Getting Started Guide for AWS IoT Greengrass

ZYMKEY4

Table of Contents

1 Document information

1.1 Document revision history

DATE	VERSION	COMMENTS
7/7/2023	1.0	Initial release

1.2 Applicable operating systems for this guide

This guide will show you how to setup AWS IoT Greengrass v2 HSI features secured by a Zymbit ZYMKEY4 on a Raspberry PI4, running Raspberry PI OS Bullseye 64bit The instructions include how to run an example script accessing the Zymbit Python API. Also included are the setup steps to test with AWS IoT Device Tester for AWS IoT Greengrass V2.

2 Overview

The Zymbit ZYMKEY4 provides private keys for X.509 certificate maintained in hardware through a PKCS#11 key store. This feature enables you to securely store the device's private key and certificate so that they aren't exposed or duplicated in software.

The AWS IoT Greengrass Core software uses a private key and X.509 certificate to authenticate connections to the AWS IoT and AWS IoT Greengrass services. The ZYMKEY4 can be configured to use either of the supported AWS IoT Greengrass signature schemes, RSA-2048 or ECC keys.

3 Hardware description

3.1 Datasheet

ZYMKEY4 Datasheet

3.2 Standard kit contents

The ZYMKEY4 ships individually with no other accessories. An optional cable is available providing an interface to tamper event circuitry.

For more details, please visit: ZYMKEY4 Getting Started/

3.3 User provided items

A Raspberry PI4 with an SD-CARD and USB-C 5VDC Power Supply. The power supply should be of good quality and provide at least 2.5 Amp. Ethernet cable. Optionally HDMI display, keyboard, and mouse.

3.4 3rd party purchasable items

No 3rd party items are purchasable from Zymbit.

4 Set up your development environment

4.1 Tools installation (IDEs, Toolchains, SDKs)

The ZYMKEY4 software environment is provided as Debian packages that are installed from a script. An API interface is available for use via Python, C, or C++. There are no modules or libraries that require compiling.

The ZYMKEY4 does not require an IDE or SDK per se. Any toolchains required would be standard Raspberry PI / Debian tools for your application.

4.2 Additional software references

For additional information on the Raspberry Pi Operating System itself, see Raspberry Pi OS
See docs.zymbit.com for additional information and examples.

5 Set up device hardware

The first step is to set up your PI itself. There are many tutorials and videos online to assist you. The Raspberry PI Foundation provides a tutorial to help you here.

The ZYMKEY occupies the first 10 pins of the Raspberry PI GPIO header. The instructions for setting up a Raspberry PI with a ZYMKEY can be found here: ZYMKEY4 Getting Started

6 About AWS IoT Greengrass

To learn more about AWS IoT Greengrass, see How AWS IoT Greengrass works and What's new in AWS IoT Greengrass Version 2.

7 Greengrass Hardware Security Integration

The AWS IoT Greengrass Core software uses a private key and X.509 certificate to authenticate connections to the AWS IoT and AWS IoT Greengrass services. AWS IoT Greengrass Core software can use a hardware security module (HSM) such as the Zymbit ZYMKEY4 through the PKCS#11 interface to protect that private key. The private key used to generate the device certificate is kept on the Zymbit module and never exposed.

PKCS#11 support for the Zymbit products is available through the Zymbit package called *zkpkcs11*. The *zkpkcs11* package is based on the SoftHSM2 source code Zymbit added two important extra features:

1. Zymbit private keys can be used for signing by specifying `--use-zkslot` when creating a new key object with `zk_pkcs11-util`. This only applies to ECC NIST-P256 (secp256r1).
2. Even though SoftHSM2 does key wrapping to protect its key objects, Zymbit goes a step further and protects all key material in its private object store with its data lock/unlock feature, even for slots that Zymbit products do not support, such as RSA. For example, if you wanted to setup a zkpkcs11 slot that was RSA, you could do that as well and, even though all actions would be done by OpenSSL in software on the host computer rather than the Zymbit module, the Zymbit module would still use its lock/unlock feature to protect the generated RSA private key.

For this Getting Started example, the first method will be used to sign with the Zymbit module based ECC 256 keys. We've made available scripts to help bootstrap the process.

