 450 file(s)
=====
= Build complete =
=====

Calculating memory consumption: CY8C624ABZI-D44 GCC_ARM -Og

-----| Section Name | Address | Size |
-----|.cy_m0p_image | 0x10000000 | 5092
|.text | 0x10002000 | 796968
|.ARM.exidx | 0x100c4928 | 8
|.copy.table | 0x100c4930 | 24
|.zero.table | 0x100c4948 | 8
|.data | 0x08002e00 | 2360
|.cy_shmem | 0x08002c18 | 8
|.noinit | 0x08002c20 | 148
|.bss | 0x08002cb8 | 266548
|.heap | 0x08043df0 | 764432
|.cy_flash_user_d | 0x16000800 | 8
|.cy_toc_part2 | 0x16007c00 | 512

Total Internal Flash (Available) 2097152
Total Internal Flash (Utilized) 807576

Total Internal SRAM (Available) 1046528
Total Internal SRAM (Utilized) 1033496
[arh (master *) aws_demos $
```

## 6.5 AWS Demo Network Manager

The AWS Demo Network Manager provides a generic API for performing common network operations e.g. connect or disconnect. These functions support WiFi, Bluetooth and Ethernet.

### 6.5.1 Interface Headers

These functions (and parameters) are defined in:

- <amazon-freertos>/demos/network\_manager/iot\_network\_manager\_private.h
- <amazon-freertos>/demos/include/aws\_iot\_demo\_network.h (extended for the demos)

### 6.5.2 Configuration Macros

The system is configured with a mix of Macros and function calls. The macros are shown in the following table, which are defined in this file:

```
<amazon-freertos>/vendors/cypress/boards/CY8CPROTO_062_4343W/
aws_demos/config_files/aws_iot_network_config.h
```

Macro Name	Description
configSUPPORTED_NETWORKS	OR'ed list of networks supported by the board. The list is defined in <amazon-freertos>/libraries/c_sdk/standard/common/include/types/iot_network_types.h  AWSIOT_NETWORK_TYPE_NONE AWSIOT_NETWORK_TYPE_WIFI AWSIOT_NETWORK_TYPE_BLE AWSIOT_NETWORK_TYPE_ETH AWSIOT_NETWORK_TYPE_ALL AWSIOT_NETWORK_TYPE_TCP_IP = (_WIFI   _ETH)
configENABLED_NETWORKS	OR'ed list of networks enabled for the project. See the description above for the network list.

### 6.5.3 Network States

The possible states of the network are defined in this file:

```
<amazon-freertos>/libraries/c_sdk/standard/common/include/types/iot_network_types.h
```

```
typedef enum AwsIotNetworkState
{
    eNetworkStateUnknown = 0, /*!< eNetworkStateUnknown State of the network is unknown */
    eNetworkStateDisabled,   /*!< eNetworkStateDisabled State of the network is disabled/disconnected */
    eNetworkStateEnabled     /*!< eNetworkStateEnabled State of the network is enabled and connected. */
} AwsIotNetworkState_t;
```

### 6.5.4 Functions

The network manager provides the following functions:

Function	Description
AwsIoTNetworkManager_Init()	Initializes the network manager.
AwsIoTNetworkManager_GetConfiguredNetworks()	Returns the OR'ed list of configured networks. The list is fixed for a board.  E.g. For CY8CPROTO-062-4343W, configured_networks = AWSIOT_NETWORK_TYPE_WIFI   AWSIOT_NETWORK_TYPE_BLE.
AwsIoTNetworkManager_GetEnabledNetworks()	Returns the OR'ed list of enabled networks. state != eNetworkStateUnknown  All the networks that are either enabled or disabled but initialized.

Function	Description
AwslotNetworkManager_GetConnectedNetworks()	Returns the OR'ed list of connected networks <code>state == eNetworkStateEnabled</code> All the networks that are both enabled and connected.
AwslotNetworkManager_EnableNetwork (uint32_t networkType)	Enables a network
AwslotNetworkManager_DisableNetwork (uint32_t networkType)	Disables a network
AwslotNetworkManager_GetNetworkInterface (uint32_t networkType)	Returns the interface of a network. The return type is <code>IotNetworkInterface</code> structure that has pointers to functions to perform operations such as create/delete a network connection, send/receive data over the connection.
AwslotNetworkManager_GetCredentials (uint32_t networkType)	Returns the credentials of a network such as client certificate, private key etc.  For Wi-Fi, these values are same as the macros defined in <code>aws_clientcredential_keys.h</code> .
AwslotNetworkManager_GetConnectionParams (uint32_t networkType)	Returns the connection parameters such as port number, host name or MQTT end point.  For Wi-Fi, these values are same as the macros defined in <code>aws_clientcredential.h</code> .
AwslotNetworkManager_SubscribeForStateChange (networkType, callback, context, handle)	Subscribes for network state change – Allows multiple application-level subscribers (or tasks or threads) to subscribe for state change indication on the same network.
AwslotNetworkManager_RemoveSubscription (handle)	Unsubscribes from the state change indication of a network

### 6.5.5 Network Manager - Caution

The system is parameterized with #defines rather than function calls in many places (e.g. network parameters). It uses the macros defined in `aws_clientcredential.h` & `aws_clientcredential_keys.h`.

For example, the `EnableNetwork()` function just uses the Wi-Fi settings (SSID, password, and security type) defined in the `aws_clientcredential.h` file for establishing a Wi-Fi connection.

Similarly, the `GetCredentials()` and `GetConnectionParams()` also return the values defined in those header files.

## 6.6 Application & Demo Firmware flow (source code)

All the application firmware follows the same general flow:

- Startup the system, FreeRTOS and connect to Wi-Fi
- Run the Demo\_runner to start the demo
- The specific task(s) run (either your application and/or the demo task)

### 6.6.1 Startup

Function	Steps	Comments
main	prvMisInitialization	Initializes BSP & retargets I/O
main	xLoggingTaskInitialize	Creates a task called “Logging” that sits on a queue and prints the messages with “configPRINT_STRING”
main	vTaskStartScheduler	Turns on FreeRTOS and runs the vApplicationDaemonTaskStartupHook
vApplicationDaemonTaskStartupHook	SYSTEM_Init	Initializes the crypto & socket metrics for the AWS libraries
vApplicationDaemonTaskStartupHook	prvWifiConnect	Makes a connection to the WiFi network
vApplicationDaemonTaskStartupHook	vModeKeyProvisioning	Provision the device with AWS certificate and private key
vApplicationDaemonTaskStartupHook	DEMO_RUNNER_RunDemos	Runs the demo – by starting task from iot_demo_runner.c

### 6.6.2 DEMO\_Runner

DEMO\_RUNNER\_RunDemos starts things going by calling `iot_CreateDetachedThread` with a function pointer to `runDemoTask` and the argument being the `demoContext_t` structure. [iot\_demo\_freertos.c]

```
static demoContext_t mqttDemoContext =
{
    .networkTypes          = DEMO_configNETWORK_TYPES,
    .demoFunction          = DEMO_entryFUNCTION,
    .networkConnectedCallback = DEMO_networkConnectedCallback,
    .networkDisconnectedCallback = DEMO_networkDisconnectedCallback
};
```

- `DEMO_configNETWORK_TYPES` is defined in `aws_demo_config.h`
- `DEMO_entryFUNCTION` is defined `iot_demo_runner.h`
- `DEMO_networkConnectedCallback` (not used)
- `DEMO_networkDisconnectedCallback` (not used)

The `runDemoTask` calls `_initialize` which calls

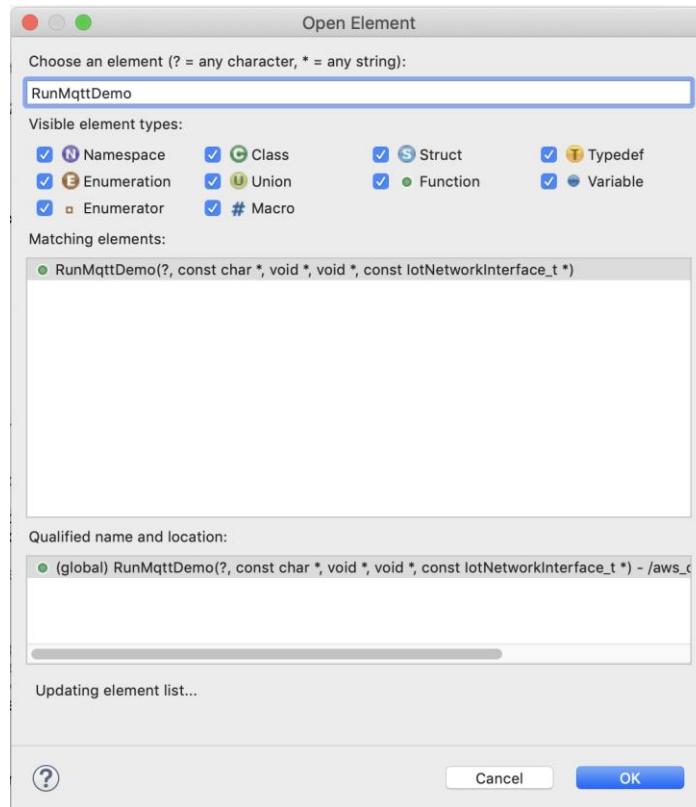
- `iotSdk_Init` (initializes a task pool)
- `AwslotNetworkManager_Init`
- `AwslotNetworkManager_SubscribeForStateChange`
- `AwslotNetworkManager_EnableNetwork`

- `_getConnectedNetworkForDemo`

Then it runs one of the demo functions (via a function pointer):

#define	Function	File
CONFIG_MQTT_DEMO_ENABLED	RunMqttDemo	iot_demo_mqtt.c
CONFIG_SHADOW_DEMO_ENABLED	RunShadowDemo	aws_iot_demo_shadow.c
CONFIG_GREENGRASS_DISCOVERY_DEMO_ENABLED	vStartGreenGrassDiscoveryTask	aws_greengrass_discovery_demo.c
CONFIG_TCP_ECHO_CLIENT_DEMO_ENABLED	vStartTCPEchoClientTasks_SingleTasks	aws_tcp_echo_client_single_task.c
CONFIG_DEFENDER_DEMO_ENABLED	vStartDefenderDemo	aws_iot_demo_defender.c
CONFIG_POSIX_DEMO_ENABLED	vStartPOSIXDemo	
CONFIG_OTA_UPDATE_DEMO_ENABLED	vStartOTAUpdateDemoTask	aws_iot_ota_update_demo.c
CONFIG_BLE_GATT_SERVER_DEMO_ENABLED	vGattDemoSvclInit	aws_ble_gatt_server_demo.c
CONFIG_HTTPS_SYNC_DOWNLOAD_DEMO_ENABLED	RunHttpsSyncDownloadDemo	iot_demo_https_s3_download_sync.c
CONFIG_HTTPS_ASYNC_DOWNLOAD_DEMO_ENABLED	RunHttpsAsyncDownloadDemo	iot_demo_https_s3_download_async.c

It can be insane to try to figure out where functions, defines, etc. exist in the demo project. A way to find them quickly is to use Cmd+Shift+R (Mac) or Ctrl+Shift+R (Windows) to run the “Open Element” dialog (You can also find this under the Navigate menu). In the following picture, you can see that I am looking for “RunMqttDemo”.



### 6.6.3 MQTT Demo

### 6.6.4 Shadow Demo

### 6.6.5 Your Application

## 6.7 FreeRTOS Configuration

FreeRTOS has a number of #defines that can be set in the FreeRTOSConfig file that change the behavior of FreeRTOS. By convention all start with “config” which means you define them inside of the FreeRTOSConfig.h.

Some of them you define as 0 or 1 and they turn off/on features; for example, configUSE\_IDLE\_HOOK. While others you link to a function; for example, configPRINTF

### 6.7.1 configUSE\_DAEMON\_TASK\_STARTUP\_HOOK – vApplicationDaemonTaskStartupHook

When you use #define configUSE\_DAEMON\_TASK\_STARTUP\_HOOK that will tell FreeRTOS to run the function vApplicationDaemonTaskStartupHook after the scheduler has started in the timer\_svc thread. This means functions like vTaskDelay are functioning. This is used by the Amazon FreeRTOS example project to do things like connect to Wi-Fi before everything else gets going.

### 6.7.2 configUSE\_IDLE\_HOOK – vApplicationIdleHook

When #define configUSE\_IDLE\_HOOK is set to “1” it tells FreeRTOS to call the function “vApplicationIdleHook” which you MUST provide when the RTOS is idle. This function is provided by Cypress in main.c and just prints out a “.” every 5 seconds.

```
④ /**
 * @brief User defined Idle task function.
 *
 * @note Do not make any blocking operations in this function.
 */
④ void vApplicationIdleHook( void )
{
    /* FIX ME. If necessary, update to application idle periodic actions. */

    static TickType_t xLastPrint = 0;
    TickType_t xTimeNow;
    const TickType_t xPrintFrequency = pdMS_TO_TICKS( 5000 );

    xTimeNow = xTaskGetTickCount();

    if( ( xTimeNow - xLastPrint ) > xPrintFrequency )
    {
        configPRINTF( "." );
        xLastPrint = xTimeNow;
    }
}
```

### 6.7.3 configUSE\_TICK\_HOOK – vApplicationTickHook

When #define configUSE\_TICK\_HOOK is set to “1” it tells FreeRTOS to call the function “vApplicationTickHook” which you MUST provide when the RTOS tick happens (that is, every 1 ms). This function is provided by Cypress and does a whole lot of nothing.

```
↳ void vApplicationTickHook()  
{  
}
```

### 6.7.4 configPRINTF – vLoggingPrintf

This is a MACRO which mimics printf. FreeRTOS uses this macro to output debugging information. This macro is defined by default to call the AFR logging library print function:

```
#define configPRINTF( X )      vLoggingPrintf X
```

If you want to turn off debugging information (or prints) you could use:

```
#define configPRINTF( X )
```

### 6.7.5 configUSE\_MALLOC\_FAILED\_HOOK – vApplicationMallocFailedHook

If #define configUSE\_MALLOC\_FAILED\_HOOK is set to “1”, when the function pvPortMalloc fails it calls this vApplicationMallocFailedHook. This function is provided in the file “demos/demo\_runner/iot\_demo\_freertos.c”. This means that YOU must define the function in your application if you remove the demo directory.

```
✉ /**
 * @brief Warn user if pvPortMalloc fails.
 *
 * Called if a call to pvPortMalloc() fails because there is insufficient
 * free memory available in the FreeRTOS heap.  pvPortMalloc() is called
 * internally by FreeRTOS API functions that create tasks, queues, software
 * timers, and semaphores.  The size of the FreeRTOS heap is set by the
 * configTOTAL_HEAP_SIZE configuration constant in FreeRTOSConfig.h.
 */
✉ void vApplicationMallocFailedHook()
{
    configPRINTF( ( "ERROR: Malloc failed to allocate memory\r\n" ) );
    taskDISABLE_INTERRUPTS();

    /* Loop forever */
    for( ; ; )
    {
    }
}
```

## 6.7.6 configCHECK\_FOR\_STACK\_OVERFLOW – vApplicationStackOverflowHook

If #define configCHECK\_FOR\_STACK\_OVERFLOW is set to “1”, when the stack overflows, FreeRTOS calls this vApplicationStackOverflowHook. This function is provided in the file “demos/demo\_runner/iot\_demo\_freertos.c”. This means that YOU must define the function in your application if you remove the demo directory.

```
/**  
 * @brief Loop forever if stack overflow is detected.  
 *  
 * If configCHECK_FOR_STACK_OVERFLOW is set to 1,  
 * this hook provides a location for applications to  
 * define a response to a stack overflow.  
 *  
 * Use this hook to help identify that a stack overflow  
 * has occurred.  
 */  
void vApplicationStackOverflowHook( TaskHandle_t xTask,  
                                    char * pcTaskName )  
{  
    configPRINTF( ( "ERROR: stack overflow with task %s\r\n", pcTaskName ) );  
    portDISABLE_INTERRUPTS();  
  
    /* Unused Parameters */  
    ( void ) xTask;  
  
