THALES

Hyperledger Fabric (Blockchain): Integration Guide

THALES LUNA HSM AND LUNA CLOUD HSM

Document Information

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Overview

This guide explains how to ensure secure storage of Hyperledger Fabric private keys using Luna HSM devices or Luna Cloud HSM services. It walks administrators through configuring the Blockchain Crypto Service Provider (BCCSP) to generate and secure Admin, Peer, and Orderer keys using Thales HSMs. Thales HSMs integrate with Hyperledger Fabric to generate 384-bit ECDSA signing key pairs for blockchain identities, Thales HSMs can also integrate with Hyperledger Fabric SDK clients for node.js and java, allowing secure signing key management. The benefits of integrating Hyperledger Fabric with Thales HSMs include:

- Ensuring secure key generation, storage, and protection through FIPS 140-2 level 3 validated hardware.
- Providing full life cycle management of the keys.
- Maintaining an audit trail through HSM.
- Achieving significant performance enhancements by offloading cryptographic operations from application servers.

> **Note:** The Luna Cloud HSM service does not have access to the secure audit trail.

Certified Platforms

- Certified Platforms for Luna HSM
- Certified Platforms for Luna Cloud HSM

Certified Platforms for Luna HSM

The following platforms are certified for integrating Hyperledger Fabric with Luna HSM:

HSM Type	Platforms	Hyperledger
Luna HSM	Alpine Linux	Hyperledger Fabric release 2.4
Luna HSM	RHEL	Hyperledger Fabric release 1.4
Luna HSM	CentOS	Hyperledger Fabric 1.4 Client SDK Node
Luna HSM	CentOS	Hyperledger Fabric 1.4 Client SDK Java

Luna HSM: Luna HSM appliances are purposefully designed to provide a balance of security, high performance, and usability that makes them an ideal choice for enterprise, financial, and government organizations. Luna HSMs physically and logically secure cryptographic keys and accelerate cryptographic processing. Luna HSM on premise offerings include Luna Network HSM, Luna PCIe HSM, and Luna USB HSM. Luna HSMs are also available for access as an offering from cloud service providers such as IBM cloud HSM and AWS cloud HSM classic.

Certified Platforms for Luna Cloud HSM

The following platforms are certified for integrating Hyperledger Fabric with Luna Cloud HSM:

HSM Type	Platforms	Hyperledger
Luna Cloud HSM	RHEL	Hyperledger Fabric release-1.4
Luna Cloud HSM	CentOS	Hyperledger Fabricn1.4 Client SDK Node
Luna Cloud HSM	CentOS	Hyperledger Fabric 1.4 Client SDK Java

Luna Cloud HSM: Luna Cloud HSM services provide on-demand HSM and Key Management services through a simple graphical user interface. With Luna Cloud HSM, security is simple, cost effective and easy to manage because there is no hardware to buy, deploy and maintain. As an Application Owner, you click and deploy services, generate usage reports, and maintain just the services you need.

Prerequisites

Before you proceed with the integration, complete the following tasks:

> Configure Luna HSM

> Configure Luna Cloud HSM service

> Set up Hyperledger Fabric, Fabric CA, and Fabric-Samples

Configure Luna HSM

If you are using Luna HSM:

1. Verify that the HSM is set up, initialized, provisioned, and ready for deployment. Refer to Luna HSM documentation for more information.
2. Create a partition that will be later used by Hyperledger.
3. If using a Luna Network HSM, register a client for the system and assign the client to the partition to create an NTLS connection. Initialize the Crypto Officer and Crypto User roles for the registered partition.

   NOTE: If you are using PCIe or USB HSMs you don't need to create NTLS connection.

4. Ensure that the partition is successfully registered and configured. The command to see the registered partitions is:

```
/usr/safenet/lunaclient/bin/lunacm
lunacm (64-bit) v10.3.0-275. Copyright (c) 2020 SafeNet. All rights reserved.
        Available HSMs:
        Slot Id ->              0
```

```
Label ->                org.example.com
Serial Number ->        1238696044924
Model ->                LunaSA 7.4.0
Firmware Version ->     7.4.0
Configuration ->        Luna User Partition With SO (PW) Signing With
                        Cloning Mode
Slot Description ->     Net Token Slot
FM HW Status ->         Non-FM
```

5. For PED-authenticated HSM, enable partition policies 22 and 23 to allow activation and auto-activation.

> **NOTE:** Refer to Luna HSM documentation for detailed steps on creating NTLS connection, initializing the partitions, and assigning various user roles.

Create additional partitions for Luna HSM

Create additional partitions if you are using Hyperledger Fabric or Hyperledger Fabric Client using the steps given below:

> Create partitions for Hyperledger Fabric

> Create partitions for Hyperledger Fabric Client

Create partitions for Hyperledger Fabric

If you are using Hyperledger Fabric, you can create additional partitions by following these steps:

1. Create a separate partition for each Peer and Orderer organization in Hyperledger on the Luna HSM and label them as follows.
   - org1.example.com
   - org2.example.com
   - orderer.example.com

> **NOTE:** For demonstration purposes, we have registered a single client for all the separate partitions with crypto officer password as *userpin* for the different organizations. For a production environment where each Identity (Peer, Orderer, and User) is running on separate systems, we recommend that you register each client Identity with their own HSM partition.

2. Ensure that the partition is successfully registered and configured. The command to see the registered partitions is:

```
/usr/safenet/lunaclient/bin/lunacm
lunacm (64-bit) v10.3.0-275. Copyright (c) 2020 SafeNet. All rights reserved.
        Available HSMs:
        Slot Id ->              0
        Label ->                org1.example.com
```

```
Serial Number ->        1238696044924
Model ->                LunaSA 7.4.0
Firmware Version ->     7.4.0
Configuration ->        Luna User Partition With SO (PW) Signing With
                        Cloning Mode
Slot Description ->     Net Token Slot
FM HW Status ->         Non-FM

Slot Id ->              1
Label ->                org2.example.com
Serial Number ->        1238696044925
Model ->                LunaSA 7.4.0
Firmware Version ->     7.4.0
Configuration ->        Luna User Partition With SO (PW) Signing With
                        Cloning Mode
Slot Description ->     Net Token Slot
FM HW Status ->         Non-FM

Slot Id ->              2
Label ->                orderer.example.com
Serial Number ->        1238696044926
Model ->                LunaSA 7.4.0
Firmware Version ->     7.4.0
Configuration ->        Luna User Partition With SO (PW) Signing With
                        Cloning Mode
Slot Description ->     Net Token Slot
FM HW Status ->         Non-FM
```

Create partitions for Hyperledger Fabric Client

If you are using Hyperledger Fabric Client you need to create additional partitions using the following steps:

1. Create a partition on the HSM that will be later used by Hyperledger Fabric Client.
2. Ensure that the partition is successfully registered and configured. The command to see the registered partitions is:

   ```
   # /usr/safenet/lunaclient/bin/lunacm
   lunacm (64-bit) v7.3.0-165. Copyright (c) 2018 SafeNet. All rights reserved.
   ```

```
Available HSMs:


Slot Id ->              0
Label ->                fabric-sdk
Serial Number ->        1280780175900
Model ->                LunaSA 7.3.0
Firmware Version ->     7.3.0
Configuration ->        Luna User Partition With SO (PW) Key Export
                        With Cloning Mode
Slot Description ->     Net Token Slot
Current Slot Id: 0
```

> **NOTE:** The end-2-end execution example uses the label “fabric-sdk” and the password “userpin”. We recommend setting the password as per your organization’s security policy if implementing in a production environment.

Set up Luna HSM High-Availability

Refer to Luna HSM documentation for HA steps and details regarding configuring and setting up two or more HSM boxes on host systems. You must enable the HAOnly setting in HA for failover to work so that if the primary goes down due to any reason, all calls automatically route to the secondary until the primary recovers and restarts.

Configure Luna Cloud HSM service

Follow these steps to set up your Luna Cloud HSM:

1. Transfer the downloaded .zip file to your client workstation using pscp, scp, or other secure means.
2. Extract the .zip file into a directory on your client workstation.
3. Extract or untar the appropriate client package for your operating system using the following command:

   ```
   tar -xvf cvclient-min.tar
   ```

   > **NOTE:** Do not extract to a new subdirectory. Place the files in the client install directory.

4. Run the `setenv` script to create a new configuration file containing information required by the Luna Cloud HSM service:

   ```
   source ./setenv
   ```

   > **NOTE:** To add the configuration to an already installed UC client, use the -addcloudhsm option when running the setenv script.

5. Run the LunaCM utility and verify that the Cloud HSM service is listed.

NOTE: If your organization requires non-FIPS algorithms for your operations, ensure that the Allow non-FIPS approved algorithms check box is checked. For more information, refer to Supported Mechanisms.