8 Greengrass prerequisites

Refer to the online documentation detailing the prerequisites needed for AWS IoT Greengrass. Follow the instructions in the following sections:

Step 1: Set up an AWS account
Step 2: Set up your environment

9 Install AWS IoT Greengrass

First, install and configure the AWS CLI on your IoT device. Then, follow the online guide to *Install with manual provisioning*. Refer to the instructions in the following steps:

- *Retrieve AWS IoT Endpoints*
- *Create an AWS IoT Thing*
- *Create the thing certificate* (Create the thing certificate from a private key in an HSM)
    - Download the scripts from *this repository* onto your IoT device to automate this step
    - Make sure your user has permission to execute them.
    - If you want a more verbose output, you can uncomment the **set -x** command at the beginning of both scripts
    - Make sure that the slot, pin, and id in bootstrap-zymbit.sh are what you want them to be based on your setup of PKCS11 on the HSM.
    - Run bootstrap-zymbit.sh to generate the CSR. If done correctly, the script will automatically invoke bootstrap-common.sh and create the certificate using the HSM for AWS.
    - Here is the example output on success:

```
shiv@raspberrypi:~ $ bash bootstrap-zymbit.sh
Hit:1 https://packages.microsoft.com/repos/code stable InRelease
Hit:2 https://deb.nodesource.com/node_19.x bullseye InRelease
Hit:3 http://archive.raspberrypi.org/debian bullseye InRelease
Hit:4 http://raspbian.raspberrypi.org/raspbian bullseye InRelease
Hit:5 https://zk-sw-repo.s3.amazonaws.com/apt-repo-bullseye-aarch64 bullseye InRelease
Reading package lists... Done
Reading package lists... Done
Building dependency tree... Done
Reading state information... Done
Calculating upgrade... Done
The following packages were automatically installed and are no longer required:
  libfuse2 raspinfo
Use 'sudo apt autoremove' to remove them.
0 upgraded, 0 newly installed, 0 to remove and 0 not upgraded.
Reading package lists... Done
Building dependency tree... Done
Reading state information... Done
jq is already the newest version (1.6-2.1).
opensc is already the newest version (0.21.0-1).
python3-pip is already the newest version (20.3.4-4+rpt1+deb11u1).
The following packages were automatically installed and are no longer required:
  libfuse2 raspinfo
Use 'sudo apt autoremove' to remove them.
0 upgraded, 0 newly installed, 0 to remove and 0 not upgraded.
Looking in indexes: https://pypi.org/simple, https://www.piwheels.org/simple
Requirement already satisfied: awscli in /usr/lib/python3/dist-packages (1.19.1)
usermod: user 'pi' does not exist
engine "zymkey_ssl" set.
certificate.arn already exists, checking if cert still exists
Certificate still exists in AWS IoT, nothing to do
If you are using GGP your HSI options will be:

  --hsi P11Provider=/usr/lib/libzk_pkcs11.so,slotLabel=greengrass,slotUserPin=1234,OpenSSLEngine=/usr/lib/libzk_pkcs11.so,pkcs11EngineForCurl=zymkey_ssl
859c4

SUCCESS: arn:aws:iot:us-east-1:746864551739:cert/bf81614afd6c9ebeb8e44d00139bc8373d9ca65992167ccb2f9160b2942859c4
```

```
shiv@raspberrypi:~ $ sudo zk_pkcs11-util --show-slots
Available slots:
Slot 395221339
    Slot info:
        Description:      SoftHSM slot ID 0x178e995b
        Manufacturer ID:  SoftHSM project
        Hardware version: 2.5
        Firmware version: 2.5
        Token present:    yes
    Token info:
        Manufacturer ID:  SoftHSM project
        Model:            SoftHSM v2
        Hardware version: 2.5
        Firmware version: 2.5
        Serial number:    204af3ce978e995b
        Initialized:      yes
        User PIN init.:   yes
        Label:            greengrass
Slot 1
    Slot info:
        Description:      SoftHSM slot ID 0x1
        Manufacturer ID:  SoftHSM project
        Hardware version: 2.5
        Firmware version: 2.5
        Token present:    yes
    Token info:
        Manufacturer ID:  SoftHSM project
        Model:            SoftHSM v2
        Hardware version: 2.5
        Firmware version: 2.5
        Serial number:
        Initialized:      no
        User PIN init.:   no
        Label:
```

- Continue the *Install with manual provisioning* guide at *Configure the thing certificate* until the end.