    /* Loop forever */  
    for( ; ; )  
    {  
    }  
}
```

## 6.8 FreeRTOS Naming Convention(s)

The definitions in this section were copied from Amazon.com.

Amazon.com, Inc. or its affiliates (2017). *Reference Manual for FreeRTOS version 10.0.0 issue 1*. Retrieved from [https://www.freertos.org/wp-content/uploads/2018/07/FreeRTOS\\_Reference\\_Manual\\_V10.0.0.pdf](https://www.freertos.org/wp-content/uploads/2018/07/FreeRTOS_Reference_Manual_V10.0.0.pdf), November 12, 2019

### 6.8.1 Variables

#### Variable Names

Variables are prefixed with their type: ‘c’ for char, ‘s’ for short, ‘l’ for long, and ‘x’ for BaseType\_t and any other types (structures, task handles, queue handles, etc.).

If a variable is unsigned, it is also prefixed with a ‘u’. If a variable is a pointer, it is also prefixed with a ‘p’. Therefore, a variable of type unsigned char will be prefixed with ‘uc’, and a variable of type pointer to char will be prefixed with ‘pc’.

## 6.8.2 Functions

### Function Names

Functions are prefixed with both the type they return and the file they are defined in. For example:

- `vTaskPrioritySet()` returns a `void` and is defined within `task.c`.
- `xQueueReceive()` returns a variable of type  `BaseType_t` and is defined within `queue.c`.
- `vSemaphoreCreateBinary()` returns a `void` and is defined within `semphr.h`.

File scope (private) functions are prefixed with 'prv'.

## 6.8.3 Macros

Table 4. Macro prefixes

Prefix	Location of macro definition
port (for example, portMAX_DELAY)	portable.h
task (for example, taskENTER_CRITICAL())	task.h
pd (for example, pdTRUE)	projdefs.h
config (for example, configUSE_PREEMPTION)	FreeRTOSConfig.h
err (for example, errQUEUE_FULL)	projdefs.h

## 6.9 Amazon FreeRTOS Libraries

### 6.9.1 MQTT

Amazon FreeRTOS provides an MQTT library that implements MQTT protocol version 3.1.1. The library implements all the features required for compatibility with the AWS IoT MQTT broker. The library can also be used to connect to any other standard MQTT broker and to publish and subscribe MQTT topics. The library provides both thread aware synchronous and asynchronous APIs.

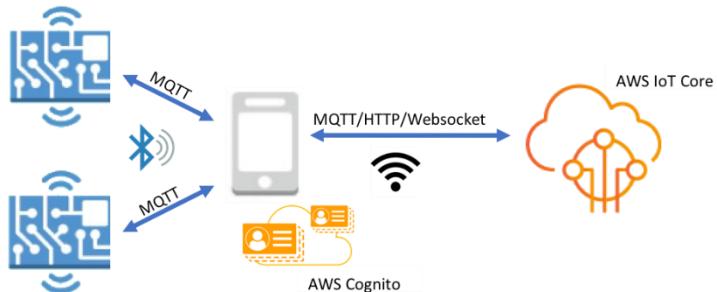
**Note:** Currently the MQTT library doesn't support QoS 2 MQTT messages.

The API reference manual for this library is available at:

[https://docs.aws.amazon.com/freertos/latest/lib-ref/c-sdk/mqtt\\_functions.html](https://docs.aws.amazon.com/freertos/latest/lib-ref/c-sdk/mqtt_functions.html).

## 6.9.2 Bluetooth

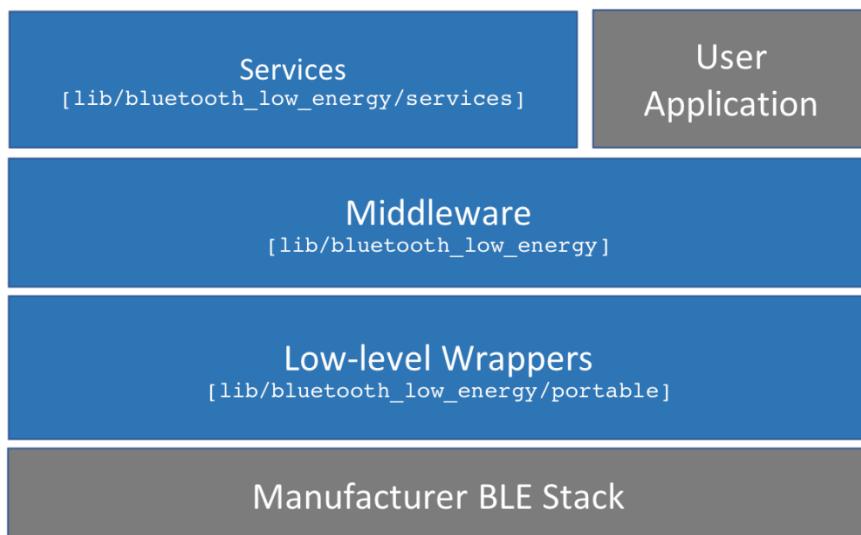
Amazon FreeRTOS has defined an abstraction layer for Bluetooth. This library attempts to simplify the Bluetooth development experience, but typically requires that you make changes to the library files. In addition the Bluetooth library provides a scheme to bridge MQTT over GATT.



The API reference manual for this library is available at:

<https://docs.aws.amazon.com/freertos/latest/lib-ref/ble/index.html>

The library sits on top of the Cypress Bluetooth Stack.



### 6.9.3 Logging

Amazon FreeRTOS has a built-in scheme that allows you to:

1. Create logging messages and send them to a logging queue/task.
2. The messages can be of the following levels:
  - 0/IOT\_LOG\_ERROR1
  - 1/IOT\_LOG\_WARN
  - 2/IOT\_LOG\_INFO
  - 3/IOT\_LOG\_DEBUG
  - 4/IOT\_LOG\_NONE
3. Messages can be suppressed on a file-by-file configurable level (only output messages < LIBRARY\_LOG\_LEVEL).
4. Files that don't specify LIBRARY\_LOG\_LEVEL will use IOT\_LOG\_LEVEL\_GLOBAL.
5. Each file can specify which library they belong to by defining LIBRARY\_LOG\_NAME.
6. The log message contains:
  - A sequence number
  - System time
  - Thread
  - Level (configurable)
  - Library Name (configurable)
  - Time (configurable)
  - The message
7. The output device can be configured.
8. The system can be configured to use a static or dynamic memory scheme.

This system is nice because:

- Messages can be printed from an ISR.
- Message are printed in a standard format.
- Messages are serialized by the queue to fix the mutex problem with the logging system.
- Messages can be redirected to any output system by changing configPRINT\_STRING.

The system is partially documented in the AWS Documentation

<https://docs.aws.amazon.com/freertos/latest/lib-ref/c-sdk/logging/>.

To configure the system, you need to initialize in FreeRTOSConfig.h

- **extern void vLoggingPrintf( const char \* pcFormat, ... );**
- **#define configPRINTF( X ) vLoggingPrintf X**
- **extern void vLoggingPrint( const char \* pcMessage );**
- **#define configPRINT( X ) vLoggingPrint( X )**

In each file you need to:

- **#define LIBRARY\_LOG\_NAME**

- `#define LIBRARY_LOG_LEVEL`
- `#include "iot_logging_setup.h"`

The flow of the logging system code is as follows:

- main.c calls `xLoggingTaskInitialize` [iot\_logging\_task\_dynamic\_buffers.c] which starts a logging task running the function `prvLoggingTask` [iot\_logging\_task\_dynamic\_buffers.c] that waits on a queue (xQueue).
- When you use the macro functions `IoTLogError`, `IoTLogWarn`, `IoTLogInfo`, `IoTLogDebug`, they call the macro `IoTLog` [iot\_logging\_setup.h].
- `IoTLog` [iot\_logging\_setup.h] calls the function `IoTLogGeneric` [iot\_logging.c].
- The function `IoTGeneric` [iot\_logging.c] calls the macro `IoTLogging_Puts` [iot\_config\_common.h].
- `IoTLogging_Puts` [iot\_config\_common.h] calls the macro `configPRINTF` [FreeRTOSConfig.h].
- `configPRINTF` [FreeRTOSConfig.h] calls the function `vLoggingPrintf` [iot\_logging\_task\_dynamic\_buffers.c].
- `vLoggingPrintf` [iot\_logging\_task\_dynamic\_buffers.c] submits the message to the logging xQueue.
- When the Logging task receives messages in the xQueue it calls macro `configPRINT_String` [FreeRTOSConfig.h].
- `configPRINT_STRING` calls the function `fputs(string, stdout)`.
- `fputs` is defined by the Cypress retarget-io library.

The files involved in the logging system are:

libraries/C_sdk/standard/common	
include/iot_logging_setup.h	Defines the macro's <code>IoTLog</code> , <code>IoTLogError</code> , <code>IoTLogWarn</code> , <code>IoTLogInfo</code> , <code>IoTLogDebug</code> , <code>IoTLogGeneric</code>
include/iot_logging_task.h	Forward declaration for <code>xLoggingTaskInitialize</code> and <code>vLoggingPrintf</code>
include/private/iot_logging.h	Forward declarations of <code>LOG_LEVEL_*</code> , <code>IotLogConfig_t</code>
logging/iot_logging_task_dynamic_buffers.c	Defines the task which handles logging. Also defines <code>vLoggingPrintf</code>
logging/iot_logging.c	Defines the code which actually does the work of creating the message before sending it with <code>configPRINTF</code>

<b>vendors/cypress/boards/cy8cproto_062_4343W/aws_demos/config_files</b>	
FreeRTOSConfig.h	#define configPRINTF vLoggingPrintf
iot_config.h	<pre>#define IOT_LOG_LEVEL_GLOBAL           IOT_LOG_INFO #define IOT_LOG_LEVEL_DEMO              IOT_LOG_INFO #define IOT_LOG_LEVEL_PLATFORM          IOT_LOG_NONE #define IOT_LOG_LEVEL_NETWORK          IOT_LOG_INFO #define IOT_LOG_LEVEL_TASKPOOL         IOT_LOG_NONE #define IOT_LOG_LEVEL_MQTT             IOT_LOG_INFO #define AWS_IOT_LOG_LEVEL_SHADOW       IOT_LOG_INFO #define AWS_IOT_LOG_LEVEL_DEFENDER     IOT_LOG_INFO</pre>
include/iot_config_common.h	<pre>#define IotLogging_Puts( str )    configPRINTF( ( "%s\r\n", str ) ) #define IotLogging_Malloc            pvPortMalloc #define IotLogging_Free              vPortFree</pre>

<b>demos/include</b>	
iot_demo_logging.h	<pre>#define LIBRARY_LOG_LEVEL IOT_LOG_LEVEL_DEMO #define LIBRARY_LOG_NAME   ( "DEMO" ) #include "iot_logging_setup.h"</pre>

#### 6.9.4 AWS Device Shadow

The AWS IoT Core Device Shadow Service maintains a shadow for each device you connect to AWS IoT. A device's shadow is a persistent JSON document that is used to store and retrieve state information for a device, regardless of the device's connected state. Shadows support MQTT and HTTP protocols and have unique IDs derived from the "Thing" name.

The Amazon FreeRTOS IoT device shadow library provides APIs to interact with an AWS IoT Thing Shadow. Common use cases for Thing Shadows include backing up device state or sending commands to devices. The device shadow library provides synchronous and asynchronous APIs for modifying Thing Shadows and for registering notifications of a Thing Shadow change. The IoT device shadow library uses the MQTT library to send the messages that interact with the AWS IoT Thing Shadow service.

The API reference manual for the library is available at:

[https://docs.aws.amazon.com/freertos/latest/lib-ref/c-sdk/shadow/shadow\\_functions.html](https://docs.aws.amazon.com/freertos/latest/lib-ref/c-sdk/shadow/shadow_functions.html).

#### 6.10 Using the Cypress HAL & PDL

The HAL and PDL in Amazon FreeRTOS are the same as for the PSoC 6 SDK chapter; refer to that chapter for more details. In order to use the HAL and PDL, include the following files in your project:

```
#include "cy_pdl.h"
#include "cyhal.h"
#include "cybsp.h"
```

## 6.11 Build System

Amazon FreeRTOS is built around the CMakeutility (which Cypress implemented). Optionally, you can use other build systems (we also implemented make).

### 6.11.1 Make

The make build system is a Cypress provided system to build projects in Amazon FreeRTOS. This build system can be used either through the Eclipse IDE or by using the command-line interface (CLI).

#### Eclipse IDE

The Eclipse IDE project is pre-configured to build the demo projects using the make build system. When the aws\_demos project is imported (per Section 6.2) and the user hits the build button it internally triggers the make build system to build the project.

#### Command-line interface (CLI)

A user can also build the project by running `make build` from the project directory (e.g. amazon-freertos/projects/cypress/CY8CPROTO\_062\_4343W/mtb/aws\_demos). For other build options the user can run the `make help` command.

#### Files

There are two primary files that the user is expected to modify:

- Makefile: This is the application makefile. It contains several user configurable options such as target board, user defines, include paths, compiler flags etc.
- afr.mk: This contains the description of source files and include paths for all Amazon provided libraries and demo projects. This also includes the amazon-freertos/vendors/cypress/boards directory. It includes all the sources required for supported demo projects by default but in order to include any additional library provided by Amazon this file is expected to be modified.

Each project for every Cypress board will have these two files.

#### Important Notes:

The make build system automatically searches for sources in the project directory and all directories under the amazon-freertos/vendors/cypress directory **with the exception of the “boards” directory under that directory**. If any sources are added to that directory hierarchy (excluding the boards sub-directory), they will be automatically picked up by the make build system and will not require any changes from the user.

### 6.11.2 CMake

Amazon also provides a CMake based build system to build projects in Amazon FreeRTOS. The instructions to using this build system are documented at:

<https://docs.aws.amazon.com/freertos/latest/qualificationguide/building-cmake.html>.

[AWS Documentation](#) » [Amazon FreeRTOS](#) » [Qualification Guide](#) » [Qualifying Your Device](#) » [Creating a CMakeLists.txt File for Your Platform](#) » [Building Amazon FreeRTOS with CMake](#)

## Building Amazon FreeRTOS with CMake

CMake targets your host operating system as the target system by default. To use CMake for cross compiling, provide a toolchain file that specifies the compiler that you want to use. You can find some examples in [`<amazon-freertos>/tools/cmake/toolchains`](#).

If you're using a compiler different from the one provided with Amazon FreeRTOS, write this toolchain file before you build Amazon FreeRTOS with CMake. You must also set the `CMAKE_TOOLCHAIN_FILE` variable before CMake reads your top-level `CMakeLists.txt` file. The `CMAKE_TOOLCHAIN_FILE` variable specifies which compiler to use and sets some CMake variables, like the system name and the default search path. For more information about cross compiling with CMake, see [Cross Compiling](#) on the official CMake wiki.

The `CMakeLists.txt` and toolchain files must be in the correct locations. Before you build Amazon FreeRTOS with CMake, make sure that you have set up the Amazon FreeRTOS directory structure on your local machine to match the Amazon FreeRTOS directory structure on [GitHub](#). See the [README.md](#) file for instructions.

## 6.12 Coming in Future Releases

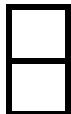
This is the first release of Cypress' Amazon FreeRTOS SDK. Cypress expects major improvements in the next few releases including but not limited to:

- OTA Support
- Easy Low Power Middleware and Configurations
- Additional Cypress Code Examples
- Middleware Management Tool (add/remove middleware to your project easily)
- Additional key middleware for your IoT designs
- Improved Eclipse workspace file organization and presentation

## 6.13 Exercises (Part 2)

### 6.13.1 AWS IoT Setup

See chapter 3 for details about setting up AWS IoT.



1. Sign in to the <https://console.aws.amazon.com/iot/> using your AWS account.
2. From the left navigation pane, click **Settings** and note the endpoint address.

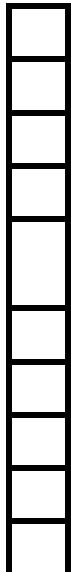
In the endpoint shown in the picture below, the AWS region will be us-west-2.

Custom endpoint

ENABLED

This is your custom endpoint that allows you to connect to AWS IoT. Each of your Things has a REST API available at this endpoint. This is also an important property to insert when using an MQTT client or the AWS IoT Device SDK.

Your endpoint is provisioned and ready to use. You can now start to publish and subscribe to topics.



3. From the left navigation pane, choose Manage and then choose Things.
4. On top right corner, click the Create button.
5. Click Create a single thing at the bottom right corner.
6. Enter a name for the thing (e.g. cykit\_app) and click Next at the bottom.
7. In the next page, click Create thing without certificate. The new thing you have created should appear under Things page.
8. From the left navigation pane, choose Secure and then Policies.
9. On top right corner, click the Create button.
10. Enter a Name for the policy (e.g. MylotPolicy).
11. Click Advanced mode under Add Statements.
12. Delete all the existing statements, copy and paste the following, and click **Create**.

The new policy you have created should appear under Policies page.

```
{  
    "Version": "2012-10-17",  
    "Statement": [  
        {  
            "Effect": "Allow",  
            "Action": "iot:*",  
            "Resource": "*"  
        }  
    ]  
}
```



13. Make a note of the name of the policy that you have just created.

## 6.13.2 AWS Cognito Setup

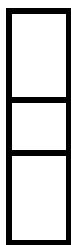
### User Pool Setup

1. In the AWS Console, click Services from the top left corner and click Cognito under Security, Identity, & Compliance.
2. Click Manage User Pools.
3. On the top right corner, click Create a user pool.
4. Enter a name under Pool name (e.g. cykit\_mqtt\_proxy\_user\_pool) and click Review defaults.
5. Under App clients, click Add app client... and click Add an app client.
6. Enter a name under App client name (e.g. mqtt\_proxy\_app\_client), ensure that Generate client secret is selected, and click Create app client button at the bottom.
7. Click Return to pool details
8. Click Create pool at the bottom. You should see a message Your user pool was created successfully.
9. Make a note of the Pool Id. The Pool Id is in the format - <region-name>\_xxxxxxxxxx
10. In the left-side navigation pane, choose App clients and click Show Details.
11. Make a note of the App client id and App client secret.

### Identity Pool Setup

1. In the AWS Console, click Services from the top left corner and click Cognito under Security, Identity, & Compliance.
2. Click Manage Identity Pools
3. On the top right corner, click Create new identity pool.
4. Enter a name under Identity pool name (e.g. afr\_mqtt\_proxy)
5. Expand Authentication providers
6. Choose the Cognito tab
7. Enter the User Pool ID and App client id created during User Pool Setup and click Create Pool at the bottom.
8. Click Allow at the bottom of the page
9. Make a note of the Identity pool ID which is in the format of <region-name>:xxxxxxxx-xxxx-xxxx-xxxx-xxxxxxxxxxxx. This ID is in red color in the code snippet that is under Get AWS Credentials.

## Attach an IAM Policy



1. Go to Cognito, choose Manage Identity Pools, and click the identity pool (e.g. afr\_mqtt\_proxy) that you just created.
2. Click Edit identity pool at the top right corner
3. Make note of the IAM Role assigned to the Authenticated role (e.g. Cognito\_afr\_mqtt\_proxyAuth\_Role).

### Edit identity pool

From this page you can modify the details of your identity pool. An identity pool must have a unique name and a user we will automatically utilize the roles you specify here. You will be required to specify the identity pool id fro

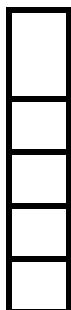


Identity pool name\* afr\_mqtt\_proxy

Identity pool ID ⓘ us-west-2:0d2b35f6-3a07-44ae-aab0-2eb4e7191041 (Show ARN)

Unauthenticated role ⓘ Cognito\_afr\_mqtt\_proxyUnauth\_Role ▾ Create new role

Authenticated role ⓘ Cognito\_afr\_mqtt\_proxyAuth\_Role ▾ **Create new role**



4. In the AWS Console, click Services from the top left corner and click IAM under Security, Identity, & Compliance.
5. In the left navigation pane, click Roles
6. Search for the role that you noted down in step 3 above and choose it.
7. Click **Add inline policy** at the right corner and choose the **JSON tab**.
8. Copy and paste the following policy into the editor:

#### json\_policy

```
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Effect": "Allow",
            "Action": [
                "iot:AttachPolicy",
                "iot:AttachPrincipalPolicy",
                "iot:Connect",
                "iot:Publish",
                "iot:Subscribe",
                "iot:Receive",
                "iot:GetThingShadow",
                "iot:UpdateThingShadow",
                "iot:DeleteThingShadow"
            ],
            "Resource": [
                "*"
            ]
        }
    ]
}
```

- 9. Click the **Review policy** button at the bottom
- 10. Enter a Name for the policy (e.g. mqtt\_proxy\_app\_policy) and click the **Create policy** button at the bottom.

### 6.13.3 Building the iOS App

Before starting, You need to complete both [AWS IoT Setup](#) and [AWS Cognito Setup](#), as well as have the following ready:

- AWS IoT policy name
- Region name
- Identity Pool ID
- User pool ID
- App client ID
- App client secret

If you are using Android, skip to [Building the Android App](#) section.

#### Steps

- 1. On the mac device, clone or download [iOS SDK for AmazonFreeRTOS Bluetooth Devices](#).
- 2. To set up the SDK:
  - a. Install Cocoapods. Open terminal and type:

```
sudo gem install cocoapods
```

You might get a prompt to enter password. Enter the login password of your mac.  
**Note:** If the above command does not work, try this:

```
sudo gem install cocoapods -n /usr/local/bin
```
  - b. Next type:

```
pod setup
```
- 3. Go to the directory where you have cloned the iOS SDK. Navigate to amazon-freertos-ble-ios-sdk/Example/AmazonFreeRTOSDemo, open podfile. In the podfile, find the line:

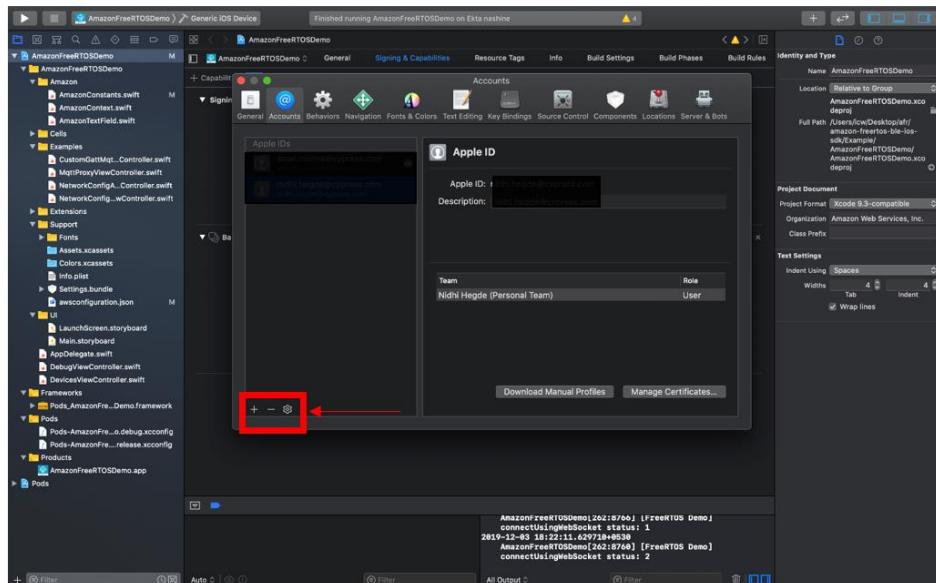
```
pod 'AmazonFreeRTOS', :path => ''
```

Replace with:

```
pod 'AmazonFreeRTOS', :git => 'https://github.com/aws/amazon-freertos-ble-ios-sdk.git'
```
- 4. Save the file.
- 5. In the terminal, navigate to amazon-freertos-ble-ios-sdk/Example/AmazonFreeRTOSDemo and type:

```
pod install
```

6. Next, open Xcode, click file > open > (directory where sdk is cloned) > amazon-freertos-ble-ios-sdk > Example > AmazonFreeRTOSDemo > AmazonFreeRTOSDemo.xcworkspace
7. In the menu bar, go to Xcode > preferences > accounts. Click on '+' in the bottom left corner of the window, and add your apple account. If you do not have an apple account, create one at apple.com. After creating, go to Xcode and add your account as described.



8. Open amazon-freertos-ble-ios-sdk/Example/AmazonFreeRTOSDemo/AmazonFreeRTOSDemo/Amazon/AmazonConstants.swift and change the values of the following variables:
  - region: your aws region
  - iotpolicyname: Your AWS IOT policy name
  - mqttCustomTopic: topic that you want to publish to
9. Open amazon-freertos-ble-ios-sdk/Example/AmazonFreeRTOSDemo/AmazonFreeRTOSDemo/Support/awsconfiguration.json

Under CognitoIdentity, redefine the following variables:

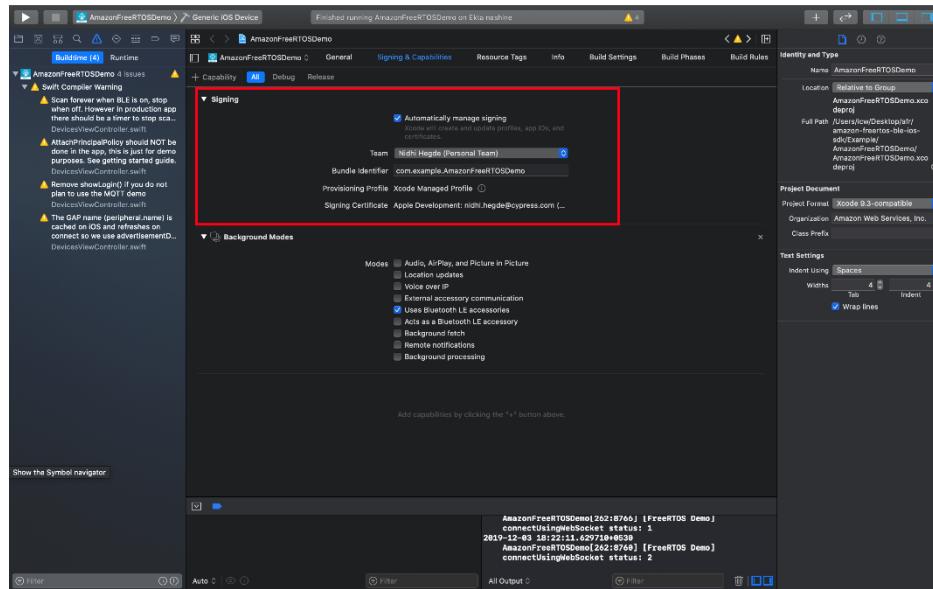
- PoolId: Your Amazon Cognito identity pool ID.
- Region: Your AWS Region

Under CognitoUserPool, redefine the following variables:

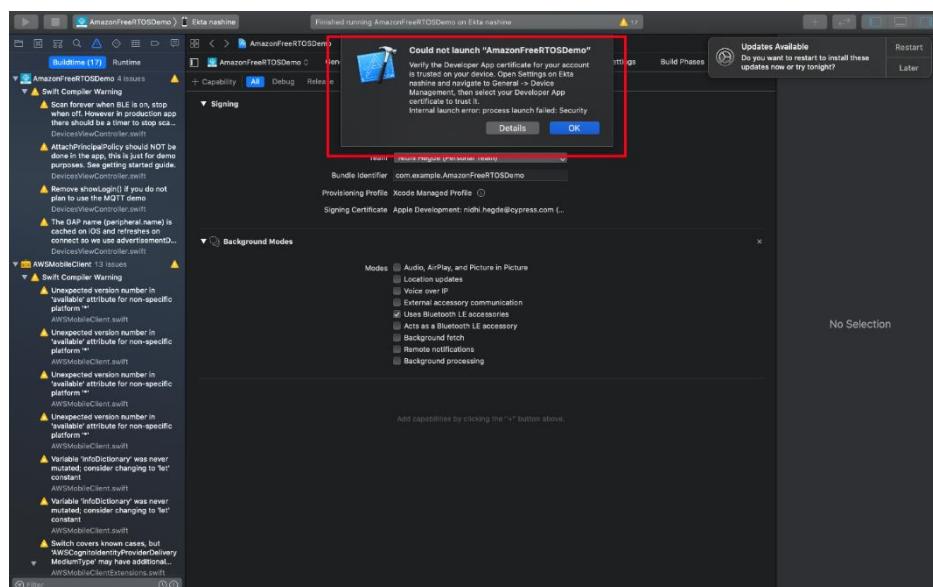
- PoolId: Your Amazon Cognito user pool ID.
- AppClientId: Your app client ID.
- AppClientSecret: Your app client secret.
- Region: Your AWS Region.

10. Go to Signing and capabilities. Select Automatically manage signing. Select the team, in this case your personal team. Add a bundle identifier.

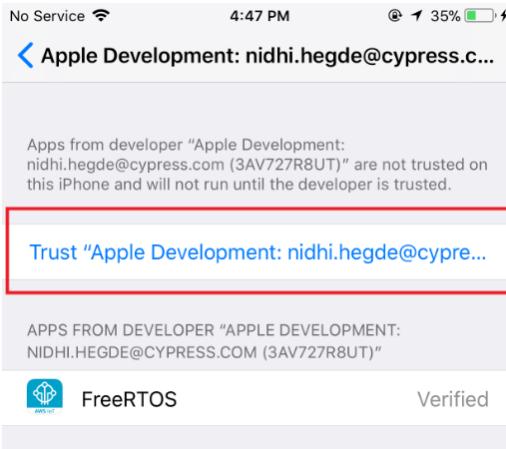
For example: com.example.AmazonFreeRTOS



11. Build the code (menu bar > **Product > Build**). The build should succeed.  
12. Next, connect your iPhone and mac with a data cable. Now run the code(menu bar > **Product > Run**).  
13. When you try to run the app for the first time, you get a pop up saying 'could not launch AmazonFreeRTOSDemo'.

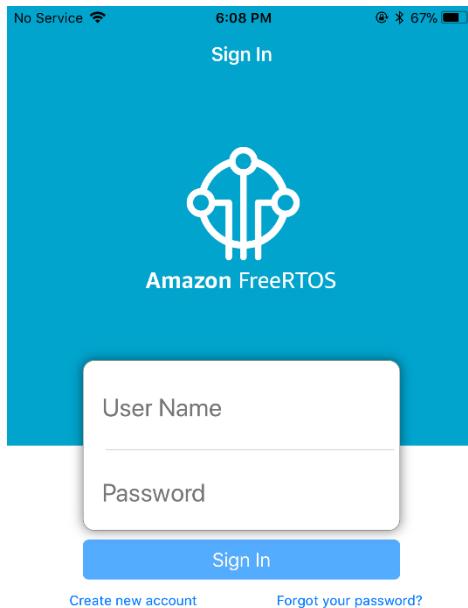


To resolve this, in the iPhone device, go to Settings > General > Device Management > Select the FreeRTOS developer app and click on 'Trust Apple Development'.



#### 14. Run the code again from Xcode.

This time the iOS FreeRTOS app will open. Create a new account and login. The app is ready to be used.



### 6.13.4 Building the Android App

Before starting, You need to complete both [AWS IoT Setup](#) and [AWS Cognito Setup](#), as well as have the following ready:

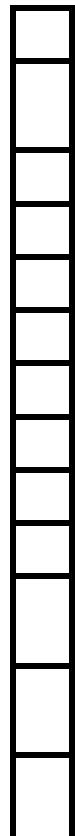
- AWS IoT policy name
- Region name
- Identity Pool ID
- User pool ID
- App client ID
- App client secret

#### Prerequisites

- An Android phone with Android 6.0 (Marshmallow) or later
- Android Studio with Android 6.0 (Marshmallow) or later (API Level 23 or later) SDK installed

If you are using iOS, skip to [Building the iOS App](#).

#### Steps

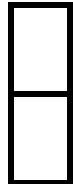
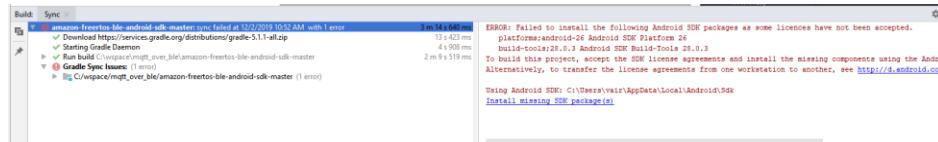


1. Download and install Android Studio from <https://developer.android.com/studio>
2. Before opening Android Studio, ensure you are connected to a network that allows Android Studio to download the SDK
3. Start Android Studio after the installation is complete
4. Choose **Do not import settings** and click **OK**.
5. Click **Don't send** when the Data Sharing dialog appears.
6. In the Welcome page of Android Studio Setup Wizard, click **Next**.
7. Under Install Type, choose **Standard** and click **Next**.
8. Under Select UI Theme, select a theme (Darcula or Light) and click **Next**.
9. Click **Finish** and wait until Android Studio downloads the SDK.
10. Click **Finish** once the SDK installation is complete.
11. Clone or download the Amazon FreeRTOS BLE SDK for Android from <https://github.com/aws/amazon-freertos-ble-android-sdk>
12. In Android Studio, click **Open an existing Android Studio project** and select the directory where Amazon FreeRTOS BLE SDK for Android is located, and click **OK**.
13. Once the project is opened in Android Studio, wait until the Gradle build task finishes.  
You can view the progress in the Build window at the bottom.

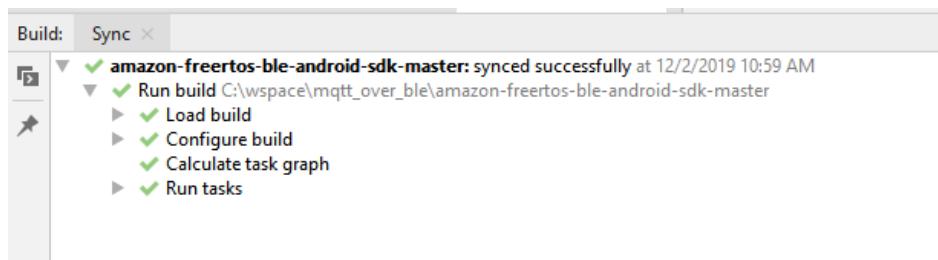


14. You may come across an error when the build finishes. Click **Install missing SDK package(s)** from the Build window.

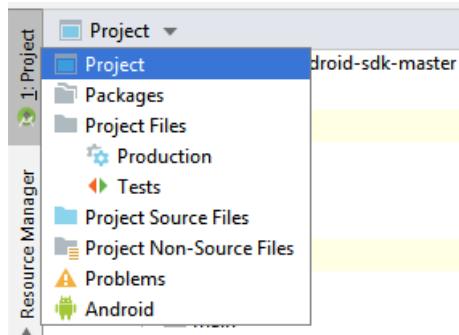
**Note:** This error appears because the App expects Android API Level 26 (Android 8.0 aka Oreo) to be installed but Android Studio installs only the API Level 29 (Android 10.0 aka Q) by default.



15. Accept the license and click **Next**. Wait until the SDK manager downloads and installs the SDK.
16. Once the installation is complete, the Build task runs again, and it should succeed as shown in the following image:



17. Ensure you have selected Project view in the Project Explorer.



18. Expand "app > src > main > java > software.amazon.freertos.demo" and open the DemoConstants.java file.

19. Update AWS\_IOT\_POLICY\_NAME to the name of the IoT policy (e.g. MyIotPolicy) that you created under [AWS IoT Setup](#), and update AWS\_IOT\_REGION to the region name (e.g. us-west-2) you noted in the same section.

**Note:** The policy name is the name of the IoT policy that you created under **IoT Core > Secure > Policies**, not the policy that you created under **IAM > Roles** under [Attach An IAM Policy](#).

```
package software.amazon.freertos.demo;

public class DemoConstants {
    /*
     * Replace with your AWS IoT policy name.
     */
    final static String AWS_IOT_POLICY_NAME = "MyIotPolicy";
    /*
     * Replace with your AWS IoT region, eg: us-west-2.
     */
    final static String AWS_IOT_REGION = "us-west-2";
}
```

20. Expand “app > src > main > res > raw” and open the awsconfiguration.json file.  
21. Update the PoolId & Region under CognitoIdentity and PoolId, AppClientId, AppClientSecret, and Region under CognitoUserPool with the data you noted in the section [AWS Cognito Setup](#).  
22. Enable [Developer Options](#) in your Android phone.

The procedure may be different for your phone. Usually, you can enable this by tapping seven times on the Build number under **Settings > About phone**. Now, you’ll see **Developer Options** under **Settings** (or under **Settings > System**).

23. Scroll down and enable **USB debugging**.  
24. Connect your phone to your computer.  
25. In Android Studio, choose **Build > Make Module ‘app’** and wait until the build finishes.

The app-debug.apk is generated inside /app/build/outputs/apk/debug directory.

26. Click **Run > Run ‘app’**.  
The app opens in your phone after the installation finishes. You can remove the USB cable at this point.

### 6.13.5 Running MQTT over BLE Demo

This section provides step-by-step instructions to run the MQTT over BLE demo bundled with Amazon FreeRTOS (AFR). This demo application shows how to make an MQTT connection to AWS cloud over BLE and perform publish & subscribe operations. Amazon provides a mobile app for both Android and iOS that acts as the MQTT proxy between the device running AFR and the AWS cloud.

Before proceeding, you must familiarize yourself with Amazon FreeRTOS solution for CY8CPROTO-062-4343W. To do this, you must follow the instructions in [Getting Started with Amazon FreeRTOS and CY8CPROTO-062-4343W](#) guide and run the MQTT demo.

#### Prerequisites

- CY8CPROTO-062-4343W kit
- USB-A to Micro-B USB cable
- [Eclipse IDE 2.1 b1266](#)
- [AFR 201910.00 release](#)
- A Smart phone:
  - An iPhone, or
  - An Android phone with Android 6.0 (Marshmallow) or later

#### Build the iOS App

See [Building the iOS App](#) section.

#### Build the Android App

See [Building the Android](#) section.

#### Working with 201910.00 Release

The [201910.00 release](#) has all the fixes provided with the patch for 201908.00 release, **except** the following:

- Replace the iot\_config.h file located in:  
vendors/cypress/boards/CY8CPROTO\_062\_4343W/aws\_demos/config\_files/
- With this file: [iot\\_config.h](#)

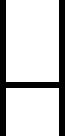
#### Configure Amazon FreeRTOS



1. In main.c, comment out `vDevModeKeyProvisioning()` inside the `vApplicationDaemonTaskStartupHook()` function. The file is located at:  
vendors/cypress/boards/CY8CPROTO\_062\_4343W/aws\_demos/application\_code/  
This is required to avoid error in parsing the client certificate and private key since we do not configure them for this demo.

- 
2. In aws\_clientcredential.h file located inside demos/include directory, update the following.
    - clientcredentialMQTT\_BROKER\_ENDPOINT[] to the endpoint you noted in [AWS IoT Setup](#)
    - clientcredentialIOT\_THING\_NAME to the name of thing you created in [AWS IoT Setup](#)

**Note:** The thing name need not match the name of the thing that you setup via AWS IoT. Other settings such as the client certificate and private key are not required since the mobile app establishes MQTT connection with AWS and it handles the authentication.

- 
3. Go to vendors/cypress/boards/CY8CPROTO\_062\_4343W/aws\_demos/config\_files directory.
  4. In aws\_demo\_config.h file:
    - Ensure #define CONFIG\_MQTT\_DEMO\_ENABLED is present.
    - Define only the BLE network for democonfigNETWORK\_TYPES.

```
#define democonfigNETWORK_TYPES      ( AWSIOT_NETWORK_TYPE_BLE )
```

- 
5. In aws\_iot\_network\_config.h file, update configENABLED\_NETWORKS to contain only the BLE network:

```
#define configENABLED_NETWORKS      ( AWSIOT_NETWORK_TYPE_BLE )
```

- 
6. In iot\_ble\_config.h file, define the following above the statement

```
#include "iot_ble_config_defaults.h".
```

```
/* Device name for this peripheral device. */  
#define IOT_BLE_DEVICE COMPLETE_LOCAL_NAME  
"YOUR_CYPRESS_INITIALS"      //The device name is limited to 4 characters.  
#define IOT_BLE_ADD_CUSTOM_SERVICES ( 1 )  
#define IOT_BLE_ENABLE_WIFI_PROVISIONING ( 1 )
```

- 
7. All the kits use same BLE address (43:43:A1:12:1F:AC) by default. You must change it to uniquely identify your kit when multiple devices are present. To change the address:
    - a. Go to libraries/c\_sdk/standard/ble/src/iot\_ble\_gap.c file
    - b. Add const uint8\_t bdAddr[] = {0x11, 0x22, 0x33, 0xAA, 0xBB, 0xCC}; above const BTProperty\_t \_deviceProperties[] = . Change the address in the array as you like.
    - c. In \_deviceProperties[] array, add a comma after the last element and add the following.

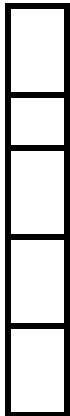
```
{  
.xType = eBTpropertyBdaddr,  
.xLen = 6,  
.pvVal = (void *)bdAddr  
}
```



8. Change configLOGGING\_MAX\_MESSAGE\_LENGTH to 200n the FreeRTOSConfig.h file located in vendors/cypress/boards/CY8CPROTO\_062\_4343W/aws\_demos/config\_files:

```
#define configLOGGING_MAX_MESSAGE_LENGTH 200
```

## Build and Program

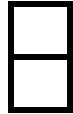


1. Import the project into the Eclipse IDE from projects/cypress/CY8CPROTO\_062\_4343W/mtb/aws\_demos directory
  2. Ensure the kit is connected over USB.
  3. Open a serial terminal software and open a connection to the kit's COM port with 115200, 8N1 setting.
  4. Click aws\_demos Program (KitProg3) from the Quick Panel to build the project and program the kit.
  5. The device boots up, starts advertisement, and waits until a BLE connection is established. The console output appears as follows.