Create additional partitions for Luna Cloud HSM

Create additional partitions if you are using Hyperledger Fabric or Hyperledger Fabric Client using the steps given below:

> Create partitions for Hyperledger Fabric

> Create partitions for Hyperledger Fabric Client

Create partitions for Hyperledger Fabric

If you are using Hyperledger Fabric you need to create additional partitions using the following steps:

1. Create the following Luna Cloud services in Luna Cloud HSM:
   - org1.example.com
   - org2.example.com
   - orderer.example.com

   NOTE: It is recommended to use minimal client package if you are using three partitions on the same host.
2. For each service, create a Linux service client and download the zip to the host system.
3. Make the following directories on the client machine:

```
# mkdir -p /etc/hyperledger/fabric/dpod/org1.example.com
# mkdir -p /etc/hyperledger/fabric/dpod/org2.example.com
# mkdir -p /etc/hyperledger/fabric/dpod/orderer.example.com
```

4. Unzip the client zip files for org1.example.com, org2.example.com and orderer.example.com in to their respective directories.
5. Complete the following processes:
   - Initialize the partition, Crypto Officer, and Crypto User roles.
   - Set the ChrystokiConfigurationPath environment variable to point to the Chrystoki.conf file.
   - Set the partition password to "userpin" for partition labels org1.example.com, org2.example.com and orderer.example.com using LunaCM.

   NOTE: It is recommended to use separate partitions for all Peers, Orderers, and Users. For this example make sure to initialize all partitions with the label provided above and that “userpin” is used as a partition password to successfully complete the demo using byfn.

   You need to set the partition password as per your organization security policy for a production environment.

Create partitions for Hyperledger Fabric Client

If you are using Hyperledger Fabric Client you need to create additional partitions using the following steps:

1. Create the fabric-sdk Luna Cloud service in Luna Cloud HSM.
2. After creating the service, create a Linux service client and download the zip to the host system.
3. Make the following directory on the client machine:

   ```
   # mkdir -p /usr/safenet/dpod
   ```

4. Unzip the client zip files for fabric-sdk in to the directory.
5. Follow the instructions in the *Application Owner Quick Start Guid*e and complete the following tasks:
   - Initialize the partition, Security Officer, Crypto Officer, and Crypto User roles.
   - Set the ChrystokiConfigurationPath environment variable or create the soft link /etc/Chrystoki.conf to point to the Chrystoki.conf file.
   - Set the partition password to "userpin" for partition label fabric-sdk using LunaCM.

   NOTE: The end-2-end execution example uses the label “fabric-sdk” and the password “userpin”. We recommend setting the password as per your organization security policy if implementing in a production environment.

Set up Hyperledger Fabric, Fabric CA, and Fabric-Samples

Both Hyperledger Fabric and the Fabric CA client must be installed to complete the integration with Luna HSM. Complete the following tasks to install both Hyperledger Fabric and the Fabric CA client on the Linux host system.

> Install Hyperledger Fabric and Fabric CA prerequisite libraries

> Install and set up Golang

> Install and set up Docker and Docker Compose

> Install and configure Hyperledger Fabric and Fabric CA

> Install and configure Hyperledger Fabric-Samples

Install Hyperledger Fabric and Fabric CA prerequisite libraries

To install Hyperledger Fabric and Fabric CA prerequisite libraries:

Ubuntu

```
# sudo apt-get install git curl alien python-pip libltdl-dev
```

RHEL/CentOS

```
# sudo yum install git curl alien python-pip libtool-ltdl-devel
```

Install and set up Golang

Hyperledger Fabric uses Go programming language for many of its components. Install **golang** using the following URLs:

> Installation steps: https://golang.org/doc/install

> Download binaries: https://golang.org/dl/

Install and set up Docker and Docker Compose

To install Docker and Docker Compose:

1. Install Docker and Docker Compose on the host system by following the instructions available in Docker documentation:
   - Docker Installation: https://docs.docker.com/engine/install/
   - Docker Compose Installation: https://docs.docker.com/compose/install/
2. Configure the docker so that sudo is not required to run further commands:

```
# sudo gpasswd -a $USER docker
# newgrp docker
```

3. Ensure that the go executable is in the PATH.

```
# export PATH=/usr/local/go/bin:$PATH
```

Install and configure Hyperledger Fabric and Fabric CA

To install and configure Hyperledger Fabric and Fabric CA:

1. Set the **GOPATH**, the value will be a directory tree child of your development workspace.

```
# export GOPATH=/opt/gopath
# mkdir -p $GOPATH/src/github.com/hyperledger
# cd $GOPATH/src/github.com/hyperledger
```

2. Create the Hyperledger Fabric repository by executing the following command.

```
# git clone https://github.com/hyperledger/fabric
# cd fabric
# git checkout -b release-1.4 origin/release-1.4  (Hypeledger Fabric)
```

3. For Client SDK run:

```
# git checkout -b v1.4.0 v1.4.0     (Hypeledger Fabric Client SDK)
```

> **NOTE:** The instructions were developed against the tag release-1.4 for Hyperledger Fabric and v1.4.0 for Hyperledger Fabric Client SDK. It is advisable to use the repo checkout from these tags as the instructions may not be compatible with the latest check-in in the master branch of Fabric and Fabric Client SDK.

4. Build the docker images and executables.

```
# GO_TAGS=pkcs11 make peer orderer cryptogen configtxgen configtxlator
```

5. Clone the fabric-ca project and build the fabric-ca-client binary.

```
# cd $GOPATH/src/github.com/hyperledger
# git clone https://github.com/hyperledger/fabric-ca
# cd fabric-ca
# git checkout -b release-1.4 origin/release-1.4 (Hypeledger Fabric)
# make fabric-ca-client
```

6. For Client SDK, run:

```
# git checkout -b v1.4.0 v1.4.0  (Hypeledger Fabric Client SDK)
```

> **NOTE:** The instructions were developed against the tag release-1.4 for Hyperledger Fabric and v1.4.0 for Hyperledger Fabric Client SDK. It is advisable to use the repo checkout from these tags as the instructions may not be compatible with the latest check-in in the master branch of Fabric and Fabric Client SDK.

Install and configure Hyperledger Fabric-Samples

To install and configure Hyperledger Fabric-Samples:

1. Clone the fabric-samples project.

```
# cd $GOPATH/src/github.com/hyperledger
# git clone https://github.com/hyperledger/fabric-samples/
# cd fabric-samples/
# git checkout -b release-1.4 origin/release-1.4
```

2. Create directory $GOPATH/src/github.com/hyperledger/fabric-samples/bin and $GOPATH/src/github.com/hyperledger/fabric-samples/first-network/bin

```
# mkdir $GOPATH/src/github.com/hyperledger/fabric-samples/bin
# mkdir $GOPATH/src/github.com/hyperledger/fabric-samples/first-network/bin
```

3. Copy the executables to $GOPATH/src/github.com/hyperledger/fabric-samples/bin directory.

```
# cp $GOPATH/src/github.com/hyperledger/fabric-ca/bin/*
$GOPATH/src/github.com/hyperledger/fabric-samples/bin/
# cp $GOPATH/src/github.com/hyperledger/fabric/.build/bin/*
$GOPATH/src/github.com/hyperledger/fabric-samples/bin
```

4. Copy the executables to $GOPATH/src/github.com/hyperledger/fabric-samples/first-network/bin directory.

```
# cp $GOPATH/src/github.com/hyperledger/fabric/.build/bin/*
$GOPATH/src/github.com/hyperledger/fabric-samples/first-network/bin
# cp $GOPATH/src/github.com/hyperledger/fabric-ca/bin/*
$GOPATH/src/github.com/hyperledger/fabric-samples/first-network/bin
```

Integrating Thales Luna HSM with Hyperledger Fabric

To integrate Thales Luna HSM with Hyperledger Fabric, you need to complete the following tasks:

> Generate a CSR using fabric-ca-client and PKCS11 BCCSP for an MSP directory

> Configure peer nodes

> Configure Orderer nodes

NOTE: Refer to Build Your First Network(BYFN) using Luna HSM section below for an example of end to end integration of Hyperledger Fabric with Luna HSM.