10 Create a Greengrass component

10.1 Create the component on your edge device

Below is an example component that you can use as the HelloWorld component for this section. This component will showcase some of Zymbit's API functions running as a Greengrass component in addition to AWS's basic HelloWorld example.

```
import zymkey
import sys

message = "Hello, %s!" % sys.argv[1]

# Print the message to stdout, which Greengrass saves in a log file.
print(message)

# Get timestamp from the Zymkey's RTC
time = zymkey.client.get_time()
print("GMT Time from Zymkey's RTC: ", time)

# Get the CPU's Temperature
temp = zymkey.client.get_cpu_temp()
print("CPU Temperature: ", temp)

# Get Model Number
```

```
model_num = zymkey.client.get_model_number()
print("Zymkey Model Number: ", model_num)

# Get Firmware Version
firmware_version = zymkey.client.get_firmware_version()
print("Zymkey Firmware Version: ", firmware_version)
```

Follow the instructions online under the section Develop and test a component on your device to create a simple component on your device.

10.2 Upload the Greengrass component

Follow the instructions online at Create your component in the AWS IoT Greengrass service to upload your component to the cloud, where it can be deployed to other devices as needed.

10.3 Deploy your component

Follow the instructions online at Deploy your component to deploy and verify that your component is running.

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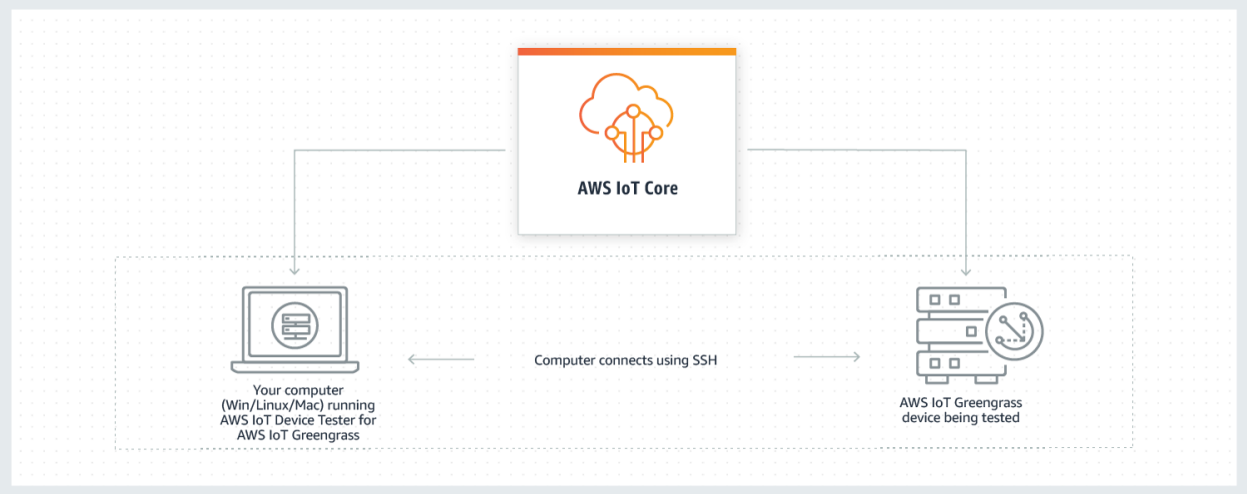
11 Setup and run IoT Device Tester Greengrass v2 test suite.

Use AWS IoT Device Tester for AWS IoT Greengrass v2 to verify that the AWS IoT Greengrass Core software runs on your hardware and can communicate with the AWS Cloud. It also performs end-to-end tests with AWS IoT Core.



Two devices will need to be setup: A computer to run the IDT tests and the Greengrass device being tested (Pi4 with ZYMKEY). For our Zymbit modules, we will include the mandatory test suites along with the optional HSM/HSI test suite. The Zymbit modules support both EC keys and RSA keys for PKCS#11. Both methods will be covered.

The AWS Greengrass site details how to setup the IDT computer to run tests as well as the Greengrass device. Follow the steps on this page to setup the IDT computer:

Use IDT to run the AWS IoT Greengrass qualification suite

The Pi4 OS and Zymbit software should be loaded and running following the steps above. The Blue LED should blink once every three seconds. Follow the steps continuing on from the above link, Configure your device to run IDT tests to enable connectivity between the IDT computer and the Pi4. Access the Pi4 via SSH from the IDT computer.

The HSI tests will require setting up the PKCS#11 key store for the HSM qualification requirements. The next section here covers the steps for both EC keys and RSA keys.