```
COM5 - Tera Term VT
File Edit Setup Control Window Help
WLAN MAC Address : CC:C0:79:24:D8:8B
WLAN Firmware   : w10: Sep 5 2019 23:24:33 version 7.45.98.92 <r722362 CY> FWID 01-f7128517
WLAN CLM        : API: 12-2 Data: 9.10.39 Compiler: 1.29.4 ClmImport: 1.36.3 Creation: 2019-09-05 23:10:00
WHD VERSION    : v1.40.0r-rc3 : v1.40.0r-rc3 : GCC 7.2 : 2019-10-02 13:25:35 +0000
1 3680 [Info Svc] Wi-Fi Connected to AP. Creating tasks which use network...
2 3680 [Info Svc] IP Address acquired 10.40.2.17
3 5324 [Info Svc] Write certificate...
4 5869 [Info Svc] Device credential provisioning succeeded.
5 5873 [iot_thread] [INFO ][INITIAL] SDN successfully initialized.
6 17685 [iot_thread] [INFO ][DEMO][lal] No networks connected for the demo. Waiting for a network connection.
```

## Run Using the iOS App

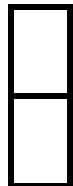
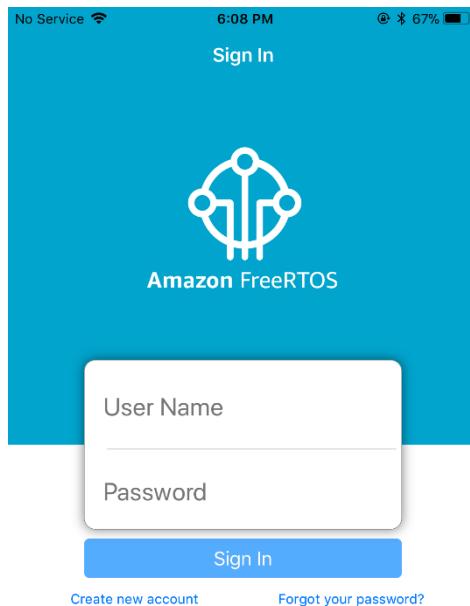
If you are using Android, skip to [Run Using the Android App](#). Tested on iOS version 11.1/iPhone 6 Plus. See [Building the iOS App](#) to build and install the app in your phone.



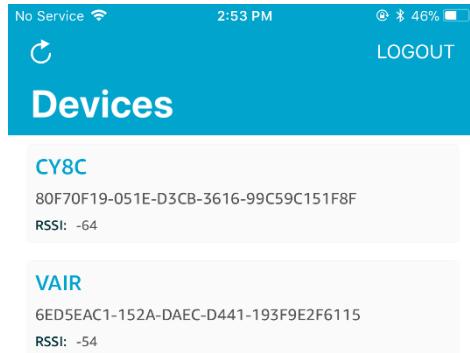
1. Open the FreeRTOS app
2. Click **Create new account**, enter the account information, and click **Sign Up**.

For the Email field, you can enter your Cypress email ID. You'll receive the confirmation code to this email ID.

**Note:** This account is not your AWS account. The account you setup here will be registered under the user pool that you setup during [AWS Cognito Setup](#).

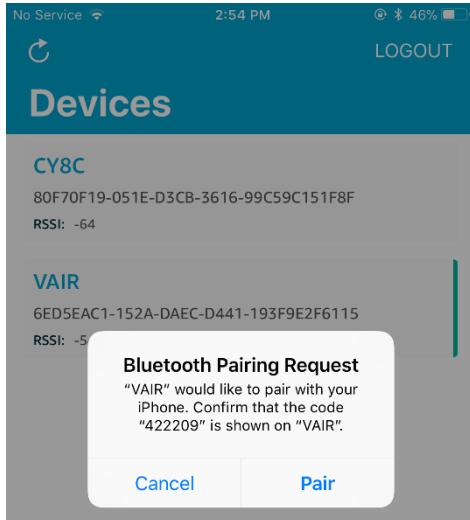


3. In the next page, enter the CONFIRMATION CODE received in your email and click Confirm. You'll see Registration Complete message and click OK.
4. Now the app signs you in, scans for the BLE devices, and lists them. You can click the refresh icon at top left corner to scan again.

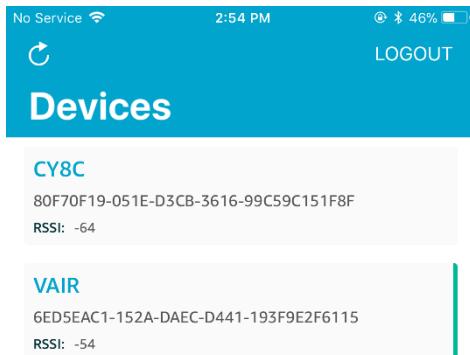


5. Touch the device in the list to connect to it.

6. Device sends pairing request to your phone. Click **Pair** when the message appears in the app. You can now see the device listed under MY DEVICES in Settings > Bluetooth.

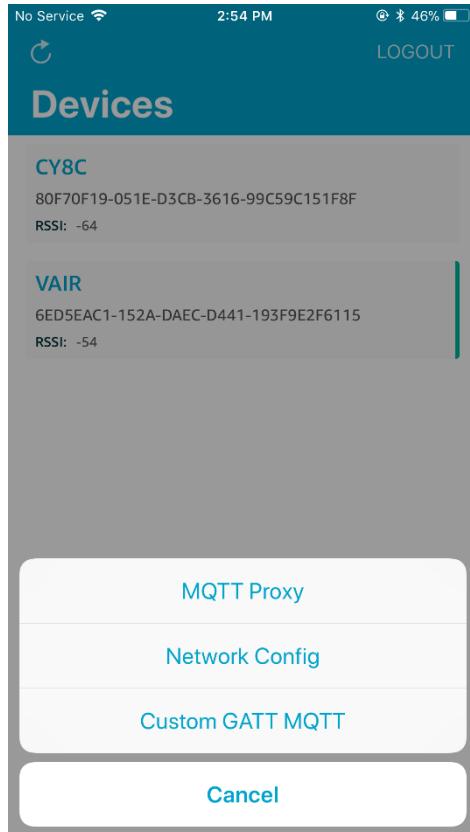


7. Type "y" and press the Enter/Return key in the Serial Terminal window to confirm the passkey.  
 8. Once the connection is successful, the device has a vertical green line at the right corner. You can swipe left on the device to disconnect.





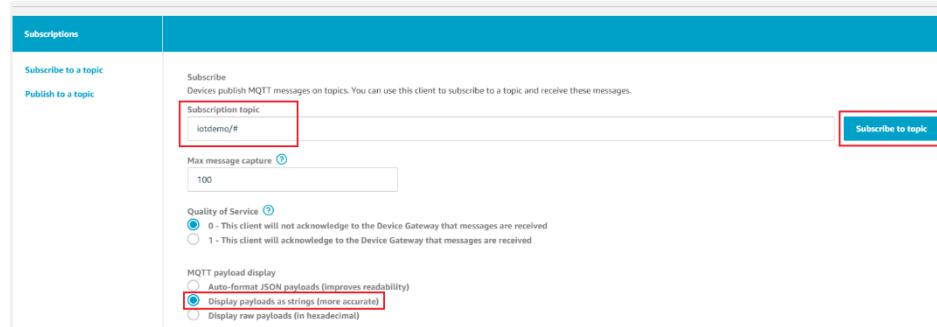
9. Tap on the device and choose MQTT Proxy.



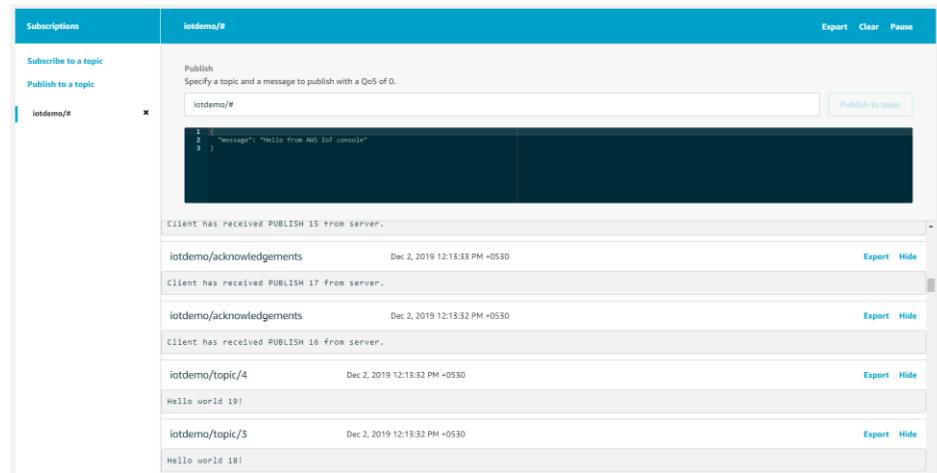
10. Now observe the UART terminal output.

The device should be able to establish MQTT connection and publish the data. If you see any error that the MQTT connection failed, reset the kit and repeat the steps.

11. You can also view the published messages in the AWS IoT Test client. To view the Test client, go to AWS Services > IoT Core and click Test from the left navigation pane.
12. Enter iotdemo/# under Subscription topic, choose Display payloads as strings, and click Subscribe to topic.



13. Sample output in the Test client is shown below. The device publishes up to 20 (0 to 19) "Hello World n!" messages where n = 0 to 19.



## Run Using the Android App

If you are using iOS, skip to Run Using the iOS App. Tested on iOS version 11.1/iPhone 6 Plus. See [Building the Android App](#) to build and install the app in your phone.

### Notes:

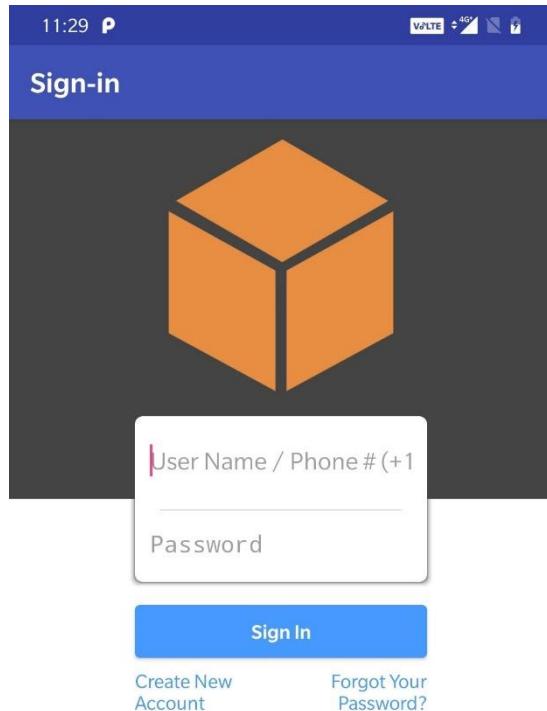
- Unlike the iOS app, the Android app does not work seamlessly. You may have to close the app, clear the data/cache, and turn off/on Bluetooth on the phone, reset the kit, and repeat the steps as necessary.
- Ensure that your phone is connected to a network that allows MQTT traffic. Some mobile operators seem to block it.
- You can keep the phone connected to your computer and open Logcat windows at the bottom of Android Studio to view log messages that provides a better picture of the progress.
- Tested on One Plus 6T/Oxygen OS 9 aka Android 9 Pie.



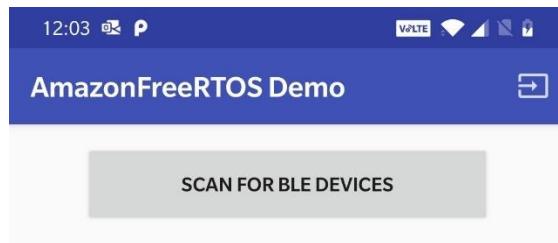
1. Open the AmazonFreeRTOS Demo app
2. In the sign-in screen that appears, click **Create New Account**, enter the details, click **Sign Up**, and wait until the next page appears.

For the **Email** field, you can enter your Cypress email ID. You'll receive the confirmation code to this email ID.

**Note:** This account is not your AWS account. The account you set up here will be registered under the user pool that you set up during [AWS Cognito Setup](#).

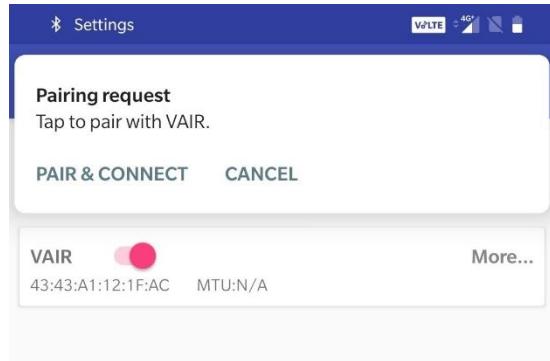


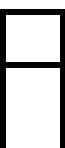
- 
3. In the next page, enter the CONFIRMATION CODE that you received via email and click **OK**.
4. Wait until the app signs you in. This might take a while. Once the sign in is successful, you'll get a screen with **SCAN FOR BLE DEVICES** button.
5. Allow when the app requests access to location.
6. Click the **SCAN FOR BLE DEVICES** button and wait until the device appears.



- 
7. Wait for about 30 seconds for the scan to finish and then Toggle the switch on the device to establish connection.
8. You'll get a pairing request and click **PAIR & CONNECT**.

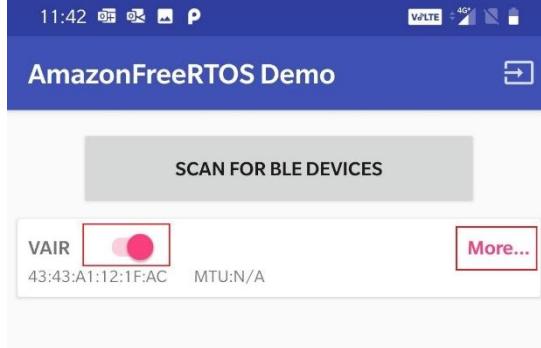
The pairing request is in the notification center. Slide down from top to access the pairing request in case if you have missed it.



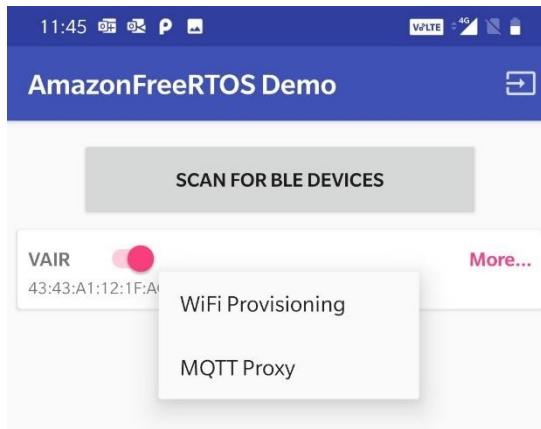
- 
9. When the Pairing Code (passkey) appears, click **Pair**.
10. Type "y" and press the Enter/Return key in the serial terminal window to confirm the passkey.



11. When the connection is successful, the app enables the **More...** menu for the device.



12. Touch **More...** and choose **MQTT Proxy**.



13. Now observe the UART terminal output.

The device should be able to establish MQTT connection and publish the data. If you see any error that the MQTT connection failed, reset the kit and repeat the steps.

**Note:** Once the app connects to the kit successfully, it automatically establishes connection upon disconnection and the whole MQTT over BLE flow just runs through without having to repeat the steps. You need to just reset the kit and wait until the app reconnects.



14. Go to the last few steps under the [Run Using the iOS App](#) exercise to see the sample terminal output and how to monitor the MQTT data using the AWS IoT Test client.

## Known Issue

"Error running demo" message appears at the end of MQTT over BLE demo

**Root cause:** The demo code publishes acknowledgement messages under the topic "iotdemo/acknowledgements" for each received message. It initiates publishing of the last acknowledgement message which is a non-blocking function call and initiates UNSUBSCRIBE immediately without waiting for the transaction to complete. The MQTT proxy (mobile app) returns error in this case and the final status results in error. This is reason you'll see all 20 "Hello World n!"

messages published in the AWS Test client but only few messages under the topic "iotdemo/acknowledgements".

**Fix:** This can be solved by adding a small delay at the end of the function \_mqttSubscriptionCallback().

```

else
{
    IoTLogWarn( "Acknowledgment message for PUBLISH %.s will NOT be sent.",
                ( int ) messageNumberLength,
                pPayload + messageNumberIndex );
}
}

vTaskDelay(pdMS_TO_TICKS(1000));

/* Increment the number of PUBLISH messages received. */
IotSemaphore_Post( pPublishesReceived );
}
}

```

### 6.13.6 Running BLE GATT Server Demo

**Note:** If you have not done [AWS IOT Setup](#) and [AWS Cognito Setup](#), do them now. After setting up your AWS account, follow these steps to run the Amazon FreeRTOS BLE Custom GATT Server demo:



- Clone the amazon-freertos repo and change to branch 201910-MTBAFR1951:

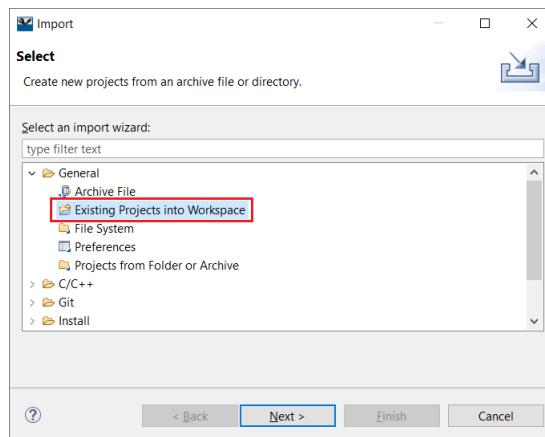
```
git clone https://github.com/cypresssemiconductorco/amazon-freertos.git -b 201910-MTBAFR1951 --recurse-submodules
```



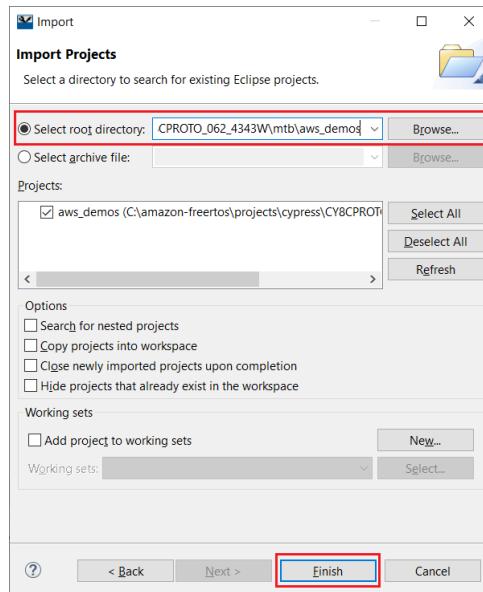
- Import the project into the Eclipse IDE.

- Open the IDE and choose or create a workspace.

- Select **File > Import**. In the dialog, expand **General**, choose **Existing Projects into Workspace**, and then click **Next >**.



- c. In **Select root directory**, enter <amazon-freertos>/projects/cypress/CY8CPROTO\_062\_4343W /mtb/aws\_demos.



- d. Click **Finish** to import the project into your workspace.



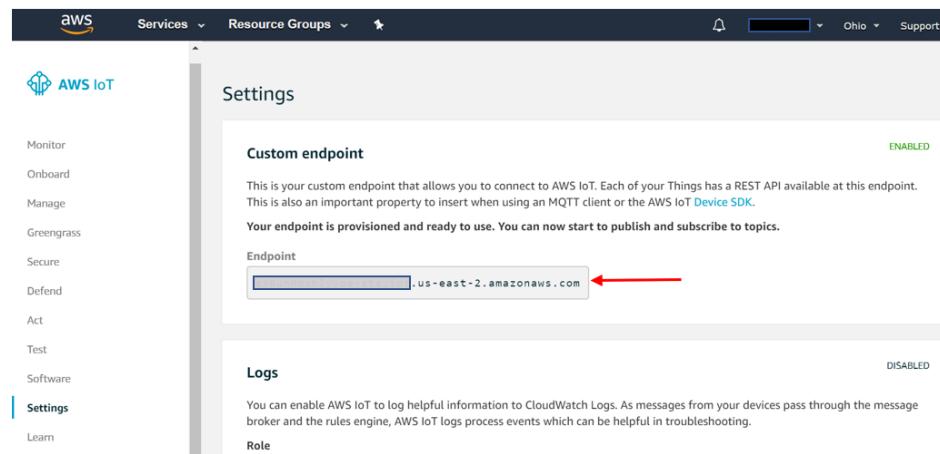
3. After importing, go to the file demos/include/aws\_clientcredential.h.

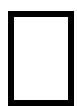
Configure the MQTT broker endpoint and IOT thing name by changing values of the following macros:

```
#define clientcredentialMQTT_BROKER_ENDPOINT      " "
#define clientcredentialIOT_THING_NAME              " "
```

**Note:** To get the thing name, login to the IOT console with your AWS account. Go to Services > IOT Core.

From the left menu bar, select **Manage**, and here you can find the "Thing" created. To get the MQTT broker endpoint, from the left menu bar, go to **Settings**. Here you can find the endpoint:





4. Next, go to file vendors/cypress/boards/CY8CPROTO\_062\_4343W/aws\_demos/config\_files/iot\_ble\_config.h

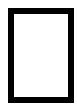
- a. Add the macro:

```
#define IOT_BLE_ADD_CUSTOM_SERVICES ( 1 )
```

- b. The device advertising name can be changed using:

```
#define IOT_BLE_DEVICE_COMPLETE_LOCAL_NAME "NAME"
```

**Note:** The device name can have a maximum of four characters.

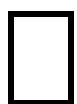


5. Go to file vendors/cypress/boards/CY8CPROTO\_062\_4343W/aws\_demos/config\_files/aws\_iot\_network\_config.h

- a. Change the value of macro as shown:

```
#define configENABLED_NETWORKS (AWSIOT_NETWORK_TYPE_BLE)
```

**Note:** This demo does not require the kit to connect to Wi-Fi.



6. Go to vendors/cypress/boards/CY8CPROTO\_062\_4343W/aws\_demos/config\_files/aws\_demo\_config.h.

- a. Comment: #define CONFIG\_MQTT\_DEMO\_ENABLED

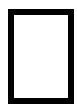
- b. Add #define CONFIG\_BLE\_GATT\_SERVER\_DEMO\_ENABLED

- c. Change the macro values as shown:

```
#define democonfigNETWORK_TYPES ( AWSIOT_NETWORK_TYPE_BLE )
```

- d. Add:

```
#define BLE_ENABLED (( configENABLED_NETWORKS & AWSIOT_NETWORK_TYPE_BLE ) == AWSIOT_NETWORK_TYPE_BLE )
```



7. Go to vendors/cypress/boards/CY8CPROTO\_062\_4343W/aws\_demos/application\_code/main.c.

Inside function vApplicationDaemonTaskStartupHook(), comment the function call:  
`vDevModeKeyProvisioning();`



8. All the kits use same BLE address (43:43:A1:12:1F:AC) by default.

You must change it to uniquely identify your kit when multiple devices are present. To change the address:

- a. Go to the libraries/c\_sdk/standard/ble/src/iot\_ble\_gap.c file.

- b. Add `const uint8_t bdAddr[] = {0x11, 0x22, 0x33, 0xAA, 0xBB, 0xCC};` above `const BTProperty_t _deviceProperties[]`. Change the address in the array as you like.

- c. In the `_deviceProperties[]` array, add a comma after the last element and add the following:

```
{
    .xType = eBTpropertyBdaddr,
    .xLen = 6,
    .pvVal = (void *)bdAddr
}
```

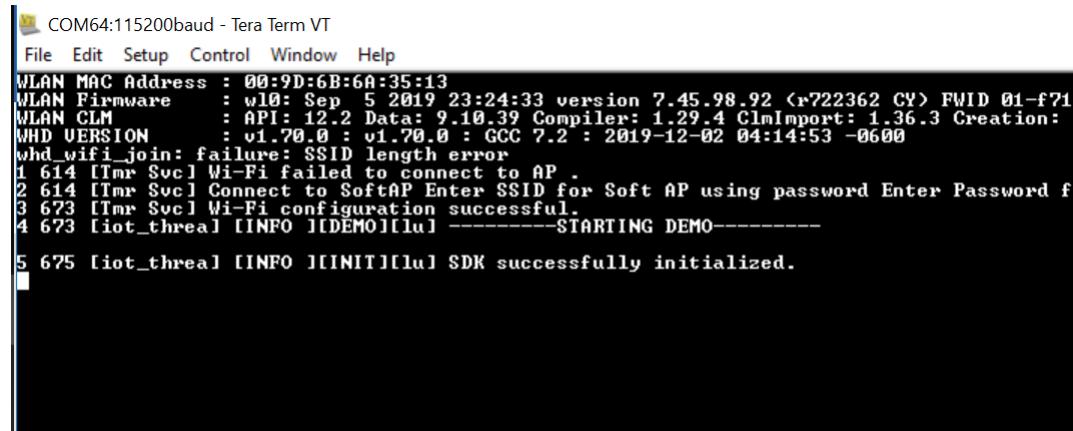


9. In the FreeRTOSConfig.h file, change configLOGGING\_MAX\_MESSAGE\_LENGTH to 200:

```
#define configLOGGING_MAX_MESSAGE_LENGTH 200
```

10. Build the project and program the kit.

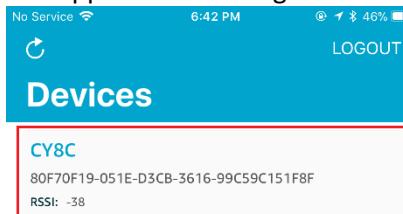
11. Open Tera Term or any other UART terminal of your choice. Choose the COM port to which the kit is connected with baud rate of 115200. Data is 8 bit with Stop bit is 1.