Generate a CSR using fabric-ca-client and PKCS11 BCCSP for an MSP directory

The fabric-ca-client utility can be used to generate certificate signing requests for Peers, Orderers, and Users in their respective MSP directories. The fabric-ca-client utility uses the BCCSP to generate crypto material. If the BCCSP is configured to use the PKCS11 implementation of the BCCSP then it can be used to generate keys on the Thales Luna HSM. The fabric-ca-client BCCSP can be configured in the ~/.fabric-ca-client/fabric-ca-client-config.yaml file. This involves following steps:

> Configure BCCSP to use the Luna PKCS#11 API

> Generate the cryptographic keys using the gencsr command

Configure BCCSP to use the Luna PKCS#11 API

1. Modify the BCCSP section in ~/.fabric-ca-client/fabric-ca-client-config.yaml:

```
bccsp:
    default: PKCS11
    sw:
        hash: SHA2
        security: 256
        filekeystore:
            keystore: msp/keystore
    pkcs11:
        hash: SHA2
        security: 384
        library: /usr/safenet/lunaclient/lib/libCryptoki2_64.so
        label: org1.example.com
        pin: userpin
        filekeystore:
       keystore: msp/keystore
```

NOTE: If the ~/.fabric-ca-client/fabric-ca-client-config.yaml file is not present run the following command to generate it: `# fabric-ca-client gencsr`

2. Add a keyrequest setting to the csr section of ~/.fabric-ca-client/fabric-ca-client-config.yaml file to specify the key size as follows:

```
csr:
  cn:
  keyrequest:
    algo: ecdsa
    size: 384
```

Generate the cryptographic keys using the gencsr command

To generate ECDSA private keys on the HSM using the PKCS#11 BCCSP and create a CSR in the msp/signcerts directory for the private key, you need to undertake the following process:

1. The PKCS11 values in the fabric-ca-client-config.yaml file can be left blank and specified using environment variables. Alternatively, the values in the file can be overridden using the following environment variables:

```
# export FABRIC_CA_CLIENT_BCCSP_DEFAULT=PKCS11
# export FABRIC_CA_CLIENT_BCCSP_PKCS11_LABEL=<HSM Partition Label>
# export FABRIC_CA_CLIENT_BCCSP_PKCS11_PIN=<Partition Password>
# export FABRIC_CA_CLIENT_BCCSP_PKCS11_LIBRARY=<HSM PKCS11 Library>
```

2. The command to generate CSRs is:

```
# ./fabric-ca-client gencsr [options]
```

Where:

```
--csr.cn string   The common name field of the certificate signing request
--mspdir string        Membership Service Provider directory (default "msp")
--csr.names stringSlice      A list of comma-separated CSR names of the form
                             <name>=<value> (e.g. C=CA,OU=peer)
```

NOTE: When generating the CSR request you need to ensure that PKCS11 BCCSP settings are correct or set the correct values in environment variables for the Peer/Orderer. Also, make sure to specify the correct CN, MSP directory and Names mainly OU (peer/orderer/client) in fabric-ca-client options.

3. To generate the key for orderer.example.com, execute the following command:

```
# ./fabric-ca-client gencsr --csr.cn orderer.example.com --mspdir
ordererOrganizations/orderer.example.com/orderers/orderer.example.com/msp --
csr.names "C=US,ST=California,L=San Francisco,OU=orderer"
```

4. Options and exported variables should be changed accordingly as per the requirement for generating the specific certificate signing request. Submit the CSR to your CA to obtain the signed certificate for the Peer/Orderer/User and place the signed certificate in their respective msp/signcerts directories.

5. To generate the CSR for the peer0 of org1.example.com, execute the following commands:

```
# export FABRIC_CA_CLIENT_BCCSP_DEFAULT=PKCS11

# export FABRIC_CA_CLIENT_BCCSP_PKCS11_LABEL=org1.example.com

# export FABRIC_CA_CLIENT_BCCSP_PKCS11_PIN=userpin

# export
FABRIC_CA_CLIENT_BCCSP_PKCS11_LIBRARY=/usr/safenet/lunaclient/lib/libCryptoki2_
64.so

# ./fabric-ca-client gencsr --csr.cn peer0.org1.example.com --mspdir ./crypto-
config/peerOrganizations/org1.example.com/peers/peer0.org1.example.com/msp --
csr.names "C=US,ST=California,L=San Francisco,OU=peer"
```

6. The above command generates the key pair for peer0.org1.example.com on HSM partition org1.example.com and creates the CSR ./crypto-config/peerOrganizations/org1.example.com/peers/peer0.org1.example.com/msp/signcerts/peer0.org1.example.com.csr. Copy the CSR and send it to your CA to obtain a signed certificate and then place the certificate in same directory.

7. Similarly, use the following command for generating the certificate request for Admin User:

```
# ./fabric-ca-client gencsr --csr.cn Admin@org1.example.com --mspdir ./crypto-
config/peerOrganizations/org1.example.com/users/Admin@org1.example.com/msp --
csr.names "C=US,ST=California,L=San Francisco,OU=client"
```

Configure peer nodes

To configure BCCSP to use the Luna HSM for peer nodes:

1. Change the core.yaml file and specify PKCS11 as the default in the BCCSP section as follows:

```
BCCSP:
  Default: PKCS11
  PKCS11:
    Library: /usr/safenet/lunaclient/lib/libCryptoki2_64.so
    Label: org1.example.com
    Pin: userpin
    Hash: SHA2
    Security: 384
```

   Alternatively, the PKCS11 values in the core.yaml file can be left blank and specified using environment variables, or the values in the file can be overridden using these environment variables. The following environment variables can be used to change the configuration settings of the core.yaml BCCSP.

```
# export CORE_PEER_BCCSP_DEFAULT=PKCS11

# export CORE_PEER_BCCSP_PKCS11_LABEL=<HSM Partition Label>

# export CORE_PEER_BCCSP_PKCS11_PIN=<Partition Password>

# export CORE_PEER_BCCSP_PKCS11_LIBRARY=<HSM PKCS11 Library>
```

Configure Orderer nodes

To configure BCCSP to use the Luna HSM for orderer nodes:

1. Change the orderer.yaml file and specify PKCS11 as the default in the BCCSP section as follows:

```
BCCSP:
  Default: PKCS11
  PKCS11:
    Library: /usr/safenet/lunaclient/lib/libCryptoki2_64.so
    Label: orderer.example.com
    Pin: userpin
    Hash: SHA2
    Security: 384
```

2. Alternatively, the PKCS11 values in the orderer.yaml file can be left blank and specified using environment variables or the values in the file can be overridden using these environment variables. The following environment variables can be used to change the configuration settings of the orderer.yaml BCCSP.

```
# export ORDERER_GENERAL_BCCSP_DEFAULT=PKCS11
# export ORDERER_GENERAL_BCCSP_PKCS11_LABEL=<HSM Partition Label>
# export ORDERER_GENERAL_BCCSP_PKCS11_PIN=<Partition Password>
# export ORDERER_GENERAL_BCCSP_PKCS11_LIBRARY=<HSM PKCS11 Library>
```

3. You have completed the integration and all the required components are installed on the platform(s) on which you'll be developing Blockchain applications and/or operating Hyperledger Fabric. All key materials have been generated on a Thales Luna HSM using the PKCS11 BCCSP. You have configured the core.yaml file and the orderer.yaml file to use the PKCS11 BCCSP and mounted them as a volume in Peer and Orderer configuration files.
4. Now start Fabric CA, Orderer and Peers to create channel artifacts and run the channel. Join the nodes in the channel to create permissioned Blockchain network. This is achieved by assigning identity certificates to the member orgs and their nodes which will be used to identify themselves and conduct transactions in the network. A library of X509 certificates (commonly termed as cryptographic material) gets created for associated Peer/Orderer nodes using the PKCS11 BCCSP which in turn generates all key pairs on the Thales Luna HSM.

> **NOTE:** Ensure to specify the required environment variable to use PKCS11 BCCSP in the script that is required to be executed for creating the Blockchain.

Build Your First Network (BYFN) using Luna HSM

To build your first network using a Luna HSM:

1. Open ~/.fabric-ca-client/fabric-ca-client-config.yaml file and change the bccsp section to:

```
bccsp:
    default: PKCS11
    sw:
        hash: SHA2
```

```
        security: 256
        filekeystore:
            keystore: msp/keystore
    pkcs11:
        hash: SHA2
        security: 384
        library: /usr/safenet/lunaclient/lib/libCryptoki2_64.so
        label:
        pin:
```

2. Add a keyrequest setting to the csr section of ~/.fabric-ca-client/fabric-ca-client-config.yaml file to specify the key size as follows:

```
csr:
  cn:
  keyrequest:
    algo: ecdsa
    size: 384
```

```
Go to first-network directory
# cd $GOPATH/src/github.com/hyperledger/fabric-samples/first-network
```