11.1 For HSI/HSM test using the Zymbit Module EC private key

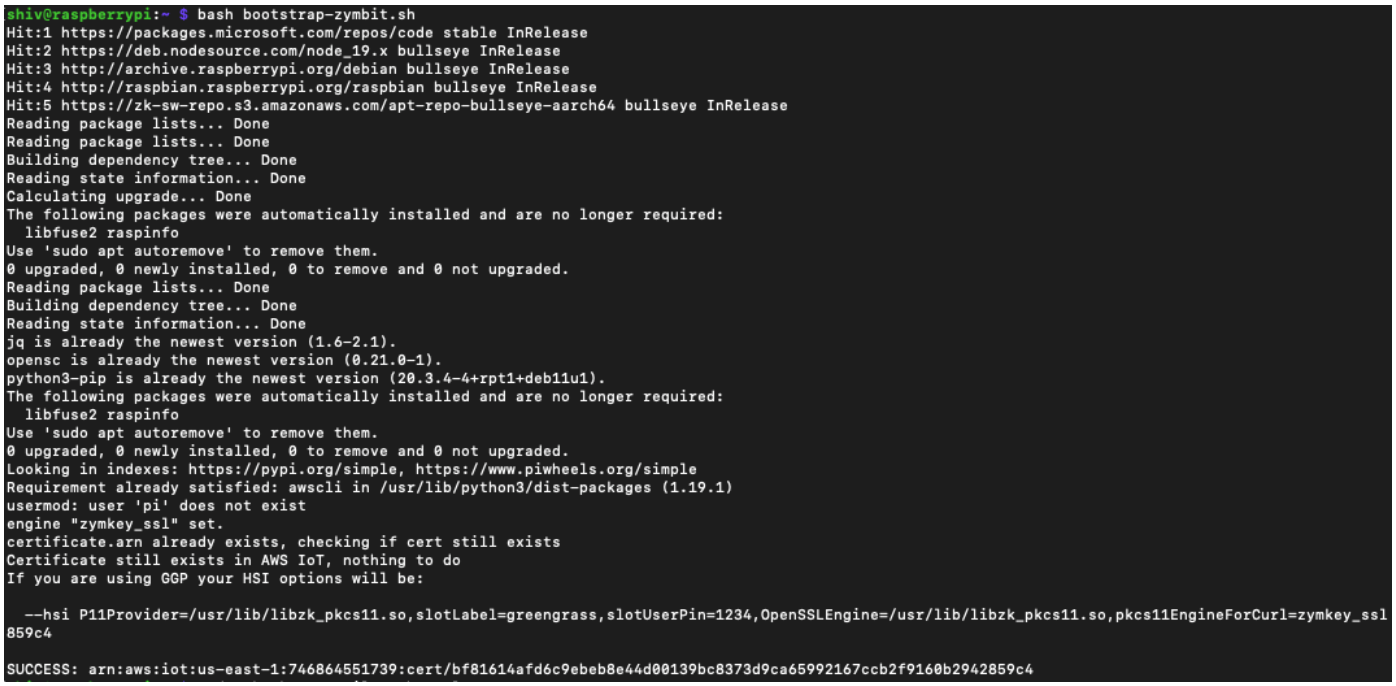
The Zymbit PKCS#11 support is based off SoftHSM2. Zymbit private keys can be used for signing by specifying --use-zkslot when creating a new key object with zk_pkcs11-util. This feature supports ECC NIST-P256 (secp256r1).

All the setup for the certs and keys is done with scripts that bootstrap the HSI setup. The scripts require the AWS cli. The script will load the AWS cli if it not installed, but will require re-running to configure credentials. Execute the following on the Pi4

11.1.1 Run the bootstrap scripts

- Download the scripts from this repository onto the Pi4.
- Make sure that the slot, pin, and id in bootstrap-zymbit.sh are what you want them to be based on your setup of PKCS11 on the HSM.
- Run bootstrap-zymbit.sh to generate the CSR. If successful, the script will automatically invoke bootstrap-common.sh and create the certificate using the HSM for AWS.
- The script will also generate a private key in the PKCS#11 storage and inserts the associated certificate in the PKCS#11 storage