```
COM64:115200baud - Tera Term VT
File Edit Setup Control Window Help
WLAN MAC Address : 00:9D:6B:6A:35:13
WLAN Firmware : w10: Sep 5 2019 23:24:33 version 7.45.98.92 <r722362 CY> FWID 01-f71
WLAN CLM : API: 12.2 Data: 9.10.39 Compiler: 1.29.4 ClmImport: 1.36.3 Creation:
WHD VERSION : v1.70.0 : v1.70.0 : GCC 7.2 : 2019-12-02 04:14:53 -0600
whd_wifi_join: failure: SSID length error
1 614 [Tmr Svc] Wi-Fi failed to connect to AP .
2 614 [Tmr Svc] Connect to SoftAP Enter SSID for Soft AP using password Enter Password f
3 673 [Tmr Svc] Wi-Fi configuration successful.
4 673 [iot_threa] [INFO ][DEMO][lu] -----STARTING DEMO-----
5 675 [iot_threa] [INFO ][INIT][lu] SDK successfully initialized.
```

12. On the SmartPhone device, enable Bluetooth and open FreeRTOS app.

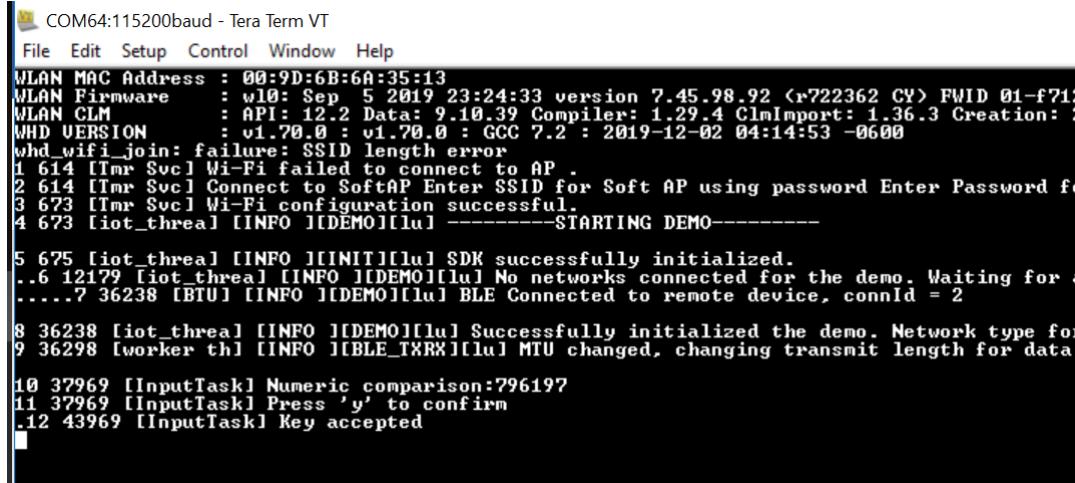
The app starts scanning for Bluetooth devices. Select your device to connect.





13. After this, a pairing request pops up in the app.

Compare the numeric keys on the displayed on the terminal and iPhone device. Accept pairing request if the keys match. A green bar at the right side of the device tab indicates active connection.



```

COM64:115200baud - Tera Term VT
File Edit Setup Control Window Help
WLAN MAC Address : 00:9D:6B:6A:35:13
WLAN Firmware : w10: Sep 5 2019 23:24:33 version 7.45.98.92 <r722362 CY> FWID 01-f71
WLAN CLM : API: 12.2 Data: 9.10.39 Compiler: 1.29.4 ClmImport: 1.36.3 Creation: 2019-12-02 04:14:53 -0600
WHD VERSION : v1.70.0 : v1.70.0 : GCC 7.2 : 2019-12-02 04:14:53 -0600
whd_wifi_join: failure: SSID length error
1 614 [Tmr Svc] Wi-Fi failed to connect to AP .
2 614 [Tmr Svc] Connect to SoftAP Enter SSID for Soft AP using password Enter Password for AP
3 673 [Tmr Svc] Wi-Fi configuration successful.
4 673 [iot_threah] [INFO ][DEMO][lu] -----STARTING DEMO-----
5 675 [iot_threah] [INFO ][INIT][lu] SDK successfully initialized.
.. 12179 [iot_threah] [INFO ][DEMO][lu] No networks connected for the demo. Waiting for connection...
.... 36238 [BTU] [INFO ][DEMO][lu] BLE Connected to remote device, connId = 2
8 36238 [iot_threah] [INFO ][DEMO][lu] Successfully initialized the demo. Network type for demo is BLE
9 36298 [worker th] [INFO ][BLE_TXRX][lu] MTU changed, changing transmit length for data
10 37969 [InputTask] Numeric comparison:796197
11 37969 [InputTask] Press 'y' to confirm
12 43969 [InputTask] Key accepted
    
```



14. Next, select your kit in the devices list.

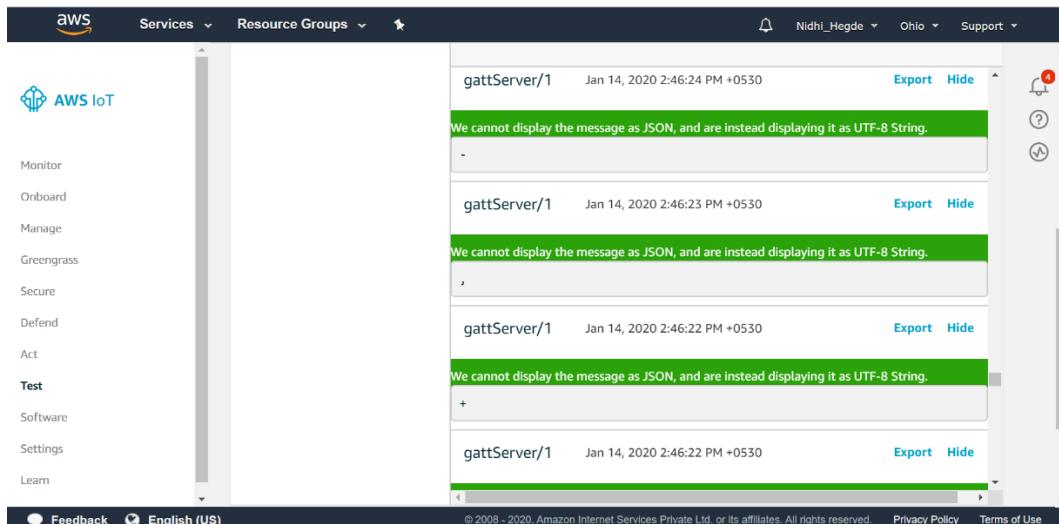
Login to the AWS IOT console and go to **Services > IOT Core**. Go to **Tests** and select **Subscribe to a Topic**. Enter the topic name and click **Subscribe**.

**Note:** The topic name is configured while building the AFR app for iOS in the file **AmazonConstants.swift** .



15. In the FreeRTOS app, select **Custom GATT MQTT**.

Here you can start, stop, or reset the counter; the values are updated in the AWS IOT console.



Message Content	Timestamp	Action
-	Jan 14, 2020 2:46:24 PM +0530	Export Hide
+	Jan 14, 2020 2:46:23 PM +0530	Export Hide
-	Jan 14, 2020 2:46:22 PM +0530	Export Hide
+	Jan 14, 2020 2:46:22 PM +0530	Export Hide

### 6.13.7 Wi-Fi Scan and Connect to Access Point

- 1. Clone the Amazon FreeRTOS repo from GitHub and check out the latest release using its tag.

The following command also clones all the submodules:

```
git clone https://github.com/cypresssemiconductorco/amazon-freertos.git -b 201910-MTBAFR1951 --recurse-submodules
```
- 2. Extract the ch06-wifi-scan-and-connect.zip file from “templates” into the following directory:

<amazon-freertos>/projects/cypress/

**Note:** <amazon-freertos> refers to the path of the Amazon FreeRTOS directory on your computer.
- 3. Import the project into an Eclipse IDE workspace:
  - a. Select **File > Import**.
  - b. Select **General > Existing Projects into Workspace** and click **Next >**.
  - c. Click the **Browse** button near “Select root directory,” choose the project directory <amazon-freertos>/projects/cypress/afr-exercise-wifi-scan-and-connect and click **Finish**.
- 4. Configure the network credentials in the wifi\_scan\_and\_connect.c file:

<amazon-freertos>/projects/cypress/afr-exercise-wifi-scan-and-connect/source/

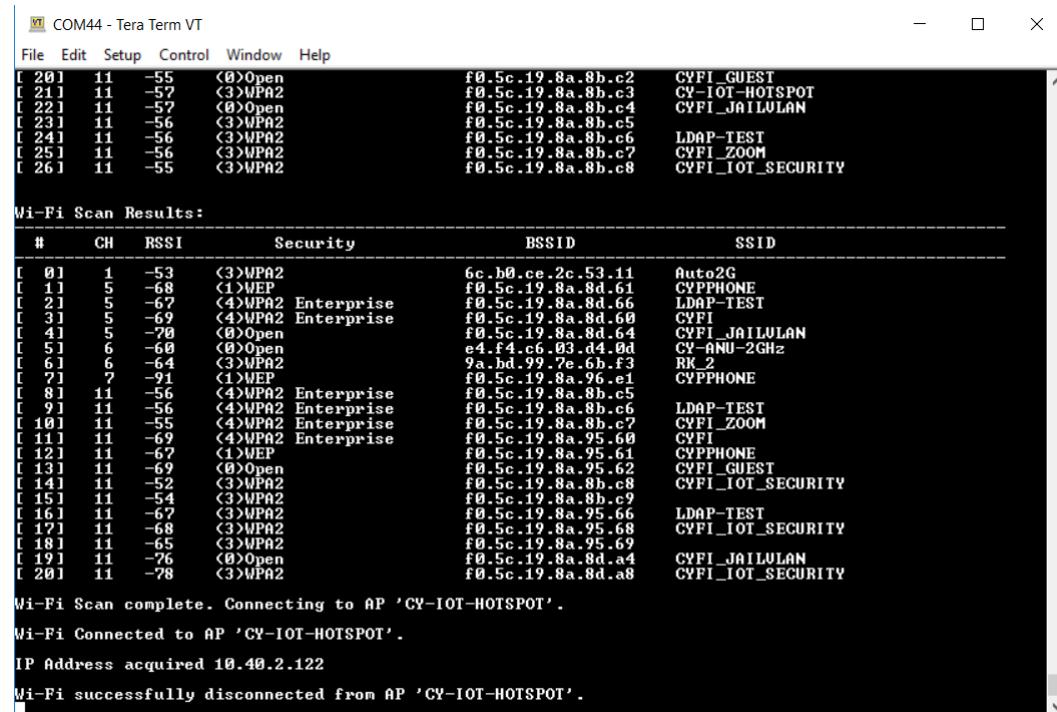
  - a. Enter the SSID and password of the network to be connected in the following macros:

```
#define clientcredentialWIFI_SSID          "<your-ssid-here>"  
#define clientcredentialWIFI_PASSWORD      "<your-password-here>"
```
  - b. Additionally, if your network’s Wi-Fi Security is not WPA2, configure the type of Wi-Fi Security in the following macro:

```
#define clientcredentialWIFI_SECURITY      eWiFiSecurityWPA2
```

Change eWiFiSecurityWPA2 to eWiFiSecurityOpen, eWiFiSecurityWEP, or eWiFiSecurityWPA, as applicable.
- 5. Build the project and program the kit.
  - a. Select the application project in the Project Explorer.
  - b. In the Quick Panel, scroll down, and click afr-exercise-wifi-scan-and-connect Program (KitProg3).
- 6. Observe the UART logs in a serial terminal program of your choice by connecting to the COM port of the device with a baud rate of 115200 and 8N1 configuration.

The following shows a sample log:



```

COM44 - Tera Term VT
File Edit Setup Control Window Help

[ 20] 11 -55 <0>Open f0.5c.19.8a.8b.c2 CYFI_GUEST
[ 21] 11 -57 <3>WPA2 f0.5c.19.8a.8b.c3 CY-IOT-HOTSPOT
[ 22] 11 -57 <0>Open f0.5c.19.8a.8b.c4 CYFI_JAILULAN
[ 23] 11 -56 <3>WPA2 f0.5c.19.8a.8b.c5
[ 24] 11 -56 <3>WPA2 f0.5c.19.8a.8b.c6 LDAP-TEST
[ 25] 11 -56 <3>WPA2 f0.5c.19.8a.8b.c7 CYFI_ZOOM
[ 26] 11 -55 <3>WPA2 f0.5c.19.8a.8b.c8 CYFI_IOT_SECURITY

Wi-Fi Scan Results:
# CH RSSI Security BSSID SSID
[ 0] 1 -53 <3>WPA2 6.c.b0.ce.2c.53.11 Auto2G
[ 1] 5 -68 <1>WEP f0.5c.19.8a.8d.61 CYPPHONE
[ 2] 5 -67 <4>WPA2 Enterprise f0.5c.19.8a.8d.66 LDAP-TEST
[ 3] 5 -69 <4>WPA2 Enterprise f0.5c.19.8a.8d.60 CYFI
[ 4] 5 -70 <0>Open f0.5c.19.8a.8d.64 CYFI_JAILULAN
[ 5] 6 -60 <0>Open e4.f4.c6.03.d4.0d CY-ANU-2GHz
[ 6] 6 -64 <3>WPA2 9.a.hd.99.2e.6b.f3 RK_2
[ 7] 7 -91 <1>WEP f0.5c.19.8a.96.e1 CYPPHONE
[ 8] 11 -56 <4>WPA2 Enterprise f0.5c.19.8a.8b.c5
[ 9] 11 -56 <4>WPA2 Enterprise f0.5c.19.8a.8b.c6 LDAP-TEST
[ 10] 11 -55 <4>WPA2 Enterprise f0.5c.19.8a.8b.c7 CYFI_ZOOM
[ 11] 11 -69 <4>WPA2 Enterprise f0.5c.19.8a.95.60 CYFI
[ 12] 11 -67 <1>WEP f0.5c.19.8a.95.61 CYPPHONE
[ 13] 11 -69 <0>Open f0.5c.19.8a.95.62 CYFI_GUEST
[ 14] 11 -52 <3>WPA2 f0.5c.19.8a.8b.c8 CYFI_IOT_SECURITY
[ 15] 11 -54 <3>WPA2 f0.5c.19.8a.8b.c9
[ 16] 11 -67 <3>WPA2 f0.5c.19.8a.95.66 LDAP-TEST
[ 17] 11 -68 <3>WPA2 f0.5c.19.8a.95.68 CYFI_IOT_SECURITY
[ 18] 11 -65 <3>WPA2 f0.5c.19.8a.95.69
[ 19] 11 -76 <0>Open f0.5c.19.8a.8d.44 CYFI_JAILULAN
[ 20] 11 -78 <3>WPA2 f0.5c.19.8a.8d.a8 CYFI_IOT_SECURITY

Wi-Fi Scan complete. Connecting to AP 'CY-IOT-HOTSPOT'.
Wi-Fi Connected to AP 'CY-IOT-HOTSPOT'.
IP Address acquired 10.40.2.122
Wi-Fi successfully disconnected from AP 'CY-IOT-HOTSPOT'.
  
```

### 6.13.8 Display using TFT

This example displays a counter on the TFT screen that updates once per second.



- Clone recursively Amazon FreeRTOS from GitHub.

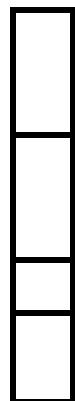
```
git clone --recurse-submodules
https://github.com/cypresssemiconductorco/amazon-freertos.git --branch
201910-MTBAFR1951
```



- Extract the ch06-tft-emwin.zip file from “templates” into the following directory:

<amazon-freertos>/projects/cypress

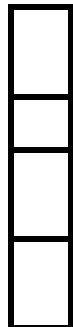
**Note:** <amazon-freertos> refers to the path of the Amazon FreeRTOS directory on your computer.



- Open <amazon-freertos>/demos/include/aws\_clientcredential.h file and configure the SSID and Wi-Fi password of the desired network, as well as the AWS parameters such as endpoint and Thing name.
- Configure the client certificate and the private key in <amazon-freertos>/demos/include/aws\_clientcredential\_keys.h for the Thing used in the previous step.
- Connect the CY8CKIT-028-TFT shield to the Arduino header.
- Connect the base kit to your PC using the provided USB cable through the USB connector.



7. Open a terminal program and select the KitProg3 COM port. Set the serial port parameters to 8N1 and 115200 baud.
8. Import the project into an Eclipse IDE workspace:
  - a. Select **File > Import**.
  - b. Select **General > Existing Projects into Workspace** and click **Next >**.
  - c. Click the **Browse** button near “Select root directory,” choose the project directory *<amazon-freertos>/projects/cypress/afr-example-tft-emwin*, and click **Finish**.



9. Right-click on the application project in the Project Explorer and select **Build Targets > Create**.
10. Specify the target name as “getlibs” and click **OK**.
11. Expand the application project and double-click on **Build Targets > getlibs**. Wait for the operation to complete.
12. Select the application project, then in the Quick Panel, scroll down, and click “afr-example-tft-emwin Program (KitProg3).”

When programming is complete, a 3-digit counter of frequency of 1 Hz displays on the center of the TFT screen

### 6.13.9 Modify the MQTT Demo with Display

This exercise displays the number of publish messages received.



1. Clone recursively Amazon FreeRTOS from GitHub.

```
git clone --recurse-submodules  
https://github.com/cypresssemiconductorco/amazon-freertos.git --branch  
201910-MTBAFR1951
```



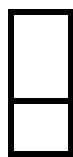
2. Extract the ch06-mqtt-counter.zip file from “templates” into the following directory:

*<amazon-freertos>/projects/cypress*

**Note:** *<amazon-freertos>* refers to the path of the Amazon FreeRTOS directory on your computer.



3. Open *<amazon-freertos>/demos/include/aws\_clientcredential.h* file and configure the SSID and Wi-Fi password of the desired network, as well as the AWS parameters such as endpoint and Thing name.
4. Configure the client certificate and the private key in *<amazon-freertos>/demos/include/aws\_clientcredential\_keys.h* for the Thing used in the previous step.
5. Connect the CY8CKIT-028-TFT shield to the Arduino header.
6. Connect the base kit to your PC using the provided USB cable through the USB connector.



7. Open a terminal program and select the KitProg3 COM port. Set the serial port parameters to 8N1 and 115200 baud.
8. Import the project into an Eclipse IDE workspace:
  - a. Select **File > Import**.
  - b. Select **General > Existing Projects into Workspace** and click **Next >**.
  - c. Click the **Browse** button near “Select root directory,” choose the project directory `<amazon-freertos>/projects/cypress/afr-example-mqtt-counter`, and click **Finish**.
9. Right-click on the application project in the Project Explorer and select **Build Targets > Create**.
10. Specify the target name as “getlibs” and click **OK**.
11. Expand the application project and double-click on **Build Targets > getlibs**. Wait for the operation to complete.
12. Select the application project, then in the Quick Panel, scroll down, and click “afr-example-mqtt-counter Program (KitProg3).”



When programming is complete, a 3-digit counter of the number of publish messages received displays on the center of the TFT screen.

### 6.13.10 Retarget configPRINTF

This exercise modifies the configPRINTF to display on the TFT.



1. Clone recursively Amazon FreeRTOS from GitHub.

```
git clone --recurse-submodules  
https://github.com/cypresssemiconductorco/amazon-freertos.git --branch  
201910-MTBAFR1951
```



2. Extract the ch06-retarget-io-tft.zip file from “templates” into the following directory:

`<amazon-freertos>/projects/cypress`

**Note:** `<amazon-freertos>` refers to the path of the Amazon FreeRTOS directory on your computer.



3. Open `<amazon-freertos>/demos/include/aws_clientcredential.h` file and configure the SSID and Wi-Fi password of the desired network, as well as the AWS parameters such as endpoint and Thing name.
4. Configure the client certificate and the private key in `<amazon-freertos>/demos/include/aws_clientcredential_keys.h` for the Thing used in the previous step.
5. Connect the CY8CKIT-028-TFT shield to the Arduino header.
6. Connect the base kit to your PC using the provided USB cable through the USB connector.



7. Open a terminal program and select the KitProg3 COM port. Set the serial port parameters to 8N1 and 115200 baud.
8. Import the project into an Eclipse IDE workspace:
  - a. Select **File > Import**.
  - b. Select **General > Existing Projects into Workspace** and click **Next >**.
  - c. Click the **Browse** button near “Select root directory,” choose the project directory `<amazon-freertos>/projects/cypress/afr-example-retarget-io-tft`, and click **Finish**.



9. Right-click on the application project in the Project Explorer and select **Build Targets > Create**.
10. Specify the target name as “getlibs” and click **OK**.
11. Expand the application project and double-click on **Build Targets > getlibs**. Wait for the operation to complete.
12. Select the application project, then in the Quick Panel, scroll down, and click “afr-example-retarget-io-tft Program (KitProg3).”

When programming is complete, all configPRINTF messages are printed on the TFT screen. The screen will auto scroll to fit new messages.

### 6.13.11 Simple MQTT over Wi-Fi



1. Clone the AFR repo from GitHub and check out the latest release using its tag.

The following command also clones all the submodules:

```
git clone https://github.com/cypresssemiconductorco/amazon-freertos.git -b 201910-MTBAFR1951 --recurse-submodules
```



2. Extract the `ch06-simple-mqtt-over-wifi.zip` from “templates” into the following directory:

`<amazon-freertos>/projects/cypress/`

**Note:** `<amazon-freertos>` refers to the path of the Amazon FreeRTOS directory in your computer.



3. Import the project into an Eclipse IDE workspace:

- a. Select **File > Import**.
- b. Select **General > Existing Projects into Workspace** and click **Next >**.
- c. Click the **Browse** button near “Select root directory,” choose the project directory `<amazon-freertos>/projects/cypress/afr-exercise-wifi-scan-and-connect`, and click **Finish**.



4. Configure the network and AWS credentials.

Use the same steps that you did previously to run the MQTT demo. .

- a. Enter the MQTT endpoint address and the AWS registered thing name in <amazon-freertos>/demos/include/aws\_clientcredential.h.
- b. Input the AWS client certificate and private key in <amazon-freertos>/demos/include/aws\_clientcredential\_keys.h file.

 5. Connect the kit, build and program.

- a. Select the application project in the Project Explorer.
- b. In the Quick Panel, scroll down, and click afr-exercise-simple-mqtt-over-wifi Program (KitProg3).

 6. Observe the UART logs in a serial terminal program of your choice by connecting to the COM port of the device with a baudrate of 115200 and 8N1 configuration.

The following shows an example log:

```
COM5 - Tera Term VT
File Edit Setup Control Window Help
WLAN MAC Address : CC:C0:79:24:DB:8B
WLAN Firmware : w10: Sep 5 2019 23:24:33 version 7.45.98.92 (r722362 GW) FWID 01-f7128517
WLAN Data : API: 1.2.2 Compiler: 9.10.39 CmImport: 1.36.3 Creation: 2019-09-05 23:10:00
WHD VERSION : v1.40.0-rc3 : v1.40.0-rc3 : GCC 7.2 : 2019-10-02 13:25:35 +0800
1 4666 [lms Svc] Wi-Fi Connected to AP. Creating tasks which use network...
2 4666 [lms Svc] IP Address acquired 10.40.2.183
3 6248 [lms Svc] Write certificate...
4 6793 [lms Svc] Device credential provisioning succeeded.
5 6794 [iot_thread] [INFO] [INIT][lu] SDK successfully initialized.
6 9845 [iot_thread] [INFO] [MQTT][lu] Successfully initialized the demo.
7 9845 [iot_thread] [INFO] [MQTT][lu] MQTT library successfully initialized.
8 15474 [iot_thread] [INFO] [MQTT][lu] Establishing new MQTT connection.
9 15475 [iot_thread] [INFO] [MQTT][lu] Anonymous metrics (SDK language, SDK version) will be provided to AWS
10 15476 [iot_thread] [INFO] [MQTT][lu] <MQTT connection 0x8011750, CONNECT operation 0x800b140> Waiting for
11 15833 [iot_thread] [INFO] [MQTT][lu] <MQTT connection 0x8011750, CONNECT operation 0x800b140> Wait complete
12 15833 [iot_thread] [INFO] [MQTT][lu] New MQTT connection 0x800c86c established.
13 15833 [iot_thread] Before publish
14 15834 [iot_thread] [INFO] [MQTT][lu] <MQTT connection 0x8011750> MQTT PUBLISH operation queued.
15 15834 [iot_thread] After publish
16 18834 [iot_thread] [INFO] [MQTT][lu] <MQTT connection 0x8011750> Disconnecting connection.
17 18834 [iot_thread] [INFO] [MQTT][lu] <MQTT connection 0x8011750, DISCONNECT operation 0x800b140> Waiting for
18 18834 [iot_thread] [INFO] [MQTT][lu] <MQTT connection 0x8011750, DISCONNECT operation 0x800b140> Wait complete
19 18834 [iot_thread] [INFO] [MQTT][lu] Connection disconnected.
20 18835 [iot_thread] [INFO] [MQTT][lu] <MQTT connection 0x8011750> Network connection closed.
21 19137 [iot_thread] [INFO] [MQTT][lu] <MQTT connection 0x8011750> Network connection destroyed.
22 19137 [iot_thread] [INFO] [DEMO][lu] MQTT library cleanup done.
23 19137 [iot_thread] [INFO] [DEMO][lu] Demo completed successfully.
24 19138 [iot_thread] [INFO] [INIT][lu] SDK cleanup done.
```

 7. View the published message by subscribing to the topic 'iotdemo/topic/1' using the MQTT Test Client provided in the AWS IoT Core console.

### 6.13.12 Simple MQTT over BLE

 1. Clone the AFR repo from GitHub and check out the latest release using its tag.

The following command also clones all the submodules:

```
git clone https://github.com/cypresssemiconductorco/amazon-freertos.git -b 201910-MTBAFR1951 --recurse-submodules
```

 2. Follow all the steps as described in the exercise 6.13.5 (Running MQTT over BLE Demo).

 3. Extract ch06-simple-mqtt-over-ble.zip from "templates" into the following directory:

<amazon-freertos>/projects/cypress/

**Note:** <amazon-freertos> refers to the path of the Amazon FreeRTOS directory in your computer.



4. Import the project into an Eclipse IDE workspace:

- a. Go to **File > Import**.
- b. Choose **General > Existing Projects into Workspace** and click **Next >**.
- c. Click the **Browse** button near “Select root directory,” choose the project directory `<amazon-freertos>/projects/cypress/afr-exercise-simple-mqtt-over-ble`, and click **Finish**.



5. Configure the network and AWS credentials.

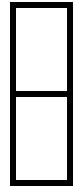
Use the same steps that you did previously to run the MQTT demo.

- a. Enter the MQTT endpoint address and the AWS registered thing name in `<amazon-freertos>/demos/include/aws_clientcredential.h`.
- b. Input the AWS client certificate and private key in `<amazon-freertos>/demos/include/aws_clientcredential_keys.h` file.



6. Build the project and program the kit:

- a. Select the application project in the Project Explorer.
- b. In the Quick Panel, scroll down, and click `afr-exercise-simple-mqtt-over-ble` Program (KitProg3).



7. Once the kit is programmed, follow the steps from exercise 6.13.5 (Running MQTT over BLE Demo) to use the smartphone app.
8. Observe the UART logs in a serial terminal program of your choice by connecting to the COM port of the device with a baud rate of 115200 and 8N1 configuration.

The following shows a sample log:

```
COM44 - Tera Term VT
File Edit Setup Control Window Help
File Edit Setup Control Window Help
VLAN MAC Address : DC:EF:CA:08:F7:8B
VLAN Firmware   : v10: Sep 5 2019 23:24:33 version 7.45.98.92 <r722362 CY> FWID 01-f7128517
VLAN CLM        : API: 12.2 Data: 9.10.39 Compiler: 1.29.4 ClmImport: 1.36.3 Creation: 2019-09-05 23:10:00
VHD VERSION    : v1.60.0-rc1 : v1.60.0-rc1 : GCC 7.2 : 2019-11-13 21:27:38 -0600
.1 7630 [Tmr Svc] Wi-Fi failed to connect to AP abc.
2 7630 [Tmr Svc] Connect to SoftAP Enter SSID for Soft AP using password Enter Password for Soft AP.
3 7646 [Tmr Svc] Wi-Fi configuration successful.
4 7647 [iot_thread] [INFO] [DEMO] SDK successfully initialized.
4 8627 [iot_thread] [INFO] [DEMO] No networks connected for the demo. Waiting for a network connection.
... 6 32479 [LBU] LINFO [DEMO] BLE Connected to remote device, connid = 2
7 32479 [iot_thread] [INFO] [DEMO] Successfully initialized the demo.
8 32479 [iot_thread] [INFO] [MQTT] MQTT library successfully initialized.
9 34819 [iot_thread] [INFO] [MQTT] Establishing new MQTT connection.
10 34819 [iot_thread] [INFO] [MQTT] [lu] <MQTT connection 0x801c9e0, CONNECT operation 0x801caf8> Waiting for operation completion.
11 37589 [iot_thread] [INFO] [MQTT] [lu] <MQTT connection 0x801c9e0, CONNECT operation 0x801caf8> Wait complete with result SUCCESS.
12 37589 [iot_thread] [INFO] [MQTT] [lu] New MQTT connection 0x8010694 established.
13 37589 [iot_thread] Before publish
14 37589 [iot_thread] [INFO] [MQTT] [lu] <MQTT connection 0x801c9e0> MQTT PUBLISH operation queued.
15 37590 [iot_thread] After publish
16 40590 [iot_thread] [INFO] [MQTT] [lu] <MQTT connection 0x801c9e0> Disconnecting connection.
17 40590 [iot_thread] [INFO] [MQTT] [lu] <MQTT connection 0x801c9e0, DISCONNECT operation 0x801c8a8> Waiting for operation completion.
18 40590 [iot_thread] [INFO] [MQTT] [lu] <MQTT connection 0x801c9e0, DISCONNECT operation 0x801c8a8> Wait complete with result SUCCESS.
19 40590 [iot_thread] [INFO] [MQTT] [lu] <MQTT connection 0x801c9e0> Connection disconnected.
20 40591 [iot_thread] [INFO] [MQTT] [lu] <MQTT connection 0x801c9e0> Network connection closed.
21 40591 [iot_thread] [INFO] [MQTT] [lu] <MQTT connection 0x801c9e0> Network connection destroyed.
22 40591 [iot_thread] [INFO] [MQTT] [lu] MQTT library cleanup done.
23 40591 [iot_thread] [INFO] [DEMO] [lu] Demo completed successfully.
24 40592 [iot_thread] [INFO] [INIT] [lu] SDK cleanup done.
```

The output on the AWS IoT Console is identical to that from previous exercise 6.13.11 (Simple MQTT over Wi-Fi). The application publishes exactly one message to the MQTT topic `iotdemo/topic/1`: “Hello world 1!”

### 6.13.13 Use TFT to display messages received via MQTT Subscribe

This exercise uses the TFT to display messages received via MQTT Subscribe.



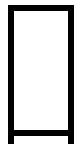
1. Clone recursively Amazon FreeRTOS from GitHub.

```
git clone --recurse-submodules  
https://github.com/cypresssemiconductorco/amazon-freertos.git --branch  
201910-MTBAFR1951
```

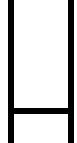


2. Extract the ch06-mqtt-message-tft.zip file from “templates” into the following directory:  
`<amazon-freertos>/projects/cypress`

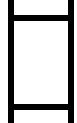
**Note:** `<amazon-freertos>` refers to the path of the Amazon FreeRTOS directory on your computer.



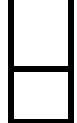
3. Open `<amazon-freertos>/demos/include/aws_clientcredential.h` file and configure the SSID and Wi-Fi password of the desired network, as well as the AWS parameters such as endpoint and Thing name.



4. Configure the client certificate and the private key in `<amazon-freertos>/demos/include/aws_clientcredential_keys.h` for the Thing used in the previous step.



5. Connect the CY8CKIT-028-TFT shield to the Arduino header.



6. Connect the base kit to your PC using the provided USB cable through the USB connector.

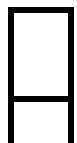


7. Open a terminal program and select the KitProg3 COM port. Set the serial port parameters to 8N1 and 115200 baud.

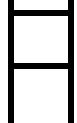


8. Import the project into an Eclipse IDE workspace:

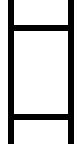
- a. Select **File > Import**.
- b. Select **General > Existing Projects into Workspace** and click **Next >**.
- c. Click the **Browse** button near “Select root directory,” choose the project directory `<amazon-freertos>/projects/cypress/afr-example-mqtt-message-tft`, and click **Finish**.



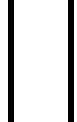
9. Right-click on the application project in the Project Explorer and select **Build Targets > Create**.



10. Specify the target name as “getlibs” and click **OK**.



11. Expand the application project and double-click on **Build Targets > getlibs**. Wait for the operation to complete.



12. Select the application project, then in the Quick Panel, scroll down, and click “afr-example-mqtt-message-tft Program (KitProg3).”

13. Publish a message to any of these four topics via test client:

1. demo/topic/1
2. demo/topic/2
3. demo/topic/3



#### 4. demo/topic/4

Messages display on the TFT screen.

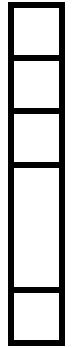
### 6.13.14 Run the shadow demo



- Clone the AFR repo from GitHub and check out the latest release using its tag.

The following command also clones all the submodules:

```
git clone https://github.com/cypresssemiconductorco/amazon-freertos.git -b 201910-MTBAFR1951 --recurse-submodules
```



- Import the project into an Eclipse workspace:

- Go to **File > Import**.

- Choose **General > Existing Projects into Workspace** and click **Next >**.

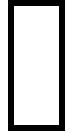
- Click the **Browse** button near “Select root directory,” choose the project directory `<amazon-freertos>/projects/cypress/afr-exercise-simple-mqtt-over-ble`, and click **Finish**.

- Configure the network and AWS credentials:

Use the same steps that you did previously for the “MQTT Demo” exercise.

- Enter the MQTT endpoint address and the AWS registered thing name in `<amazon-freertos>/demos/include/aws_clientcredential.h`.

- Input the AWS client certificate and private key in `<amazon-freertos>/demos/include/aws_clientcredential_keys.h` file.



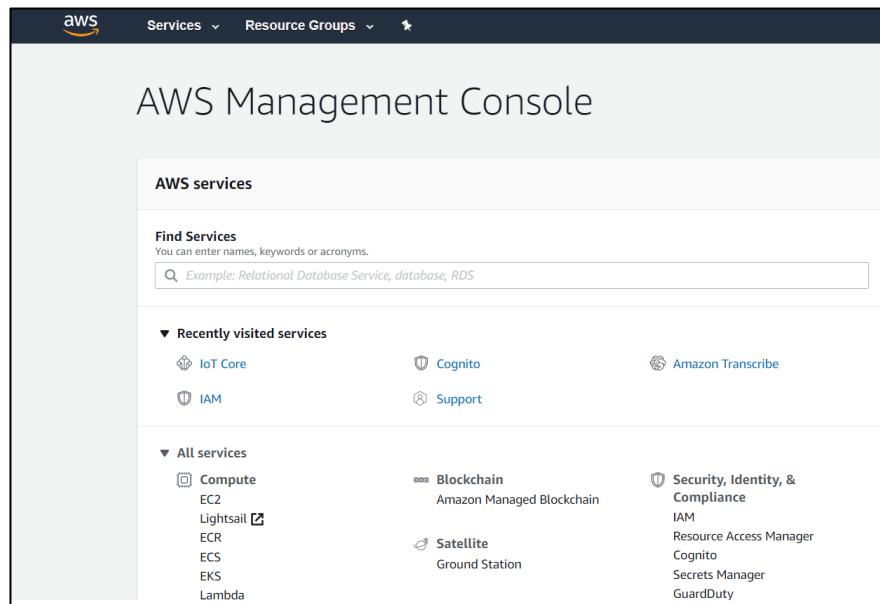
- Enable the MQTT Shadow demo in the `<amazon-freertos>/vendors/cypress/boards/CY8CPROTO_062_4343W/aws_demos/config_files/aws_demo_config.h` file by adding the following line. Make sure that only one demo is enabled.

```
#define CONFIG_SHADOW_DEMO_ENABLED
```

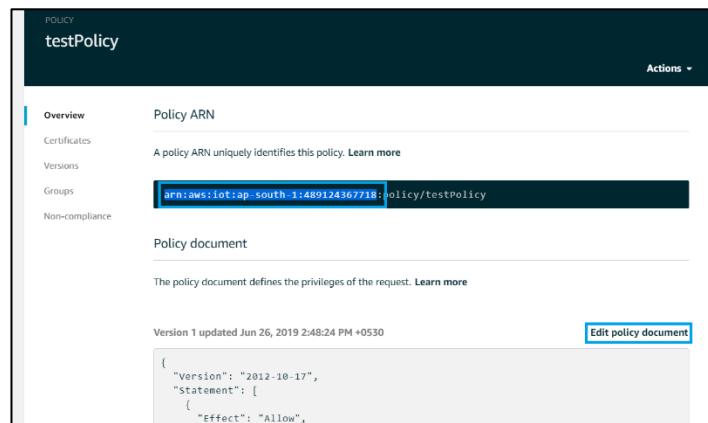


- Opening the AWS IoT Console

Go to the [AWS Console](#) web page. Once signed in using your AWS account credentials, you should be able to see a list of AWS services as shown:



6. Click on **IoT Core** or type 'IoT Core' in the **Find Services** search bar.
7. Editing the policy.
  - a. Go back to the home page of the AWS IoT Console.
  - b. From the navigation pane on the left, click on **Secure > Policies**. Click on the policy that is associated with the configured thing.
  - c. Click on **Edit policy document** as shown:

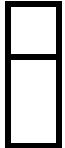


- d. Replace the existing text with the following policy.

**Note:** Replace the bolded text with the selected text (also shown in blue box) in the above image. Also replace <your-thing-name> with the name of the thing that you configured in aws\_clientcredential.h.

```
{  
    "Version": "2012-10-17",  
    "Statement": [  
        {  
            "Effect": "Allow",  
            "Action": "iot:Connect",  
            "Resource": "arn:aws:iot:ap-south-1:489124367718:client/<your-thing-  
name>"  
        },  
        {  
            "Effect": "Allow",  
            "Action": "iot:Subscribe",  
            "Resource": "arn:aws:iot:ap-south-  
1:489124367718:topicfilter/$aws/things/Proto_Thing/shadow/*"  
        },  
        {  
            "Effect": "Allow",  
            "Action": "iot:Receive",  
            "Resource": "arn:aws:iot:ap-south-  
1:489124367718:topic/$aws/things/Proto_Thing/shadow/*"  
        },  
        {  
            "Effect": "Allow",  
            "Action": "iot:Publish",  
            "Resource": "arn:aws:iot:ap-south-  
1:489124367718:topic/$aws/things/Proto_Thing/shadow/*"  
        }  
    ]  
}
```

8. Build and program the project.  
9. Observe the UART logs in a serial terminal program with a configuration of 115200 baud rate and 8N1. The following shows a sample log:

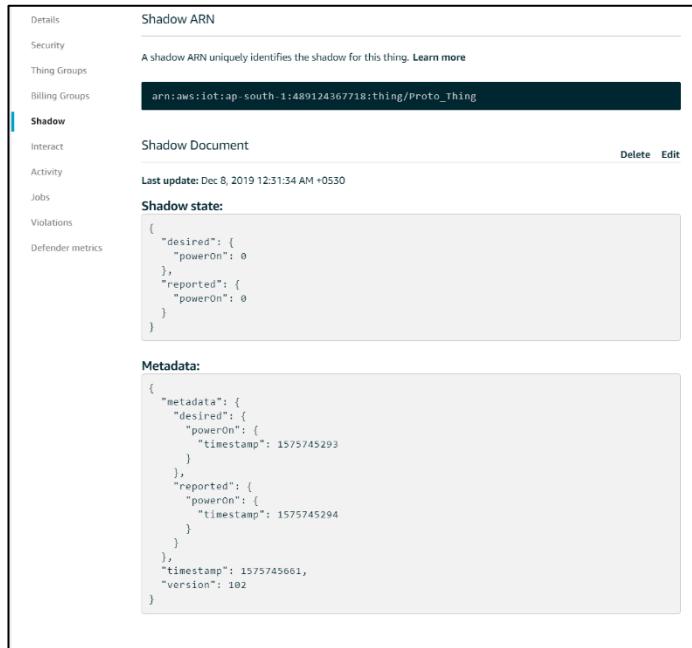


```
COM44 - Tera Term VT  
File Edit Setup Control Window Help  
VLAN CLM : API: 12.2 Data: 9.10.39 Compiler: 1.29.4 ClmImport: 1.36.3 Creation: 2019-09-05 23:10:  
WHD VERSION : v1.40.0-rc3 : v1.40.0-rc3 : GCC 7.2 : 2019-10-02 13:25:35 +0800  
1 3522 [I]m[ S]c[ Wi-Fi Connected to AP. Creating tasks which use network...  
2 3522 [I]m[ S]c[ IP Address acquired 192.168.43.111  
3 5110 [I]m[ S]c[ Write certificate...  
4 6474 [I]m[ S]c[ Device credential provisioning succeeded.  
5 14747 [I]ot[ thre[ INFO ]IMQTT[lu] SDK successfully initialized.  
6 10645 [I]ot[ thre[ INFO ]IDEMO[lu] Successfully initialized the demo. Network type for the demo: 1  
7 10645 [I]ot[ thre[ INFO ]IMQTT[lu] MQTT library successfully initialized.  
8 10645 [I]ot[ thre[ INFO ]IShadow[lu] Shadow library successfully initialized.  
9 10645 [I]ot[ thre[ INFO ]IDEMO[lu] Shadow Thing Name is Proto_Thing (length 11).  
.10 14605 [I]ot[ thre[ INFO ]IMQTT[lu] Establishing new MQTT connection.  
.11 14605 [I]ot[ thre[ INFO ]IMQTT[lu] Establishing new MQTT connection. Autonomous metrics (autonomous SDK version) will be provided to AWS IoT. Recompile with AWS_IOT_MQTT_ENABLE_METRICS set to 0 to disable.  
.12 14607 [I]ot[ thre[ INFO ]IMQTT[lu] MQTT connection 0x800b2d0, CONNECT operation 0x800b2d0) Waiting for operation completion.  
.13 14736 [I]ot[ thre[ INFO ]IMQTT[lu] <MQTT connection 0x800b598. CONNECT operation 0x800b2d0) Wait complete with result SUCCESS  
.14 14737 [I]ot[ thre[ INFO ]IMQTT[lu] New MQTT connection 0x800b598 established.  
.15 14737 [I]ot[ thre[ INFO ]IShadow[lu] <Proto_Thing> Modifying Shadow DELTA callback.  
.16 14729 [I]ot[ thre[ INFO ]IShadow[lu] <Proto_Thing> Adding new DELTA callback.  
.17 14729 [I]ot[ thre[ INFO ]IMQTT[lu] <MQTT connection 0x800b598> SUBSCRIBE operation scheduled.  
.18 14737 [I]ot[ thre[ INFO ]IMQTT[lu] <MQTT connection 0x800b598. SUBSCRIBE operation 0x800b2d0) Waiting for operation completion.  
.19 14842 [I]ot[ thre[ INFO ]IMQTT[lu] <MQTT connection 0x800b598, SUBSCRIBE operation 0x800b2d0) Wait complete with result SUCCESS.  
.20 14843 [I]ot[ thre[ INFO ]IShadow[lu] <Proto_Thing> Shadow DELTA callback operation complete with result SUCCESS.  
.21 14843 [I]ot[ thre[ INFO ]IShadow[lu] <Proto_Thing> Modifying Shadow UPDATED callback.  
.22 14843 [I]ot[ thre[ INFO ]IShadow[lu] <Proto_Thing> Adding new UPDATED callback.  
.23 14843 [I]ot[ thre[ INFO ]IMQTT[lu] <MQTT connection 0x800b598> SUBSCRIBE operation scheduled.  
.24 14843 [I]ot[ thre[ INFO ]IMQTT[lu] <MQTT connection 0x800b598. SUBSCRIBE operation 0x800b2d0) Waiting for operation completion.  
.25 14923 [I]ot[ thre[ INFO ]IMQTT[lu] <MQTT connection 0x800b598, SUBSCRIBE operation 0x800b2d0) Wait complete with result SUCCESS.  
.26 14924 [I]ot[ thre[ INFO ]IShadow[lu] <Proto_Thing> Shadow UPDATED callback operation complete with result SUCCESS.  
.27 14924 [I]ot[ thre[ INFO ]IMQTT[lu] <MQTT connection 0x800b598> SUBSCRIBE operation scheduled.  
.28 14924 [I]ot[ thre[ INFO ]IMQTT[lu] <MQTT connection 0x800b598, SUBSCRIBE operation 0x800b780> Waiting
```



10. View the device's shadow in AWS IoT Console.

From the AWS IoT Core's home page, click on **Manage > Things**. On the right, click on the thing that you configured in `aws_clientcredential.h`. Click on **Shadow** in the left pane. You should be able to see the shadow state and metadata if the demo ran successfully. The following shows a sample shadow state:



The screenshot shows the AWS IoT Shadow Details page. The left sidebar has tabs: Details, Security, Thing Groups, Billing Groups, **Shadow**, Interact, Activity, Jobs, Violations, and Defender metrics. The **Shadow** tab is selected. The main area has two sections: **Shadow ARN** (arn:aws:iot:ap\_south\_1:489124367718:thing/Proto\_Thing) and **Shadow Document**.

**Shadow Document** (Last update: Dec 8, 2019 12:31:34 AM +0530)