3. Copy the below script and save it as gencerts.sh to generate crypto material on Thales Luna HSM. It works in conjunction with the cryptogen tool. The script generates all of the Peer, Orderer and Admin User MSPs using "fabric-ca-client gencsr" and certificates are generated using openssl and the CAs that come from cryptogen.

```
#!/bin/bash
#############################################################################
# This script generates certificates and keys to work with the cryptogen util
# to be used with the hyperledger fabric BYFN example.
# This allows the keys for the certificate to be generated with the
# PKCS11 BCCSP which in turn allows keys to be generated in an HSM.
#############################################################################



CA_CLIENT=./bin/fabric-ca-client
CRYPTO_CONFIG=$PWD/crypto-config
ROOT=$PWD
BCCSP_DEFAULT=PKCS11
PIN=userpin
```

```
check_error() {
  if [ $? -ne 0 ]; then
    echo "ERROR: Something went wrong!"
    exit 1
  fi
}



signcsr() {
  MSP=$1
  CN=$2
  CA_DIR=$3
  CA_NAME=$4
  CA_CERT=$(find $CA_DIR -name "*.pem")
  CA_KEY=$(find $CA_DIR -name "*_sk")
  CSR=$MSP/signcerts/$CN.csr
  CERT=$MSP/signcerts/$CN-cert.pem
  openssl x509 -req -sha256 -days 3650 -in $CSR -CA $CA_CERT -CAkey $CA_KEY -
CAcreateserial -out $CERT
  check_error
}



genmsp() {
  ORG_DIR=$1
  ORG_NAME=$2
  NODE_DIR=$3
  NODE_NAME=$4
  NODE_OU=$6
  CN=${NODE_NAME}${ORG_NAME}
  CA_PATH=$CRYPTO_CONFIG/$ORG_DIR/$ORG_NAME
  NODE_PATH=$CA_PATH/$NODE_DIR/$CN
  MSP=$NODE_PATH/msp
  TLS=$NODE_PATH/tls
  LABEL=$5
```

```
  rm -rf $MSP/keystore/*
  rm -rf $MSP/signcerts/*
  echo $LABEL
  export FABRIC_CA_CLIENT_BCCSP_DEFAULT=$BCCSP_DEFAULT
  export FABRIC_CA_CLIENT_BCCSP_PKCS11_LABEL=$LABEL
  export FABRIC_CA_CLIENT_BCCSP_PKCS11_PIN=$PIN
  $CA_CLIENT gencsr --csr.cn $CN --mspdir $MSP --csr.names
"C=US,ST=California,L=San Francisco,OU=$NODE_OU"
  check_error
  signcsr $MSP $CN $CA_PATH/ca $ORG_NAME
 }

copy_admin_cert_node() {
  ORG_DIR=$1
  ORG_NAME=$2
  NODE_DIR=$3
  NODE_NAME=$4
  CN=$NODE_NAME.$ORG_NAME
  CA_PATH=$CRYPTO_CONFIG/$ORG_DIR/$ORG_NAME
  NODE_PATH=$CA_PATH/$NODE_DIR/$CN
  MSP=$NODE_PATH/msp
  ADMIN_CN=Admin@$ORG_NAME
  ADMIN_CERT=$CA_PATH/users/$ADMIN_CN/msp/signcerts/$ADMIN_CN-cert.pem
  cp $ADMIN_CERT $NODE_PATH/msp/admincerts
  check_error
 }


copy_admin_cert_ca() {
  ORG_DIR=$1
  ORG_NAME=$2
  CA_PATH=$CRYPTO_CONFIG/$ORG_DIR/$ORG_NAME
  ADMIN_CN=Admin@$ORG_NAME
  ADMIN_CERT=$CA_PATH/users/$ADMIN_CN/msp/signcerts/$ADMIN_CN-cert.pem
  cp $ADMIN_CERT $CA_PATH/msp/admincerts
```

```
  check_error
  cp $ADMIN_CERT $CA_PATH/users/$ADMIN_CN/msp/admincerts
  check_error
}



for org in 1 2; do
  for peer in 0 1; do
    genmsp peerOrganizations org${org}.example.com peers peer${peer}.
org${org}.example.com peer
  done
  genmsp peerOrganizations org${org}.example.com users Admin@
org${org}.example.com client
  for peer in 0 1; do
    copy_admin_cert_node peerOrganizations org${org}.example.com peers
peer${peer}
  done
  copy_admin_cert_ca peerOrganizations org${org}.example.com
done
genmsp ordererOrganizations example.com orderers orderer. orderer.example.com
orderer
genmsp ordererOrganizations example.com users Admin@ orderer.example.com client
copy_admin_cert_node ordererOrganizations example.com orderers orderer
orderer.example.com
copy_admin_cert_ca ordererOrganizations example.com
################################################################################
# End of generate.sh script
################################################################################
```

4. Copy $GOPATH/src/github.com/hyperledger/fabric/sampleconfig/orderer.yaml to $GOPATH/src/github.com/hyperledger/fabric-samples/first-network/orderer.yaml

   `# cp $GOPATH/src/github.com/hyperledger/fabric/sampleconfig/orderer.yaml $GOPATH/src/github.com/hyperledger/fabric-samples/first-network/orderer.yaml`

5. Copy $GOPATH/src/github.com/hyperledger/fabric/sampleconfig/core.yaml to $GOPATH/src/github.com/hyperledger/fabric-samples/first-network/core.yaml

   `# cp $GOPATH/src/github.com/hyperledger/fabric/sampleconfig/core.yaml $GOPATH/src/github.com/hyperledger/fabric-samples/first-network/core.yaml`

6. Open $GOPATH/src/github.com/hyperledger/fabric-sample/first-network/orderer.yaml and modify the bccsp section to:

```
BCCSP:
    Default: PKCS11
    PKCS11:
        Library:
        Label:
        Pin:
        Hash: SHA2
        Security: 384
```

7. Open $GOPATH/src/github.com/hyperledger/fabric-samples/first-network/core.yaml file and add or modify the bccsp and system section to:

```
BCCSP:
    Default: PKCS11
    PKCS11:
        Library:
        Label:
        Pin:
        Hash: SHA2
        Security: 384
            system:
                escc: enable
                vscc: enable
```

8. Open $GOPATH/src/github.com/hyperledger/fabric-samples/first-network/base/peer-base.yaml file and perform the following steps:

   i. Add or modify the following text in service peer-base:

```
image: fabric-peer-pkcs11:${IMAGE_TAG}
build:
  context: ..
  dockerfile: ../docker-files/Dockerfile.peer
  args:
    - IMAGE_TAG=${IMAGE_TAG}
```

ii. Add the following text in service peer-base:

```
      -
CORE_PEER_BCCSP_PKCS11_LIBRARY=/usr/safenet/lunaclient/lib/libCryptoki2_64.s
o
      - CORE_PEER_BCCSP_PKCS11_PIN=userpin
```

iii. Add volumes section in service peer-base:

```
volumes:
  - /usr/safenet/lunaclient:/usr/safenet/lunaclient
  - /etc/Chrystoki.conf:/etc/Chrystoki.conf
  - ../core.yaml:/etc/hyperledger/fabric/core.yaml
```

iv. In service orderer-base add or modify the following:

```
image: fabric-orderer-pkcs11:${IMAGE_TAG}
build:
  context: ..
  dockerfile: ../docker-files/Dockerfile.orderer
  args:
    - IMAGE_TAG=${IMAGE_TAG}
```

9. Open $GOPATH/src/github.com/hyperledger/fabric-samples/first-network/base/docker-compose-base.yaml file and perform the following tasks:

i. Add the following text in service orderer.example.com under the volume section:

```
  - /usr/safenet/lunaclient:/usr/safenet/lunaclient
  - /etc/Chrystoki.conf:/etc/Chrystoki.conf
  - ../orderer.yaml:/etc/hyperledger/fabric/orderer.yaml
```

ii. Add the environment section in service orderer.example.com:

```
   environment:
     - ORDERER_GENERAL_BCCSP_PKCS11_LABEL=orderer.example.com
     -
ORDERER_GENERAL_BCCSP_PKCS11_LIBRARY=/usr/safenet/lunaclient/lib/libCryptoki2_
64.so
     - ORDERER_GENERAL_BCCSP_PKCS11_PIN=userpin
```

iii. Add the following text in service peer0.org1.example.com, under the environment section:

```
- CORE_PEER_BCCSP_PKCS11_LABEL=org1.example.com
```

iv. Add the following text in service peer1.org1.example.com under the environment section:

```
- CORE_PEER_BCCSP_PKCS11_LABEL=org1.example.com
```

v. Add the following text in service peer0.org2.example.com under the environment section:

```
- CORE_PEER_BCCSP_PKCS11_LABEL=org2.example.com
```

vi. Add the following text in service peer1.org2.example.com, under the environment section:

```
- CORE_PEER_BCCSP_PKCS11_LABEL=org2.example.com
```

10. Open $GOPATH/src/github.com/hyperledger/fabric-samples/first-network/docker-compose-cli.yaml file and make the following changes in the cli section:

i. Add or modify the following text:

```
image: fabric-tools-pkcs11:${IMAGE_TAG}
build:
  context: .
  dockerfile: ../docker-files/Dockerfile.tools
  args:
       - IMAGE_TAG=${IMAGE_TAG}
```

ii. Add the following under the environment section:

```
-
CORE_PEER_BCCSP_PKCS11_LIBRARY=/usr/safenet/lunaclient/lib/libCryptoki2_64.s
o
- CORE_PEER_BCCSP_PKCS11_PIN=userpin
```

iii. Add the following under the volumes section:

```
- /usr/safenet/lunaclient:/usr/safenet/lunaclient
- /etc/Chrystoki.conf:/etc/Chrystoki.conf
- ./core.yaml:/etc/hyperledger/fabric/core.yaml
```

11. Open $GOPATH/src/github.com/hyperledger/fabric-samples/first-network/scripts/utils.sh file and make the following changes to the setGlobals function:

i. After “if [$ORG -eq 1]” line add the following code:

```
export CORE_PEER_BCCSP_PKCS11_LABEL=org1.example.com
```

ii. After “elif [$ORG -eq 2]” line add the following code:

```
export CORE_PEER_BCCSP_PKCS11_LABEL=org2.example.com
```

12. Create a directory $GOPATH/src/github.com/hyperledger/fabric-samples/docker-files as follows:

```
# mkdir $GOPATH/src/github.com/hyperledger/fabric-samples/docker-files
```