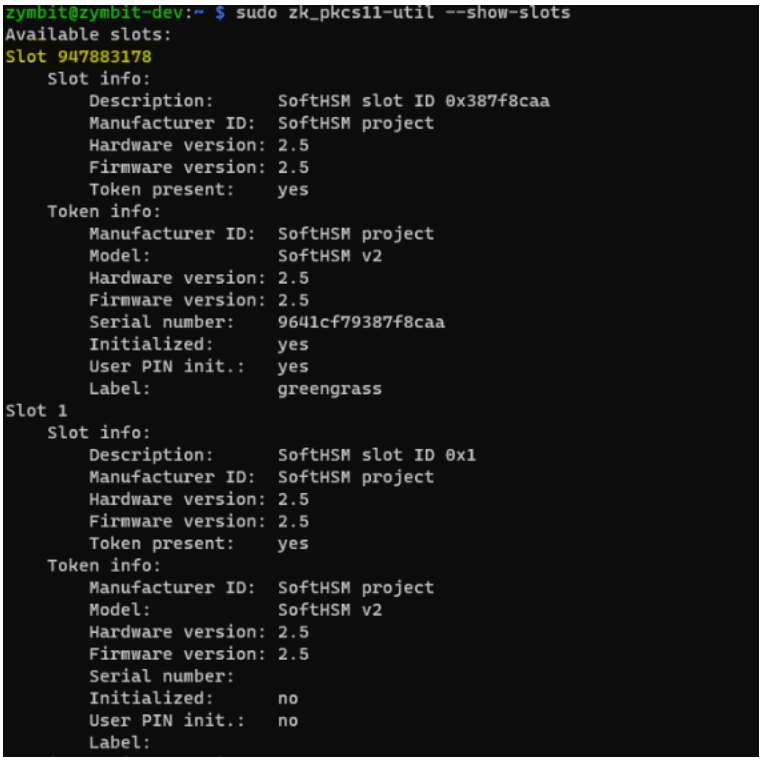
Here is the example output on success:



The last line indicating SUCCESS contains the ARN that will be needed for configuring the HSI test in the next section.

To verify the information is in the PKCS#11 storage:

```
sudo zk_pkcs11-util --show-slots
```



The slot number (a large number, not 0 or 1) will be needed for configuring the HSI test in the next section.

Insert the certificate into the PKCS#11 slot. You can determine the –id parameter and –label from the Private Key object displayed in the output from the following command

```
sudo pkcs11-tool --module /usr/lib/libzk_pkcs11.so --list-objects --
login
```

You will need to provide the PIN (the script sets to 1234 by default). You should see the private key and the certificate in this display. The slot label and key label from this display will be needed for configuring the HSI test in the next section. They must both be the same. Add the certificate:

```
sudo pkcs11-tool --module /usr/lib/libzk_pkcs11.so -l --pin 1234 --
write-object certificate.pem --type cert --id 947883178 --label iotkey
```

11.1.2 Setup the HSI test parameters section on the IDT computer.

On the IDT computer, edit `<device-tester-root>/configs/userdata.json`. Change this section:

```
  "hsm": {
    "greengrassPkcsPluginJar": "<device-tester-
root>/products/downloadedgreengrass/pkcsProvider.jar",
    "pkcs11ProviderLibrary": "/usr/lib/libzk_pkcs11.so",
    "slotId": "<slot_number from above>",
    "slotLabel": "<label from above>",
    "slotUserPin": "1234",
    "keyLabel": "<label from above>",
    "preloadedCertificateArn": "<certificateArn_generated_above>"
  }
```

Example:

```
  "hsm": {
    "greengrassPkcsPluginJar":
"/home/laptop/devicetester_greengrass_v2_linux/products/downloadedgreen
grass/pkcsProvider.jar",
    "pkcs11ProviderLibrary": "/usr/lib/libzk_pkcs11.so",
    "slotId": "947883178 ",
    "slotLabel": "iotkey",
    "slotUserPin": "1234",
    "keyLabel": "iotkey",
    "preloadedCertificateArn": "arn:aws:iot:us-east-
1:746864551739:cert/A2484ff2d536948acfe4b466706d5f3ffff6912438a8e6cf7c7
875d968ba0ee9d"
  }
```

Everything should be ready to run the HSI tests now. Enable the test suite in `<device-tester-root>/configs/device.json`. Change the features.hsi value"from "no" to "hsm".

```
    {
        "name": "hsi",
        "value": "hsm"
      }
```

You can now run the HSI test individually:

```
./devicetester_linux_x86-64 run-suite -g hsi
```

Or run the full suite:

```
./devicetester_linux_x86-64 run-suite
```

11.2 For HSI/HSM test using an external RSA private key

The Zymbit PKCS#11 support is based off SoftHSM2. Even though SoftHSM2 does key wrapping to protect its key objects, Zymbit goes a step further and protects all key material in its private object store with its data lock/unlock feature, even for slots that Zymbit products do not support, such as RSA. Though all actions are done by OpenSSL in software on the host computer rather than the Zymbit module, the Zymbit module still uses its lock/unlock feature to protect the generated RSA private key.