```
{
  "desired": {
    "poweron": 0
  },
  "reported": {
    "poweron": 0
  }
}
```

**Metadata:**

```
{
  "metadata": {
    "desired": {
      "poweron": {
        "timestamp": 1575745293
      }
    },
    "reported": {
      "poweron": {
        "timestamp": 1575745294
      }
    },
    "timestamp": 1575745661,
    "version": 102
  }
}
```

### 6.13.15 Update shadow with count of button presses



1. Clone Amazon FreeRTOS from GitHub and checkout the latest release using its tag.

The following command also clones all the submodules:

```
git clone https://github.com/cypresssemiconductorco/amazon-freertos.git -b 201910-MTBAFR1951 --recurse-submodules
```



2. Extract the `ch06-shadow-button-count.zip` file from “templates” into the following directory:

<`amazon-freertos`>/projects/cypress/

**Note:** <`amazon-freertos`> refers to the path of the Amazon FreeRTOS directory in your computer.



3. Import the project into an Eclipse IDE workspace:

- Go to **File > Import**.
- Choose **General > Existing Projects into Workspace** and click **Next >**.
- Click the **Browse** button near “Select root directory,” choose the project directory <`amazon-freertos`>/projects/cypress/afr-exercise-shadow-button-count, and click **Finish**.

4. Configure the network and AWS credentials:

Use the same steps that you did previously to run the MQTT demo.

- a. Enter the MQTT endpoint address and the AWS registered thing name in <amazon-freertos>/demos/include/aws\_clientcredential.h.
- b. Input the AWS client certificate and private key in <amazon-freertos>/demos/include/aws\_clientcredential\_keys.h file.

5. In the AWS IoT Console, edit the policy that is associated with the configured thing in the same way as described in exercise 6.13.14 (Run the shadow demo).
6. Delete any previously exiting device shadow documents in AWS IoT Console

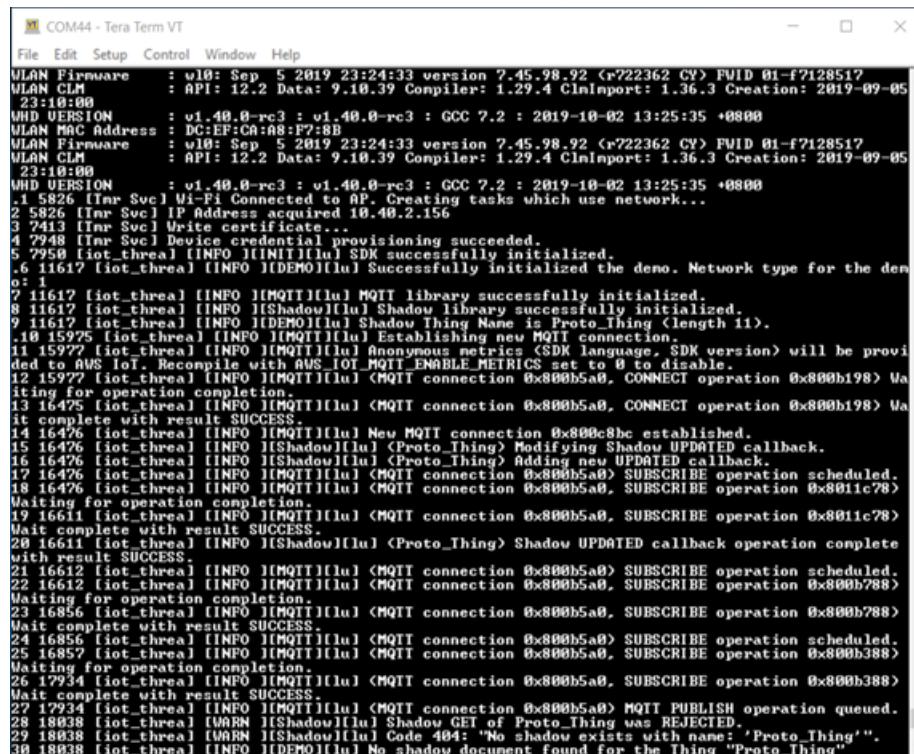
From the AWS IoT Core's home page, click to Manage > Things. On the right, click on the thing that you configured in aws\_clientcredential.h. Click on Shadow from the left pane. If you see any exiting shadow document, click on 'Delete' to clear existing shadow documents.

7. Build the project and program the kit:

- a. Select the application project in the Project Explorer.
- b. In the Quick Panel, scroll down, and click afr-exercise-shadow-button-count Program (KitProg3).

8. Observe the UART logs in a serial terminal program of your choice by connecting to the COM port of the device with a baudrate of 115200 and 8N1 configuration.

The following shows a sample log:



```
COM44 - Tera Term VT
File Edit Setup Control Window Help
WLAN Firmware : v10: Sep 5 2019 23:24:33 version 7.45.98.92 <r722362 CY> FVID 01-f7128517
WLAN CLM : API: 12.2 Data: 9.10.39 Compiler: 1.29.4 ClmImport: 1.36.3 Creation: 2019-09-05
23:10:00
WHD VERSION : vi.40.0-rc3 : vi.40.0-rc3 : GCC 7.2 : 2019-10-02 13:25:35 +0800
WLAN MAC Address : DC:EF:CA:AB:F7:8B
WLAN Firmware : v10: Sep 5 2019 23:24:33 version 7.45.98.92 <r722362 CY> FVID 01-f7128517
WLAN CLM : API: 12.2 Data: 9.10.39 Compiler: 1.29.4 ClmImport: 1.36.3 Creation: 2019-09-05
23:10:00
WHD VERSION : vi.40.0-rc3 : vi.40.0-rc3 : GCC 7.2 : 2019-10-02 13:25:35 +0800
1 5826 [Tmr Svc] Wi-Fi Connected to AP. Creating tasks which use network...
2 5826 [Tmr Svc] IP Address acquired 10.40.2.156
3 7413 [Tmr Svc] Write certificate...
4 7948 [Tmr Svc] Device credential provisioning succeeded.
5 7950 [iot_thread] [INFO] [INIT][lu] SDK successfully initialized.
6 11617 [iot_thread] [INFO] [DEMO][lu] Successfully initialized the demo. Network type for the demo: 1
7 11617 [iot_thread] [INFO] [MQTT][lu] MQTT library successfully initialized.
8 11617 [iot_thread] [INFO] [Shadow][lu] Shadow library successfully initialized.
9 11617 [iot_thread] [INFO] [DEMO][lu] Shadow Thing Name is Proto_Thing (length 11).
10 15975 [iot_thread] [INFO] [MQTT][lu] Establishing new MQTT connection.
11 15977 [iot_thread] [INFO] [MQTT][lu] Anonymous metrics (SDK language, SDK version) will be provided to AWS IoT. Recompile with AWS_IOT_ENABLE_METRICS set to 0 to disable.
12 15977 [iot_thread] [INFO] [MQTT][lu] <MQTT connection 0x8000b5a0, CONNECT operation 0x800b198> Waiting for operation completion.
13 16475 [iot_thread] [INFO] [MQTT][lu] <MQTT connection 0x8000b5a0, CONNECT operation 0x800b198> Wait complete with result SUCCESS.
14 16476 [iot_thread] [INFO] [MQTT][lu] New MQTT connection 0x8000b5c0 established.
15 16476 [iot_thread] [INFO] [Shadow][lu] (Proto_Thing) Modifying Shadow UPDATED callback.
16 16476 [iot_thread] [INFO] [Shadow][lu] (Proto_Thing) Adding new UPDATED callback.
17 16476 [iot_thread] [INFO] [MQTT][lu] <MQTT connection 0x8000b5a0> SUBSCRIBE operation scheduled.
18 16476 [iot_thread] [INFO] [MQTT][lu] <MQTT connection 0x8000b5a0>, SUBSCRIBE operation 0x80011c78> Waiting for operation completion.
19 16611 [iot_thread] [INFO] [MQTT][lu] <MQTT connection 0x8000b5a0, SUBSCRIBE operation 0x80011c78> Wait complete with result SUCCESS.
20 16611 [iot_thread] [INFO] [Shadow][lu] <Proto_Thing> Shadow UPDATED callback operation complete with result SUCCESS.
21 16612 [iot_thread] [INFO] [MQTT][lu] <MQTT connection 0x8000b5a0> SUBSCRIBE operation scheduled.
22 16612 [iot_thread] [INFO] [MQTT][lu] <MQTT connection 0x8000b5a0>, SUBSCRIBE operation 0x800b788> Waiting for operation completion.
23 16856 [iot_thread] [INFO] [MQTT][lu] <MQTT connection 0x8000b5a0, SUBSCRIBE operation 0x800b788> Wait complete with result SUCCESS.
24 16856 [iot_thread] [INFO] [MQTT][lu] <MQTT connection 0x8000b5a0> SUBSCRIBE operation scheduled.
25 16857 [iot_thread] [INFO] [MQTT][lu] <MQTT connection 0x8000b5a0>, SUBSCRIBE operation 0x800b388> Waiting for operation completion.
26 17934 [iot_thread] [INFO] [MQTT][lu] <MQTT connection 0x8000b5a0, SUBSCRIBE operation 0x800b388> Wait complete with result SUCCESS.
27 17934 [iot_thread] [INFO] [MQTT][lu] <MQTT connection 0x8000b5a0> MQTT PUBLISH operation queued.
28 18038 [iot_thread] [WARN] [Shadow][lu] Shadow GET of Proto_Thing was REJECTED.
29 18038 [iot_thread] [WARN] [Shadow][lu] Code 404: 'No shadow exists with name: "Proto_Thing"'.
30 18038 [iot_thread] [INFO] [DEMO][lu] No shadow document found for the Thing "Proto_Thing"
```

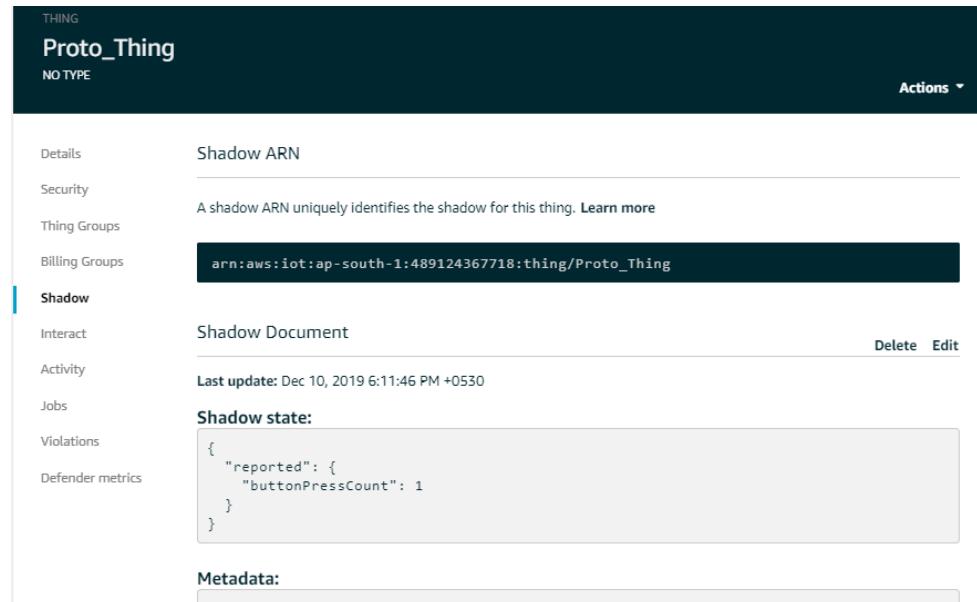


## 9. Viewing the device's shadow in AWS IoT Console

- From the AWS IoT Core's home page, click to **Manage > Things**.
- On the right, click on the configured thing.
- Click on **Shadow** from the left pane.

You should be able to see the shadow state and metadata if the demo ran successfully.

The following shows a sample shadow state:



Details	Shadow ARN
Security	A shadow ARN uniquely identifies the shadow for this thing. <a href="#">Learn more</a>
Thing Groups	
Billing Groups	
<b>Shadow</b>	
Interact	Shadow Document
Activity	Last update: Dec 10, 2019 6:11:46 PM +0530
Jobs	
Violations	
Defender metrics	

**Shadow state:**

```
{
  "reported": {
    "buttonPressCount": 1
  }
}
```

**Metadata:**

### 6.13.16 Advertise with BLE

This exercise shows how to set BLE custom advertisement message and enable BLE with two services (Device information service and data transfer service) provided by AFR library. For enabling BLE with a custom service, refer to the BLE custom GATT server exercise.



- Clone amazon-freertos repo and change to branch 201910-MTBAFR1951:

```
git clone https://github.com/cypresssemiconductorco/amazon-freertos.git -b 201910-MTBAFR1951 --recurse-submodules
```



- Extract the ch06-ble-adv.zip file from “templates” to the following directory:

<amazon-freertos>/projects /cypress/

**Note:** <amazon-freertos> refers to the path of the Amazon FreeRTOS directory in your computer.



- Import the project to ModusTool Box IDE.

- Click Files> Import>Existing projects into workspace and click Next.
- Click Browse. Navigate to the file path where you have cloned amazon-freertos repo and go to project-> cypress and select afr-exercise-ble-adv.
- Click Finish to import the project into your workspace



- Go to the main.c file located in the following directory:

vendors/cypress/boards/CY8CPROTO\_062\_4343W/aws\_demos/application\_code/

Inside function vApplicationDaemonTaskStartupHook(), comment the function call:  
vDevModeKeyProvisioning();

5. All the kits use same BLE address (43: 43: A1: 12: 1F: AC) by default.

You must change it to uniquely identify your kit when multiple devices are present. To change the address:

- a. Go to libraries/c\_sdk/standard/ble/src/iot\_ble\_gap.c file
- b. Add `const uint8_t bdAddr[] = {0x11, 0x22, 0x33, 0xAA, 0xBB, 0xCC};` above `const BTProperty_t _deviceProperties[] = .` Change the address in the array as you like.
- c. In `_deviceProperties[]` array, add a comma after the last element and add the following:

```
{  
    .xType = eBTpropertyBdaddr,  
    .xLen = 6,  
    .pvVal = (void *)bdAddr  
}
```

6. Open to the ble\_custom\_adv.c source file (from the extracted zip file).

Use the structures `CustomAdvParams` and `CustomScanRspParams` to set your own adv message.

**Note:** ADV message packet length should not exceed 31 bytes.

In our case:

- 3 bytes are used for advertisement type (1-byte adv type + 1-byte type flag + 1-byte length)
- 18 bytes for UUID (16 bytes UUID + 1- byte type flag + 1-byte length)
- 9 bytes for name (7 bytes name + 1-byte type flag + 1-byte length): Totally 30 bytes.

7. To change name of device, use macro `IOT_BLE_DEVICE_COMPLETE_LOCAL_NAME`.

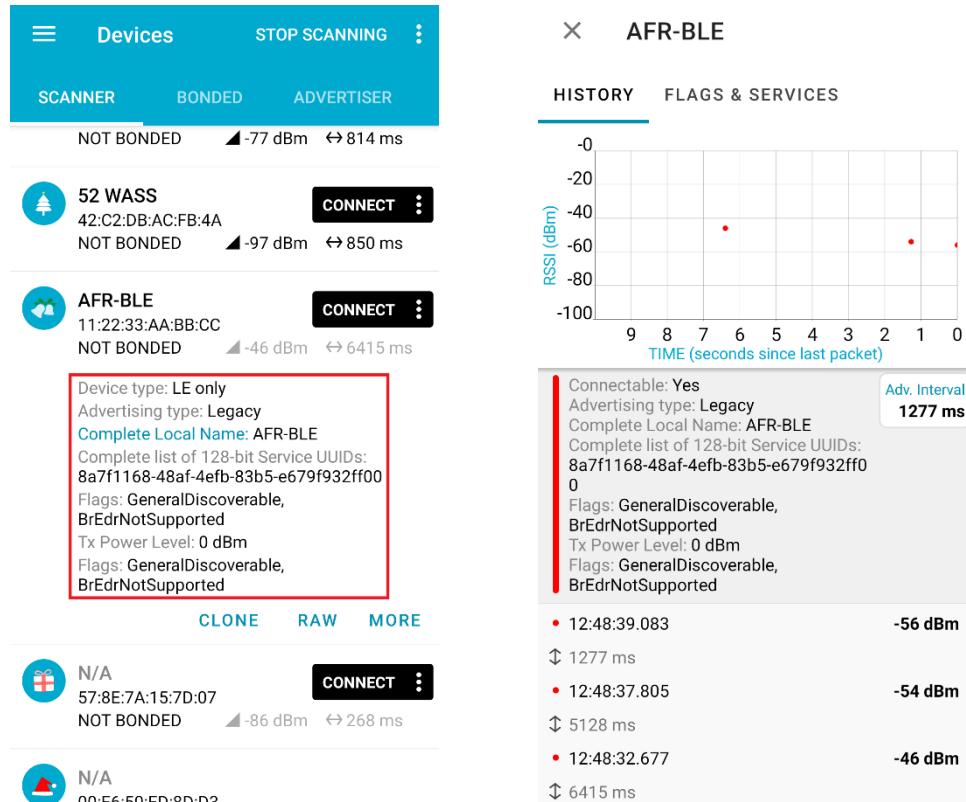
Go to vendors/cypress/boards/CY8CPROTO\_062\_4343W/aws\_demos/config\_files/iot\_ble\_config.c.