13. Create a file $GOPATH/src/github.com/hyperledger/fabric-samples/docker-files/Dockerfile.orderer and add the following code:

```
ARG IMAGE_TAG
FROM hyperledger/fabric-orderer:$IMAGE_TAG
RUN apt-get update && apt-get install -y libtool
COPY ./bin/orderer /usr/local/bin
```

14. Create a file $GOPATH/src/github.com/hyperledger/fabric-samples/docker-files/Dockerfile.peer and add the following code:

```
ARG IMAGE_TAG

FROM hyperledger/fabric-peer:$IMAGE_TAG

RUN apt-get update && apt-get install -y libtool

COPY ./bin/peer /usr/local/bin
```

15. Create a file $GOPATH/src/github.com/hyperledger/fabric-samples/docker-files/Dockerfile.tools and add the following code:

```
ARG IMAGE_TAG

FROM hyperledger/fabric-tools:$IMAGE_TAG

RUN apt-get update && apt-get install -y libtool

COPY ./bin/peer /usr/local/bin

COPY ./bin/fabric-ca-client /usr/local/bin
```

16. Open the $GOPATH/src/github.com/hyperledger/fabric-samples/first-network/byfn.sh file and make the following changes:

    i. In function networkDown comment the following code:

    ```
    rm -rf channel-artifacts/*.block channel-artifacts/*.tx crypto-config
    ./org3-artifacts/crypto-config/ channel-artifacts/org3.json
    ```

    ii. Add ./gencerts.sh between replacePrivateKey and generateChannelArtifacts in main function after line no.599. For example:

    ```
    elif [ "${MODE}" == "generate" ]; then

      generateCerts

      replacePrivateKey

      ./gencerts.sh

      generateChannelArtifacts
    ```

17. Go to `$GOPATH/src/github.com/hyperledger`/fabric-samples/first-network directory:

```
# cd $GOPATH/src/github.com/hyperledger/fabric-samples/first-network
```

18. Generate the crypto material in the HSM partitions, create CSRs, and issue certificates.

```
# ./byfn.sh generate
```

19. Run the first-network example:

```
# ./byfn.sh up -i 1.4.8
```

20. Ensure that you see the following message upon successful completion of the above steps:

```
========= All GOOD, BYFN execution completed ===========


 _____   _   _   ____
| ____| | \ | | |  _ \
|  _|   |  \| | | | | |
| |___  | |\  | | |_| |
|_____| |_| \_| |____/
```

Integrating Luna Cloud HSM with Hyperledger Fabric

To integrate Thales Luna Cloud HSM with Hyperledger Fabric, you need to complete the following tasks:

> Generate CSR using fabric-ca-client and PKCS11 BCCSP for MSP directory

> Configure Peer Nodes

> Configure the Orderer Nodes

NOTE: Refer to Build Your First Network(BYFN) using Luna Cloud HSM service section below for an example of end to end integration of Hyperledger Fabric with Luna Cloud HSM.

Generate CSR using fabric-ca-client and PKCS11 BCCSP for MSP directory

The fabric-ca-client utility is used to generate certificate signing requests for Peers, Orderers, and Users in their respective MSP directories. The fabric-ca-client utility uses the BCCSP to generate crypto material. If the BCCSP is configured to use the PKCS#11 implementation of BCCSP, it can be used to generate keys on the Luna Cloud service. The fabric-ca-client BCCSP can be configured in the ~/.fabric-ca-client/fabric-ca-client-config.yaml file. This involves following steps:

> Configure BCCSP to use Luna Cloud HSM services PKCS#11 API

> Generate the cryptographic keys using the gencsr command

Configure BCCSP to use Luna Cloud HSM services PKCS#11 API

1. Modify the BCCSP section in ~/.fabric-ca-client/fabric-ca-client-config.yaml file:

NOTE: If the ~/.fabric-ca-client/fabric-ca-client-config.yaml file is not present, run the following command to generate it: `# fabric-ca-client gencsr`

```
bccsp:
    default: PKCS11
    sw:
        hash: SHA2
        security: 256
        filekeystore:
            keystore: msp/keystore
    pkcs11:
        hash: SHA2
        security: 384
        library:
/etc/hyperledger/fabric/dpod/org1.example.com/libs/64/libCryptoki2.so
        label: org1.example.com
        pin: userpin
```

```
            filekeystore:
                keystore: msp/keystore
```

2. Add a keyrequest setting to the csr section of ~/.fabric-ca-client/fabric-ca-client-config.yaml file to specify the key size as follows:

```
   csr:
     cn:
     keyrequest:
       algo: ecdsa
       size: 384
```

Generate the cryptographic keys using the gencsr command

To generate ECDSA private keys on the HSM using the PKCS#11 BCCSP and create a CSR in the msp/signcerts directory for the private key, you need to perform the following steps:

1. The PKCS11 values in the fabric-ca-client-config.yaml file can be left blank and specified using environment variables. Alternatively, the values in the file can be overridden using the following environment variables:

```
# export FABRIC_CA_CLIENT_BCCSP_DEFAULT=PKCS11
# export FABRIC_CA_CLIENT_BCCSP_PKCS11_LABEL=<HSM Partition Label>
# export FABRIC_CA_CLIENT_BCCSP_PKCS11_PIN=<Partition Password>
# export FABRIC_CA_CLIENT_BCCSP_PKCS11_LIBRARY=<HSM PKCS11 Library>
```

2. The command to generate CSR is as follows:

```
# ./fabric-ca-client gencsr [options]
```

Where options are:

```
--csr.cn string   The common name field of the certificate signing request.
--mspdir string         Membership Service Provider directory (default "msp").
--csr.names stringSlice      A list of comma-separated CSR names of the form
                             <name>=<value> (e.g. C=CA,OU=peer)
```

> **NOTE:** When generating a CSR request, ensure that you have exported the correct partition label and that the ChrystokiConfigurationPath environment variable points to the path of the correct Chrystoki.conf file. Ensure you specify the correct CN, MSP directory, Names, and OU (the OU should be either peer, orderer, or client) in the fabric-ca-client options.

3. To generate the key for orderer.example.com, execute the following command:

```
# ./fabric-ca-client gencsr --csr.cn orderer.example.com –mspdir
ordererOrganizations/orderer.example.com/orderers/orderer.example.com/msp
--csr.names "C=US,ST=California,L=San Francisco,OU=orderer"
```

4. Options and exported variables should be changed as per the requirement for generating the specific certificate signing request. Submit the CSR to your CA to obtain the signed certificate for the Peer/Orderer/User and place the signed certificate in their respective msp/signcerts directories.

5. To generate the CSR for the peer0 of org1.example.com, execute the following command:

```
# export FABRIC_CA_CLIENT_BCCSP_DEFAULT=PKCS11

# export FABRIC_CA_CLIENT_BCCSP_PKCS11_LABEL=org1.example.com

# export FABRIC_CA_CLIENT_BCCSP_PKCS11_PIN=userpin

# export
   ChrystokiConfigurationPath=/etc/hyperledger/fabric/dpod/org1.example.com
```

6. The following command generates the key pair for peer0.org1.example.com on the HSM service org1.example.com and creates the CSR ./crypto-config/peerOrganizations/org1.example.com/peers/peer0.org1.example.com/msp/signcerts/peer0.org1.example.com.csr.

```
# export

FABRIC_CA_CLIENT_BCCSP_PKCS11_LIBRARY=/etc/hyperledger/fabric/dpod/org1.example
.com/libs/64/libCryptoki2.so

# ./fabric-ca-client gencsr --csr.cn peer0.org1.example.com --mspdir ./crypto
config/peerOrganizations/org1.example.com/peers/peer0.org1.example.com/msp --
csr.names "C=US,ST=California,L=San Francisco,OU=peer"
```

7. Copy the CSR and send it to your CA to obtain a signed certificate and then place the certificate in same directory.

8. Similarly, to generate the certificate request for Admin User for org1:

```
# ./fabric-ca-client gencsr --csr.cn Admin@org1.example.com --mspdir ./crypto-
config/peerOrganizations/org1.example.com/users/Admin@org1.example.com/msp --
csr.names "C=US,ST=California,L=San Francisco,OU=client"
```

Configure Peer Nodes

To configure BCCSP to use Luna Cloud Service for peer nodes:

1. Change the core.yaml file and specify PKCS#11 as default in the BCSSP section as follows:

```
BCCSP:

  Default: PKCS11

  PKCS11:

    Library:
/etc/hyperledger/fabric/dpod/org1.example.com/libs/64/libCryptoki2.so

    Label: org1.example.com

    Pin: userpin

    Hash: SHA2

    Security: 384
```

2. Alternatively, the PKCS#11 values in the core.yaml file can be left blank and specified using environment variables. The following environment variables can be used to change the configuration settings of the core.yaml BCCSP.

```
# export CORE_PEER_BCCSP_DEFAULT=PKCS11

# export CORE_PEER_BCCSP_PKCS11_LABEL=<HSM Partition Label>
```

```
# export CORE_PEER_BCCSP_PKCS11_PIN=<Partition Password>

# export CORE_PEER_BCCSP_PKCS11_LIBRARY=<HSM PKCS11 Library>
```