11.2.1 Create RSA certs straight from AWS. Certs and keys returned are registered and signed. Nothing more to do on the AWS side.

On the IDT computer,

```
aws iot create-keys-and-certificate \
    --set-as-active \
    --certificate-pem-outfile idtCert.pem \
    --public-key-outfile idtPubKey.pem \
    --private-key-outfile idtPrivKey.pem
```

You will need the "certificateArn" returned for your configuration file.
Example: "certificateArn": "arn:aws:iot:us-east-1:746864551739:cert/9c484ff2d536948acfe4b466706d5f80936912438a8e6cf7c7875d968ba0ee9d"

11.2.2 Copy the pem files from the IDT computer over to the PI/device.

```
scp *pem pi@pi:
```

11.2.3 On the PI/device Load the cert and private key into Zymbit locked PKCS11 database

On the PI/device, add permissions to token store. Add your username to the zk_pkcs11 group. Substitute your actual username for <username> (ex. "zymbit")

```
sudo usermod -aG zk_pkcs11 <username>
sudo chgrp -R zk_pkcs11 /var/lib/zymbit/zk_pkcs11
sudo chmod -R 770 /var/lib/zymbit/zk_pkcs11/tokens
```

Initialize a new token at the next free slot. The label can be anything.

```
sudo zk_pkcs11-util --init-token --free --label "greengrass"
```

Note the <slot_number> returned (ex. "632244755".) Use the <slot_number> to load the private key and cert. The same <slot_number> will be used in the userdata.json configuration file later. The <label> for the private key and the certificate must match but can be anything (ex. "idt"). This <label> also will be used in the userdata.json configuration file later.

Load the private key and cert into PKCS#11,

```
sudo apt install opensc


sudo pkcs11-tool --module /usr/lib/libzk_pkcs11.so -l --pin 1234 --
write-object idtPrivKey.pem --type privkey --id <slot_number> --label
<label>
sudo pkcs11-tool --module /usr/lib/libzk_pkcs11.so -l --pin 1234 --
write-object idtCert.pem --type cert --id <slot_number> --label <label>
```

11.2.4 Setup the HSI test parameters section on the IDT computer.

On the IDT computer, edit `<device-tester-root>/configs/userdata.json`. Change this section:

```
  "hsm": {
    "greengrassPkcsPluginJar": "<device-tester-
root>/products/downloadedgreengrass/pkcsProvider.jar",
    "pkcs11ProviderLibrary": "/usr/lib/libzk_pkcs11.so",
    "slotId": "<slot_number from above>",
    "slotLabel": "<label from above>",
```

```
    "slotUserPin": "1234",
    "keyLabel": "<label from above>",
    "preloadedCertificateArn": "<certificateArn_generated_above>"
  }
```

Example:

```
  "hsm": {
    "greengrassPkcsPluginJar":
"/home/laptop/devicetester_greengrass_v2_linux/products/downloadedgreen
grass/pkcsProvider.jar",
    "pkcs11ProviderLibrary": "/usr/lib/libzk_pkcs11.so",
    "slotId": "632244755",
    "slotLabel": "idt",
    "slotUserPin": "1234",
    "keyLabel": "idt",
    "preloadedCertificateArn": "arn:aws:iot:us-east-
1:746864551739:cert/9c484ff2d536948acfe4b466706d5f39086912438a8e6cf7c78
75d968ba0ee9d"
  }
```

Everything should be ready to run the HSI tests now. Enable the test suite in `<device-tester-root>/configs/device.json`. Change the features.hsi value"from "no" to "hsm".

```
    {
        "name": "hsi",
        "value": "hsm"
      }
```

You can now run the HSI test individually:

```
./devicetester_linux_x86-64 run-suite -g hsi
```

Or run the full suite:

```
./devicetester_linux_x86-64 run-suite
```

If you need to check the token info,

```
sudo zk_pkcs11-util --show-slots
sudo pkcs11-tool --module /usr/lib/libzk_pkcs11.so --list-objects --
login
```

12 Troubleshooting

A troubleshooting section for the ZYMKEY4 can be found on our doc server:

General Troubleshooting
ZYMKEY4 Troubleshooting

The ZYMBIT Community pages can also be helpful

In addition, make sure that the PKCS#11 key store is configured correctly. The following command allows one to display a list of tokens:
p11tool --list-token-urls

The following command allows one to display a list of keys associated with a token:
p11tool --login --list-keys 'pkcs11:token=greengrass'

If you need additional support, please contact
For more information, refer to the online documentation *Troubleshooting Greengrass v2*.