```
#define IOT_BLE_DEVICE_COMPLETE_LOCAL_NAME      "AFR-BLE"
```

8. Build and program the kit.

Changes in msg packet can be observed using any client app (preferably nrfConnect).

The following show screen captures from the Client app nrfConnect on Android. Before connecting, tap on the device in the list. This shows ADV parameters.



### 6.13.17 Make the logging system send log messages to an MQTT Topic



- Clone Amazon FreeRTOS from GitHub and checkout the latest release using its tag.

The following command also clones all the submodules:

```
git clone https://github.com/cypresssemiconductorco/amazon-freertos.git -b 201910-MTBAFR1951 --recurse-submodules
```



- Extract the ch06-mqtt-logging.zip file from “templates into the following directory:

<amazon-freertos>/projects /cypress/

**Note:** <amazon-freertos> refers to the path of the Amazon FreeRTOS directory in your computer.



- Import the project into an Eclipse IDE workspace:

a. Go to File > Import.

b. Choose Existing Projects into Workspace under General and click Next.

- c. Click the Browse button near Select root directory, choose the project directory <amazon-freertos>/projects/cypress/afr-exercise-mqtt-logging, and click Finish.



- 4. Configure the network and AWS credentials.

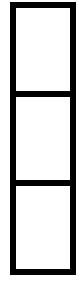
Use the same steps that you did previously to run the MQTT demo.

- a. Enter the MQTT endpoint address and the AWS registered thing name in <amazon-freertos>/demos/include/aws\_clientcredential.h.
- b. Input the AWS client certificate and private key in <amazon-freertos>/demos/include/aws\_clientcredential\_keys.h file.



- 5. Build the project and program the kit:

- a. Select the application project in the Project Explorer.
- b. In the Quick Panel, scroll down, and click afr-exercise-mqtt-logging Program (KitProg3).



- 6. Observe the UART logs in a serial terminal program of your choice by connecting to the COM port of the device with a baudrate of 115200 and 8N1 configuration.
- 7. View the published message by subscribing to the topic 'iotdemo/topic/1' using the MQTT Test Client provided in the AWS IoT Core console.
- 8. View the logs by subscribing to the topic 'mqttlogging/logs' using the MQTT Test Client provided in the AWS IoT Core console.

The prefix to the topic to which the logs are published is defined by the macro MQTT\_LOGGING\_TOPIC\_PREFIX in <amazon-freertos>/projects/cypress/afr-exercise-mqtt-logging /source/cy\_logging\_mqtt.c. The messages will be published to the topic - MQTT\_LOGGING\_TOPIC\_PREFIX followed by "/logs".

**Note:** The configPRINTF() function will publish the logs to the MQTT topic instead of printing on the UART terminal. In this exercise this MQTT logging functionality is demonstrated by printing count value from 0 to 9. To run any application of your choice, call the initialization function of the desired demo after MqttLoggingInit(...) in RunApplication() function in <amazon-freertos>/projects/cypress /afr-exercise-mqtt-logging/source/cy\_sample\_code.c.

### 6.13.18 Use HTTPS to Update a Shadow State



- 1. Clone Amazon FreeRTOS from GitHub and checkout the latest release using its tag.

The following command also clones all the submodules:

```
git clone https://github.com/cypresssemiconductorco/amazon-freertos.git -b 201910-MTBAFR1951 --recurse-submodules
```



2. Extract the ch06-update-shadow-https.zip file into the following directory:

<amazon-freertos>/projects /cypress/

**Note:** <amazon-freertos> refers to the path of the Amazon FreeRTOS directory in your computer.



3. Import the project into an Eclipse IDE workspace:

a. Go to File > Import.

b. Choose Existing Projects into Workspace under General and click Next.

c. Click the Browse button near Select root directory, choose the project directory <amazon-freertos>/projects/cypress/afr-exercise-update-shadow-https, and click Finish.



4. Configure the network and AWS credentials:

Use the same steps that you did previously to run the MQTT demo.

a. Enter the MQTT endpoint address and the AWS registered thing name in <amazon-freertos>/demos/include/aws\_clientcredential.h.

b. Input the AWS client certificate and private key in <amazon-freertos>/demos/include/aws\_clientcredential\_keys.h file.



5. In the AWS IoT Console, edit the policy that is associated with the configured thing in the same way as described in '6.13.14 Run the shadow demo'.

6. Delete any previously exiting device shadow documents in AWS IoT Console

From the AWS IoT Core's home page, click to Manage > Things. On the right, click on the thing that you configured in aws\_clientcredential.h. Click on Shadow from the left pane. If you see any exiting shadow document, click on 'Delete' to clear existing shadow documents.



7. Build the project and program the kit:

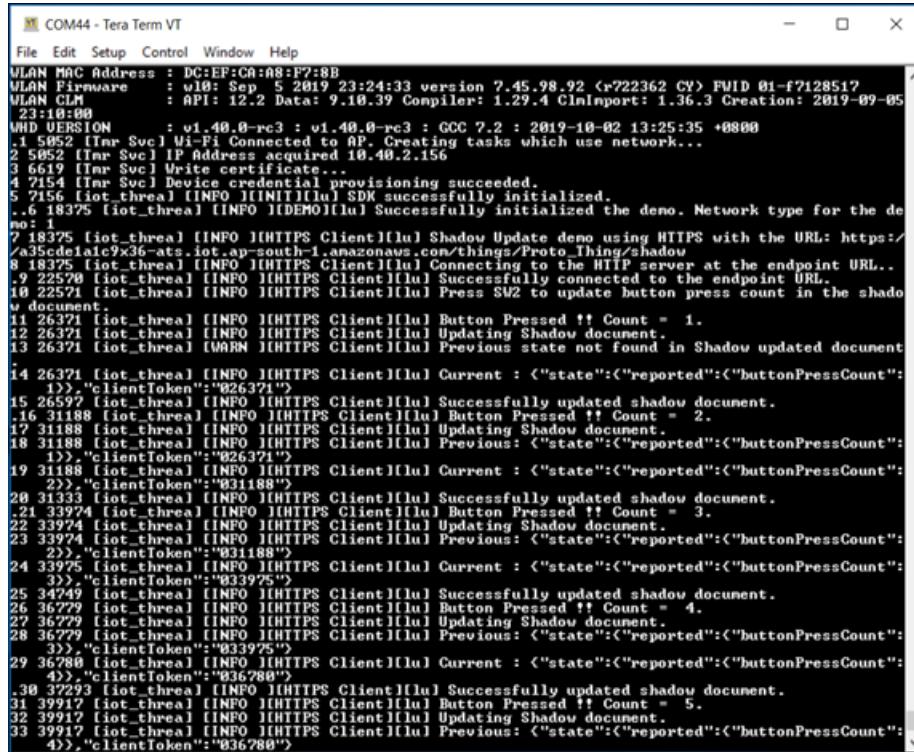
a. Select the application project in the Project Explorer.

b. In the Quick Panel, scroll down, and click afr-exercise-update-shadow-https Program (KitProg3).



8. Observe the UART logs in a serial terminal program of your choice by connecting to the COM port of the device with a baudrate of 115200 and 8N1 configuration.

The following shows a sample log after 5 button presses.



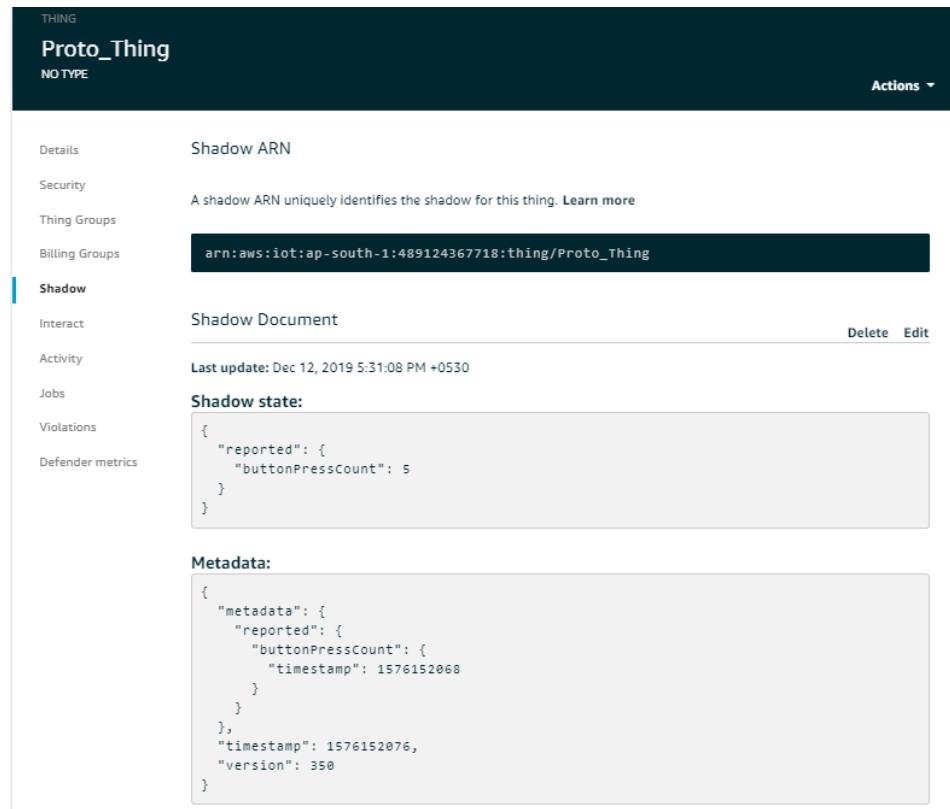
```
COM44 - Tera Term VT
File Edit Setup Control Window Help
VLAN MAC Address : DC:EF:CA:08:F7:8B
VLAN Firmware   : v10: Sep 5 2019 23:24:33 version 7.45.98.92 (r722362 CY) FWID 01-f7128517
VLAN CLM        : API: 12.2 Data: 9.10.39 Compiler: 1.29.4 ClmImport: 1.36.3 Creation: 2019-09-05
23:10:00
WIFI PROVISION : v1.48.0-rc3 : v1.48.0-rc3 : GCC 7.2 : 2019-10-02 13:25:35 +0800
1. 5052 [Iot_Svc] Wi-Fi Connected to AP. Creating tasks which use network...
2. 5052 [Iot_Svc] IP Address acquired 16.48.2.156
3. 6519 [Iot_Svc] Write certificate...
4. 6514 [Iot_Svc] Device credentials provisioning succeeded.
5. 2156 [iot_thread] [INFO] [INIT][INFO] SDK successfully initialized.
6. 18375 [iot_thread] [INFO] [DEMO][lu] Successfully initialized the demo. Network type for the de
net: 1
7. 18375 [iot_thread] [INFO] [HTTPS Client][lu] Shadow Update demo using HTTPS with the URL: https://
<35cdedac1c9x36-ats.iot.ap-south-1.amazonaws.com/things/Proto_Thing/shadow
8. 18375 [iot_thread] [INFO] [HTTPS Client][lu] Connecting to the HTTP server at the endpoint URL...
9. 22570 [iot_thread] [INFO] [HTTPS Client][lu] Successfully connected to the endpoint URL.
10. 22571 [iot_thread] [INFO] [HTTPS Client][lu] Press SW2 to update button press count in the shado
w document.
11. 26371 [iot_thread] [INFO] [HTTPS Client][lu] Button Pressed !! Count = 1.
12. 26371 [iot_thread] [INFO] [HTTPS Client][lu] Updating Shadow document.
13. 26371 [iot_thread] [WARN] [HTTPS Client][lu] Previous state not found in Shadow updated document
14. 26371 [iot_thread] [INFO] [HTTPS Client][lu] Current : {"state": {"reported": {"buttonPressCount": "1"}}, "clientToken": "026371"}
15. 26597 [iot_thread] [INFO] [HTTPS Client][lu] Successfully updated shadow document.
16. 31188 [iot_thread] [INFO] [HTTPS Client][lu] Button Pressed !! Count = 2.
17. 31188 [iot_thread] [INFO] [HTTPS Client][lu] Updating Shadow document.
18. 31188 [iot_thread] [INFO] [HTTPS Client][lu] Previous: {"state": {"reported": {"buttonPressCount": "1"}}, "clientToken": "026371"}
19. 31188 [iot_thread] [INFO] [HTTPS Client][lu] Current : {"state": {"reported": {"buttonPressCount": "2"}}, "clientToken": "031188"}
20. 31333 [iot_thread] [INFO] [HTTPS Client][lu] Successfully updated shadow document.
21. 33974 [iot_thread] [INFO] [HTTPS Client][lu] Button Pressed !! Count = 3.
22. 33974 [iot_thread] [INFO] [HTTPS Client][lu] Updating Shadow document.
23. 33974 [iot_thread] [INFO] [HTTPS Client][lu] Previous: {"state": {"reported": {"buttonPressCount": "2"}}, "clientToken": "031188"}
24. 33975 [iot_thread] [INFO] [HTTPS Client][lu] Current : {"state": {"reported": {"buttonPressCount": "3"}}, "clientToken": "033975"}
25. 34749 [iot_thread] [INFO] [HTTPS Client][lu] Successfully updated shadow document.
26. 36779 [iot_thread] [INFO] [HTTPS Client][lu] Button Pressed !! Count = 4.
27. 36779 [iot_thread] [INFO] [HTTPS Client][lu] Updating Shadow document.
28. 36779 [iot_thread] [INFO] [HTTPS Client][lu] Previous: {"state": {"reported": {"buttonPressCount": "3"}}, "clientToken": "033975"}
29. 36780 [iot_thread] [INFO] [HTTPS Client][lu] Current : {"state": {"reported": {"buttonPressCount": "4"}}, "clientToken": "036780"}
30. 32233 [iot_thread] [INFO] [HTTPS Client][lu] Successfully updated shadow document.
31. 39917 [iot_thread] [INFO] [HTTPS Client][lu] Button Pressed !! Count = 5.
32. 39917 [iot_thread] [INFO] [HTTPS Client][lu] Updating Shadow document.
33. 39917 [iot_thread] [INFO] [HTTPS Client][lu] Previous: {"state": {"reported": {"buttonPressCount": "4"}}, "clientToken": "036780"}
```

## 9. Viewing the device's shadow in AWS IoT Console

- a. From the AWS IoT Core's home page, click to **Manage > Things**.
- b. On the right, click on the configured thing.
- c. Click on **Shadow** from the left pane.

You should be able to see the shadow state and metadata if the demo ran successfully.

A sample shadow state is shown below.



The screenshot shows the AWS IoT Thing Details page for a thing named "Proto\_Thing". The "Shadow" tab is selected. The "Shadow Document" section displays the following JSON:

```
{
  "reported": {
    "buttonPressCount": 5
  }
}
```

The "Metadata" section displays the following JSON:

```
{
  "metadata": {
    "reported": {
      "buttonPressCount": {
        "timestamp": 1576152068
      }
    }
  },
  "timestamp": 1576152076,
  "version": 350
}
```

### 6.13.19 Use HTTPS to Get the Shadow State

**Note:** This exercise is based on the code from the previous exercise (Use HTTPS to update a Shadow state). The only difference between the previous exercise and this one is that the buttonPressCount from the previous exercise always starts at zero on power up. Hence, the button press count in the shadow document always starts from one. In this exercise, the buttonPressCount is set to the previous count value from the shadow and to get this data from the Shadow document HTTPS GET is used.



- Clone Amazon FreeRTOS from [GitHub](#) and checkout the latest release using its tag.

The following command also clones all the submodules:

```
git clone https://github.com/cypresssemiconductorco/amazon-freertos.git -b 201910-MTBAFR1951 --recurse-submodules
```



- Extract the ch06-get-shadow-https.zip file into the following directory:

<amazon-freertos>/projects /cypress/

**Note:** <amazon-freertos> refers to the path of the Amazon FreeRTOS directory in your computer.



- Import the project into an Eclipse IDE workspace:
  - Go to **File > Import**.
  - Choose **General > Existing Projects into Workspace** and click **Next >**.

- c. Click the **Browse** button near Select root directory, choose the project directory <amazon-freertos>/projects/cypress/afr-exercise-get-shadow-https, and click **Finish**.

4. Configure the network and AWS credentials in.

Use the same steps that you did previously to run the MQTT demo.

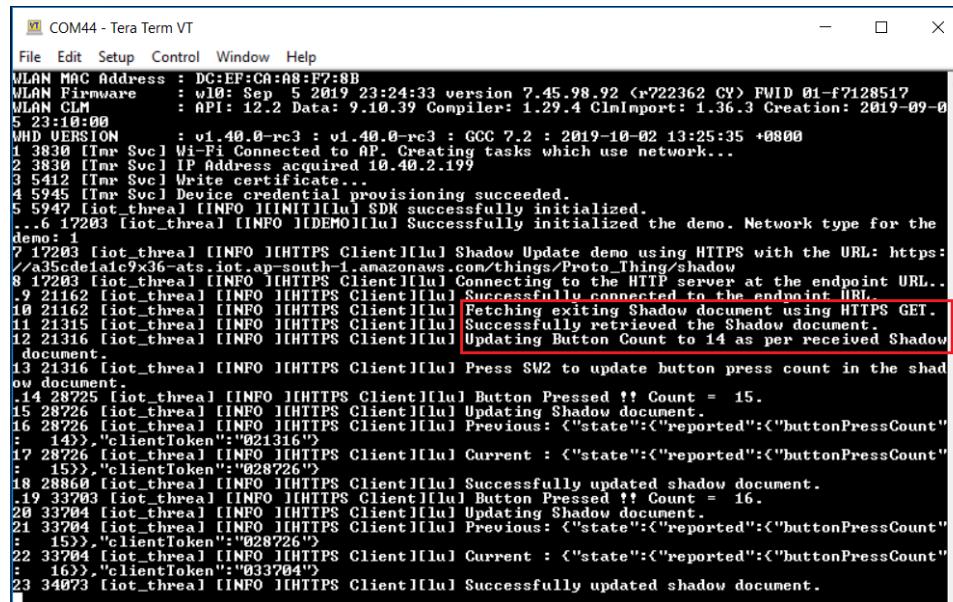
- a. Enter the MQTT endpoint address and the AWS registered thing name in <amazon-freertos>/demos/include/aws\_clientcredential.h.
- b. Input the AWS client certificate and private key in <amazon-freertos>/demos/include/aws\_clientcredential\_keys.h file.

5. Build the project and program the kit:

- a. Select the application project in the Project Explorer.
- b. In the Quick Panel, scroll down, and click afr-exercise-get-shadow-https Program (KitProg3).

6. Observe the UART logs in a serial terminal program of your choice by connecting to the COM port of the device with a baudrate of 115200 and 8N1 configuration.

The following shows a sample log. The highlighted section in the red box shows the logs from the HTTPS GET functions to update the button press count. The rest of the logs are the same as previous demo.



```
COM44 - Tera Term VT
File Edit Setup Control Window Help
MLAN MAC Address : DC:EF:CA:AB:F7:8B
MLAN Firmware : v10: Sep 5 2019 23:24:33 version 7.45.98.92 (r722362 CY) FWID 01-f7128517
MLAN CLM : API: 12.2 Data: 9.10.39 Compiler: 1.29.4 ClmImport: 1.36.3 Creation: 2019-09-05 23:10:00
NHD VERSION : v1.40.0-rc3 : v1.40.0-rc3 : GCC 7.2 : 2019-10-02 13:25:35 +0800
1 3830 [Imx Svc] Wi-Fi Connected to AP. Creating tasks which use network...
2 3830 [Imx Svc] IP Address acquired 10.40.2.199
3 5412 [Imx Svc] Write certificate...
4 5945 [Imx Svc] Device credential provisioning succeeded.
5 5947 [iot_thread] [INFO] [lu] SDI successfully initialized.
... 6 17203 [iot_thread] [INFO] [lu] Successfully initialized the demo. Network type for the demo...
7 17203 [iot_thread] [INFO] [HTTPS Client][lu] Shadow Update demo using HTTPS with the URL: https://a35cde1ac936-ats.iot.ap-south-1.amazonaws.com/things/Proto_Thing/shadow
8 17203 [iot_thread] [INFO] [HTTPS Client][lu] Connecting to the HTTP server at the endpoint URL...
9 21162 [iot_thread] [INFO] [HTTPS Client][lu] Successfully connected to the endpoint URL.
10 21162 [iot_thread] [INFO] [HTTPS Client][lu] Fetching existing Shadow document using HTTPS GET.
11 21315 [iot_thread] [INFO] [HTTPS Client][lu] Successfully retrieved the Shadow document.
12 21316 [iot_thread] [INFO] [HTTPS Client][lu] Updating Button Count to 14 as per received Shadow document.
13 21316 [iot_thread] [INFO] [HTTPS Client][lu] Press SW2 to update button press count in the shadow document.
14 28725 [iot_thread] [INFO] [HTTPS Client][lu] Button Pressed !! Count = 15.
15 28726 [iot_thread] [INFO] [HTTPS Client][lu] Updating Shadow document.
16 28726 [iot_thread] [INFO] [HTTPS Client][lu] Previous: {"state": {"reported": {"buttonPressCount": 14}}, "clientToken": "021316"}
17 28726 [iot_thread] [INFO] [HTTPS Client][lu] Current : {"state": {"reported": {"buttonPressCount": 15}}, "clientToken": "028726"}
18 28860 [iot_thread] [INFO] [HTTPS Client][lu] Successfully updated shadow document.
19 33703 [iot_thread] [INFO] [HTTPS Client][lu] Button Pressed !! Count = 16.
20 33704 [iot_thread] [INFO] [HTTPS Client][lu] Updating Shadow document.
21 33704 [iot_thread] [INFO] [HTTPS Client][lu] Previous: {"state": {"reported": {"buttonPressCount": 15}}, "clientToken": "028726"}
22 33704 [iot_thread] [INFO] [HTTPS Client][lu] Current : {"state": {"reported": {"buttonPressCount": 16}}, "clientToken": "033704"}
23 34073 [iot_thread] [INFO] [HTTPS Client][lu] Successfully updated shadow document.
```

7. Viewing the device's shadow in AWS IoT Console

- a. From the AWS IoT Core's home page, click to **Manage > Things**.
- b. On the right, click on the configured thing.
- c. Click on **Shadow** from the left pane.

You should be able to see the shadow state and metadata if the demo ran successfully.

## 6.13.20 Fix the logging system to print out the time instead of [lu]

### Issue

The reason you see [lu] at the end instead of the time is that the function `IotClock_GetTimestring()` in `<amazon-freertos>/libraries/abstractions/platform/freertos /iot_clock_freertos.c` tries to format a `uint64_t` variable into a char array using the “%llu” format specifier. The issue could be with the compiler not supporting 64-bit format specifiers. The fix is to print a 32-bit truncated value of the time:

### Fix



1. Edit the `iot_clock_freertos.c` file. Inside the `IotClock_GetTimestring()` function:

**Replace:**

```
timestringLength = snprintf( pBuffer, bufferSize, "%llu", milliSeconds );
```

**With:**

```
timestringLength = snprintf( pBuffer, bufferSize, "%lu", (unsigned long) milliSeconds );
```