3. Ensure that the Luna Cloud HSM client directory is available to the peer and correct partition is used. The ChrystokiConfigurationPath must point to the Luna Cloud HSM client directory where Chrystoki.conf is available.

```
# export ChrystokiConfigurationPath=<PATH of Chrystoki.conf>
```

Configure the Orderer Nodes

To configure BCCSP to use Luna Cloud Service for orderer nodes:

1. Change the orderer.yaml file and specify the PKCS11 to default in the BCCSP section as follows:

```
BCCSP:

  Default: PKCS11

  PKCS11:

    Library:
/etc/hyperledger/fabric/dpod/orderer.example.com/libs/64/libCryptoki2.so

    Label: orderer.example.com

    Pin: userpin

    Hash: SHA2

    Security: 384
```

2. Alternatively, the PKCS11 values in the orderer.yaml file can be left blank and specified using the following environment variables, or the values in the file can be overridden using these environment variables.

```
# export ORDERER_GENERAL_BCCSP_DEFAULT=PKCS11

# export ORDERER_GENERAL_BCCSP_PKCS11_LABEL=<HSM Partition Label>

# export ORDERER_GENERAL_BCCSP_PKCS11_PIN=<Partition Password>

# export ORDERER_GENERAL_BCCSP_PKCS11_LIBRARY=<HSM PKCS11 Library>
```

3. Ensure that the Luna Cloud HSM client directory is available to the Orderer and correct partition is used for that Orderer. The ChrystokiConfigurationPath must point to the Luna Cloud HSM client directory of the Orderer where Chrystoki.conf is available.

```
# export ChrystokiConfigurationPath=<PATH of Chrystoki.conf>
```

4. You have completed the integration and all the required components are installed on the platform(s) on which you will be developing Blockchain applications and/or operating Hyperledger Fabric. All key materials have been generated on the Luna Cloud service using the PKCS11 BCCSP. You have configured the core.yaml and the orderer.yaml to use the PKCS11 BCCSP. If you are deploying your nodes using docker compose, after building your own images you can update your docker compose files to mount the hsm library and configuration file inside the container using volumes.
5. Now start the Fabric CA, Orderer, and Peers to create channel artifacts and run the channel. Join the nodes in the channel to create a permissioned Blockchain network. This is achieved by assigning identity certificates to the member orgs and their nodes which will be used to identify themselves and conduct transactions in the network. A library of X509 certificates (commonly termed as cryptographic material) gets

created for the associated Peer/Orderer nodes using the PKCS11 BCCSP which in turn generates all key pairs on the Luna Cloud HSM.

> **NOTE:** Ensure you include the PKCS#11 BCCSP in the script that will be used to create the Blockchain. Failure to include the PKCS#11 BCCSP will result in the Blockchain not using the Luna Cloud service.

Build Your First Network (BYFN) using Luna Cloud HSM service

This section of the guide demonstrates creating the Blockchain network, invoking transactions, and querying the state of the Blockchain using a byfn example.

Build your first network using Luna Cloud HSM service

To build your first network using Luna Cloud HSM service:

1. Open ~/.fabric-ca-client/fabric-ca-client-config.yaml file and change the bccsp section to:

```
bccsp:
    default: PKCS11
    sw:
        hash: SHA2
        security: 256
        filekeystore:
            keystore: msp/keystore
    pkcs11:
        hash: SHA2
        security: 384
        library:
/etc/hyperledger/fabric/dpod/org1.example.com/libs/64/libCryptoki2.so
        label:
        pin:
```

2. Add a keyrequest setting to the csr section of ~/.fabric-ca-client/fabric-ca-client-config.yaml file to specify the key size as follows:

```
  csr:
    cn:
    keyrequest:
      algo: ecdsa
      size: 384
```

3. Go to first-network directory:

```
# cd $GOPATH/src/github.com/hyperledger/fabric-samples/first-network
```

4. Copy the following script and save it as gencerts.sh to generate crypto material on Thales Luna Cloud HSM. It works in conjunction with the cryptogen tool. The script generates all of the Peer, Orderer and Admin User MSPs using "fabric-ca-client gencsr" and certificates are generated using openssl and the CAs that come from cryptogen.

```
#!/bin/bash
#################################################################################
# This script generates certificates and keys to work with the cryptogen util
# to be used with the hyperledger fabric BYFN example.
# This allows the keys for the certificate to be generated with the
# PKCS11 BCCSP which in turn allows keys to be generated in an HSM.
#################################################################################

CA_CLIENT=./bin/fabric-ca-client
CRYPTO_CONFIG=$PWD/crypto-config
ROOT=$PWD
BCCSP_DEFAULT=PKCS11
PIN=userpin
check_error() {
  if [ $? -ne 0 ]; then
    echo "ERROR: Something went wrong!"
    exit 1
  fi
}

signcsr() {
  MSP=$1
  CN=$2
  CA_DIR=$3
  CA_NAME=$4
  CA_CERT=$(find $CA_DIR -name "*.pem")
  CA_KEY=$(find $CA_DIR -name "*_sk")
  CSR=$MSP/signcerts/$CN.csr
  CERT=$MSP/signcerts/$CN-cert.pem
  openssl x509 -req -sha256 -days 3650 -in $CSR -CA $CA_CERT -CAkey $CA_KEY -
CAcreateserial -out $CERT
  check_error
}

genmsp() {
```

```
  ORG_DIR=$1
  ORG_NAME=$2
  NODE_DIR=$3
  NODE_NAME=$4
  NODE_OU=$6
  CN=${NODE_NAME}${ORG_NAME}
  CA_PATH=$CRYPTO_CONFIG/$ORG_DIR/$ORG_NAME
  NODE_PATH=$CA_PATH/$NODE_DIR/$CN
  MSP=$NODE_PATH/msp
  TLS=$NODE_PATH/tls
  LABEL=$5
  rm -rf $MSP/keystore/*
  rm -rf $MSP/signcerts/*
  echo $LABEL
  export FABRIC_CA_CLIENT_BCCSP_DEFAULT=$BCCSP_DEFAULT
  export FABRIC_CA_CLIENT_BCCSP_PKCS11_LABEL=$LABEL
  export FABRIC_CA_CLIENT_BCCSP_PKCS11_PIN=$PIN
  export ChrystokiConfigurationPath=/etc/hyperledger/fabric/dpod/$LABEL
  export
FABRIC_CA_CLIENT_BCCSP_PKCS11_LIBRARY=/etc/hyperledger/fabric/dpod/$LABEL/libs/
64/libCryptoki2.so
  $CA_CLIENT gencsr --csr.cn $CN --mspdir $MSP --csr.names
"C=US,ST=California,L=San Francisco,OU=$NODE_OU"
  check_error
  signcsr $MSP $CN $CA_PATH/ca $ORG_NAME
 }


copy_admin_cert_node() {
  ORG_DIR=$1
  ORG_NAME=$2
  NODE_DIR=$3
  NODE_NAME=$4
  CN=$NODE_NAME.$ORG_NAME
  CA_PATH=$CRYPTO_CONFIG/$ORG_DIR/$ORG_NAME
  NODE_PATH=$CA_PATH/$NODE_DIR/$CN
```

```
  MSP=$NODE_PATH/msp
  ADMIN_CN=Admin@$ORG_NAME
  ADMIN_CERT=$CA_PATH/users/$ADMIN_CN/msp/signcerts/$ADMIN_CN-cert.pem
  cp $ADMIN_CERT $NODE_PATH/msp/admincerts
  check_error
 }

copy_admin_cert_ca() {
  ORG_DIR=$1
  ORG_NAME=$2
  CA_PATH=$CRYPTO_CONFIG/$ORG_DIR/$ORG_NAME
  ADMIN_CN=Admin@$ORG_NAME
  ADMIN_CERT=$CA_PATH/users/$ADMIN_CN/msp/signcerts/$ADMIN_CN-cert.pem
  cp $ADMIN_CERT $CA_PATH/msp/admincerts
  check_error
  cp $ADMIN_CERT $CA_PATH/users/$ADMIN_CN/msp/admincerts
  check_error
}

for org in 1 2; do
  for peer in 0 1; do
    genmsp peerOrganizations org${org}.example.com peers peer${peer}.
org${org}.example.com peer
  done
  genmsp peerOrganizations org${org}.example.com users Admin@
org${org}.example.com client
  for peer in 0 1; do
    copy_admin_cert_node peerOrganizations org${org}.example.com peers
peer${peer}
  done
  copy_admin_cert_ca peerOrganizations org${org}.example.com
done
genmsp ordererOrganizations example.com orderers orderer. orderer.example.com
orderer
genmsp ordererOrganizations example.com users Admin@ orderer.example.com client
```

```
copy_admin_cert_node ordererOrganizations example.com orderers orderer
orderer.example.com

copy_admin_cert_ca ordererOrganizations example.com

################################################################################

# End of generate.sh script

################################################################################
```

5. Copy the $GOPATH/src/github.com/hyperledger/fabric/sampleconfig/orderer.yaml file to $GOPATH/src/github.com/hyperledger/fabric-samples/first-network/orderer.yaml file:

```
# cp $GOPATH/src/github.com/hyperledger/fabric/sampleconfig/orderer.yaml
$GOPATH/src/github.com/hyperledger/fabric-samples/first-network/orderer.yaml
```

6. Copy the $GOPATH/src/github.com/hyperledger/fabric/sampleconfig/core.yaml file to $GOPATH/src/github.com/hyperledger/fabric-samples/first-network/core.yaml file:

```
# cp $GOPATH/src/github.com/hyperledger/fabric/sampleconfig/core.yaml
$GOPATH/src/github.com/hyperledger/fabric-samples/first-network/core.yaml
```

7. Open the $GOPATH/src/github.com/hyperledger/fabric-sample/first-network/orderer.yaml file and modify the bccsp section as follows:

```
BCCSP:
    Default: PKCS11
    PKCS11:
        Library:
        Label:
        Pin:
        Hash: SHA2
        Security: 384
```

8. Open the $GOPATH/src/github.com/hyperledger/fabric-samples/first-network/core.yaml file and add or modify the bccsp and system section to:

```
BCCSP:
    Default: PKCS11
    PKCS11:
        Library:
        Label:
        Pin:
        Hash: SHA2
        Security: 384
system:
    escc: enable
    vscc: enable
```

9. Open the $GOPATH/src/github.com/hyperledger/fabric-samples/first-network/base/peer-base.yaml file and make the following changes:

   i. In service peer-base, add or modify the following:

```
image: fabric-peer-pkcs11:${IMAGE_TAG}
build:
  context: ..
  dockerfile: ../docker-files/Dockerfile.peer
  args:
    - IMAGE_TAG=${IMAGE_TAG}
```

   ii. In service peer-base, add the following code under the environment section:

```
- CORE_PEER_BCCSP_PKCS11_PIN=userpin
```

   iii. In service peer-base, add a volumes section:

```
volumes:
  - ../core.yaml:/etc/hyperledger/fabric/core.yaml
```

   iv. In service orderer-base, add or modify the following code:

```
image: fabric-orderer-pkcs11:${IMAGE_TAG}
build:
  context: ..
  dockerfile: ../docker-files/Dockerfile.orderer
  args:
    - IMAGE_TAG=${IMAGE_TAG}
```

10. Open the $GOPATH/src/github.com/hyperledger/fabric-samples/first-network/base/docker-compose-base.yaml file and perform these steps:

   i. In service orderer.example.com, under volume section, add the following code:

```
- ../orderer.yaml:/etc/hyperledger/fabric/orderer.yaml
-
/etc/hyperledger/fabric/dpod/orderer.example.com:/etc/hyperledger/fabric/dpod/orderer.example.com
```

   ii. In service orderer.example.com, add an environment section:

```
environment:
      - ORDERER_GENERAL_BCCSP_PKCS11_LABEL=orderer.example.com
      -
ORDERER_GENERAL_BCCSP_PKCS11_LIBRARY=/etc/hyperledger/fabric/dpod/orderer.example.com/libs/64/libCryptoki2.so
      -
ChrystokiConfigurationPath=/etc/hyperledger/fabric/dpod/orderer.example.com
      - ORDERER_GENERAL_BCCSP_PKCS11_PIN=userpin
```

iii. In service peer0.org1.example.com, under the environment section, add:

```
- CORE_PEER_BCCSP_PKCS11_LABEL=org1.example.com
-
CORE_PEER_BCCSP_PKCS11_LIBRARY=/etc/hyperledger/fabric/dpod/org1.example.com
/libs/64/libCryptoki2.so
- ChrystokiConfigurationPath=/etc/hyperledger/fabric/dpod/org1.example.com
```

iv. In service peer0.org1.example.com, under the volumes section, add:

```
-
/etc/hyperledger/fabric/dpod/org1.example.com:/etc/hyperledger/fabric/dpod/o
rg1.example.com
```

v. In service peer1.org1.example.com, under environment section, add:

```
- CORE_PEER_BCCSP_PKCS11_LABEL=org1.example.com
-
CORE_PEER_BCCSP_PKCS11_LIBRARY=/etc/hyperledger/fabric/dpod/org1.example.com
/libs/64/libCryptoki2.so
- ChrystokiConfigurationPath=/etc/hyperledger/fabric/dpod/org1.example.com
```

vi. In service peer1.org1.example.com, under volumes section, add:

```
-
/etc/hyperledger/fabric/dpod/org1.example.com:/etc/hyperledger/fabric/dpod/o
rg1.example.com
```

vii. In service peer0.org2.example.com, under environment section, add:

```
- CORE_PEER_BCCSP_PKCS11_LABEL=org2.example.com
-
CORE_PEER_BCCSP_PKCS11_LIBRARY=/etc/hyperledger/fabric/dpod/org2.example.com
/libs/64/libCryptoki2.so
- ChrystokiConfigurationPath=/etc/hyperledger/fabric/dpod/org2.example.com
```

viii. In service peer0.org2.example.com, under volumes section, add:

```
-
/etc/hyperledger/fabric/dpod/org2.example.com:/etc/hyperledger/fabric/dpod/o
rg2.example.com
```

ix. In service peer1.org2.example.com, under environment section, add:

```
- CORE_PEER_BCCSP_PKCS11_LABEL=org2.example.com
-
CORE_PEER_BCCSP_PKCS11_LIBRARY=/etc/hyperledger/fabric/dpod/org2.example.com
/libs/64/libCryptoki2.so
- ChrystokiConfigurationPath=/etc/hyperledger/fabric/dpod/org2.example.com
```

x. In service peer1.org2.example.com, under volumes section, add:

```
-
/etc/hyperledger/fabric/dpod/org2.example.com:/etc/hyperledger/fabric/dpod/o
rg2.example.com
```

11. Open the $GOPATH/src/github.com/hyperledger/fabric-samples/first-network/docker-compose-cli.yaml file and make the following changes in the cli section:

    i. Add or modify the following code:

```
image: fabric-tools-pkcs11:${IMAGE_TAG}
build:
  context: .
  dockerfile: ../docker-files/Dockerfile.tools
  args:
    - IMAGE_TAG=${IMAGE_TAG}
```

    ii. Add the following code under the environment section:

```
- CORE_PEER_BCCSP_PKCS11_PIN=userpin
```

    iii. Add the following code under the volumes section:

```
- /etc/hyperledger/fabric/dpod:/etc/hyperledger/fabric/dpod
- ./core.yaml:/etc/hyperledger/fabric/core.yaml
```

12. Open the $GOPATH/src/github.com/hyperledger/fabric-samples/first-network/scripts/utils.sh file and make the following changes to the setGlobals function:

    i. After “if [$ORG -eq 1]” line, add the following code:

```
export CORE_PEER_BCCSP_PKCS11_LABEL=org1.example.com
export CORE_PEER_BCCSP_PKCS11_LIBRARY=/etc/hyperledger/fabric/dpod/org1.example.com/libs/64/libCryptoki2.so
export ChrystokiConfigurationPath=/etc/hyperledger/fabric/dpod/org1.example.com
```

    ii. After “elif [$ORG -eq 2]” line, add the following code:

```
export CORE_PEER_BCCSP_PKCS11_LABEL=org2.example.com
export CORE_PEER_BCCSP_PKCS11_LIBRARY=/etc/hyperledger/fabric/dpod/org2.example.com/libs/64/libCryptoki2.so
export ChrystokiConfigurationPath=/etc/hyperledger/fabric/dpod/org2.example.com
```

13. Create a directory $GOPATH/src/github.com/hyperledger/fabric-samples/docker-files:

```
# mkdir $GOPATH/src/github.com/hyperledger/fabric-samples/docker-files
```

14. Create a file $GOPATH/src/github.com/hyperledger/fabric-samples/docker-files/Dockerfile.orderer and add the following code:

```
ARG IMAGE_TAG
FROM hyperledger/fabric-orderer:$IMAGE_TAG
RUN apt-get update && apt-get install -y libtool
COPY ./bin/orderer /usr/local/bin
```

15. Create a file $GOPATH/src/github.com/hyperledger/fabric-samples/docker-files/Dockerfile.peer and add the following code:

```
ARG IMAGE_TAG

FROM hyperledger/fabric-peer:$IMAGE_TAG

RUN apt-get update && apt-get install -y libtool

COPY ./bin/peer /usr/local/bin
```

16. Create a file $GOPATH/src/github.com/hyperledger/fabric-samples/docker-files/Dockerfile.tools and add the following code:

```
ARG IMAGE_TAG

FROM hyperledger/fabric-tools:$IMAGE_TAG

RUN apt-get update && apt-get install -y libtool

COPY ./bin/peer /usr/local/bin

COPY ./bin/fabric-ca-client /usr/local/bin
```

17. Open the $GOPATH/src/github.com/hyperledger/fabric-samples/first-network/byfn.sh file and make the following changes:

    i. Comment the following line in function networkDown:

    ```
    rm -rf channel-artifacts/*.block channel-artifacts/*.tx crypto-config
    ./org3-artifacts/crypto-config/ channel-artifacts/org3.json
    ```

    ii. Add ./gencerts.sh between replacePrivateKey and generateChannelArtifacts in main function after line no.599. For example:

    ```
    elif [ "${MODE}" == "generate" ]; then

      generateCerts

      replacePrivateKey

      ./gencerts.sh

      generateChannelArtifacts
    ```

18. Go to `$GOPATH/src/github.com/hyperledger`/fabric-samples/first-network directory:

```
# cd $GOPATH/src/github.com/hyperledger/fabric-samples/first-network
```

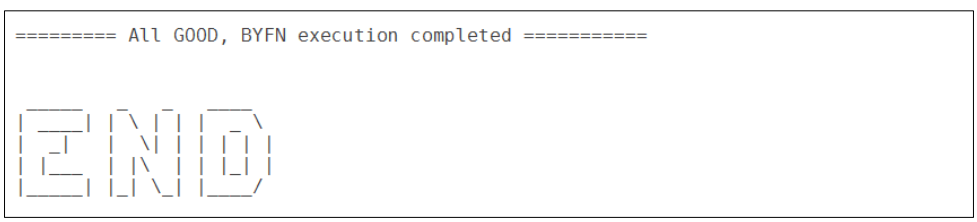
19. Generate the crypto material in the HSM partitions, create CSRs, and issue certificates:

```
# ./byfn.sh generate
```

20. Run the first-network example:

```
# ./byfn.sh up -i 1.4.8
```

Upon successful completion of the above steps, the following message will appear on your screen:



Integrating Luna HSM or Luna Cloud HSM with Hyperledger Fabric Client

To integrate Luna HSM or Luna Cloud HSM with Hyperledger Fabric Client, you need to perform the following tasks:

> Integrate Hyperledger Fabric Client SDK for Node.js with Luna HSM or Luna Cloud HSM

> Integrate Hyperledger Fabric Client SDK for Java with a Luna HSM or Luna Cloud HSM

Integrate Hyperledger Fabric Client SDK for Node.js with Luna HSM or Luna Cloud HSM

The Hyperledger Fabric Client (HFC) SDK for Node.js provides a powerful and easy to use API to interact with a Hyperledger Fabric Blockchain. The HFC is designed to be used in the Node.js JavaScript runtime. To generate the keys on the Thales Luna HSM or Luna Cloud service and run end-2-end execution, complete the following steps:

1. Install the nodejs and npm using Linux package manager.
2. Add the fabric-ca-client and configtxgen binaries in the path.

   ```
   # export PATH=/opt/gopath/src/github.com/hyperledger/fabric-ca/bin:/opt/gopath/src/github.com/hyperledger/fabric/release/linux-amd64/bin:$PATH
   ```

3. Check out the fabric-sdk-node source code.

   ```
   # cd $GOPATH/src/github.com/hyperledger
   # git clone https://gerrit.hyperledger.org/r/fabric-sdk-node
   # cd fabric-sdk-node
   # git checkout -b v1.4.0 v1.4.0
   # cd ..
   ```

   NOTE: The instructions were developed against the tag v1.4.0 for Hyperledger Fabric and Hyperledger Fabric Client SDK. It is advisable to use the repo checkout from these tags as the instructions may not be compatible with the latest check-in in the master branch of Fabric and Client SDK.

4. Check out the Fabric SDK HSM Integration repo.

   ```
   # git clone https://github.com/gemalto/fabric-sdk-hsm
   ```

5. Generate the fabric-ca-client default configuration file.

   ```
   # fabric-ca-client gencsr
   ```

6. Modify the bccsp section in ~/.fabric-ca-client/fabric-ca-client-config.yaml to add PKCS11 as default bccsp.

   ```
   bccsp:
       default: PKCS11
       pkcs11:
           hash: SHA2
   ```

```
security: 256
library: /usr/safenet/lunaclient/lib/libCryptoki2_64.so
label:
pin:
filekeystore:
    keystore: msp/keystore
```

NOTE: Use spaces not tabs and pay attention to the indentation. Ensure that the library path points to the correct Thales Cryptoki library.

7. Run the helper script to generate private keys in the HSM, create CSRs for the Peer and Orderer Admin users, and create certificates.

   ```
   # PKCS11_LABEL=fabric-sdk PKCS11_PIN=userpin ./fabric-sdk-hsm/node/genAdminPkcs11Node.sh
   ```

   Where `fabric-sdk` is the partition label and `userpin` is partition CO password. The helper script executes configtxgen and generates the genesis block with new certificates.

8. Copy the required javascript files from fabric-sdk-hsm to fabric-sdk-node.

   ```
   # cp fabric-sdk-hsm/node/e2eHSM.js fabric-sdk-node/test/integration/
   # cp fabric-sdk-hsm/node/utilHSM.js fabric-sdk-node/test/unit/
   ```

9. Install gulp and the required dependencies.

   ```
   # cd fabric-sdk-node
   # sudo npm install -g gulp
   # npm install
   # gulp ca
   ```

10. Open a new terminal in the fabric-sdk-node directory and start the fabric docker containers.

    ```
    # cd test/fixtures
    # export DOCKER_IMG_TAG=:1.4.0
    # docker-compose up
    ```

11. In the previous terminal, configure the constant values for the slot and partition password if required in the test/unit/utilHSM.js file.

    ```
    const PKCS11_LIB = '/usr/safenet/lunaclient/lib/libCryptoki2_64.so';
    const PKCS11_SLOT = 0;
    const PKCS11_PIN = 'userpin';
    const PKCS11_USER_TYPE = 1;
    ```

NOTE: Ensure that the PKCS11_LIB path points to the correct Thales Cryptoki library when using Thales Luna HSM or Luna Cloud Service.

12. Run the end-2-end HSM integration test.

```
# node test/integration/e2eHSM.js
```

Once the test is completed successfully, you will see the following snippet:

```
***** TransientMap Support in Proposals *****
ok 207 Successfully retrieved TLS certificate
ok 208 Successfully loaded member from persistence
ok 209 Successfully enrolled user 'admin' (e2eUtil 4)
ok 210 Checking the result has the transientMap value returned by the chaincode
ok 211 Checking the result has the transientMap value returned by the chaincode
ok 212 Successfully verified transient map values
1..212
# tests 212
# pass  212
# ok
```

13. To clean up the docker containers in the docker-compose terminal, press CTRL-C and run the following commands:

```
# docker rm -f $(docker ps -aq)
# docker-compose up
```

14. Perform step 12 to execute end-2-end HSM integration test again.

Integrate Hyperledger Fabric Client SDK for Java with a Luna HSM or Luna Cloud HSM

The Hyperledger Fabric Client (HFC) SDK for Java provides a powerful and easy to use API to interact with a Hyperledger Fabric Blockchain. The SDK facilitates Java applications to manage the lifecycle of Hyperledger channels and user chaincode. The SDK also provides a means to execute user chaincode, query blocks, and transactions on the channel, and to monitor events on the channel.

Integrate Hyperledger Fabric Client SDK Java

1. Install java and maven using Linux package manager.
2. Add the fabric-ca-client and configtxgen binaries in the path.

```
# export PATH=/opt/gopath/src/github.com/hyperledger/fabric-ca/bin:/opt/gopath/src/github.com/hyperledger/fabric/release/linux-amd64/bin:$PATH
```

3. Copy the LunaProvider.jar and libLunaAPI.so in the <Java installation path>/jre/lib/ext directory.

```
# cp /usr/safenet/lunaclient/jsp/lib/LunaProvider.jar /usr/lib/jvm/java-1.8.0-openjdk-1.8.0.201.b09-2.el7_6.x86_64/jre/lib/ext
# cp /usr/safenet/lunaclient/jsp/lib/libLunaAPI.so /usr/lib/jvm/java-1.8.0-openjdk-1.8.0.201.b09-2.el7_6.x86_64/jre/lib/ext
```

> **NOTE:** LunaProvider.jar and libLunaAPI.so for Luna Cloud are available at <Luna Cloud HSM Installation Directory>/jsp/LunaProvider.jar and <Luna Cloud HSM Installation Directory>/jsp/64/ libLunaAPI.so.

4. Checkout the fabric-sdk-java source code.

```
# git clone https://gerrit.hyperledger.org/r/fabric-sdk-java
# cd fabric-sdk-java
# git checkout -b v1.4.0 v1.4.0
# cd ..
```

> **NOTE:** The instructions were developed against the tag v1.4.0 for Hyperledger Fabric and Hyperledger Fabric Client SDK. It is advisable to use the repo checkout from these tags as the instructions may not be compatible with the latest check-in in the master branch of Fabric and Fabric Client SDK.

5. Checkout the Fabric SDK HSM Integration repo.

```
# git clone https://github.com/gemalto/fabric-sdk-hsm
```

6. Generate the fabric-ca-client default configuration file.

```
# fabric-ca-client gencsr
```

7. Modify the bccsp section in ~/.fabric-ca-client/fabric-ca-client-config.yaml to add PKCS11 as the default bccsp.

```
bccsp:
    default: PKCS11
    pkcs11:
        hash: SHA2
        security: 256
        library: /usr/safenet/lunaclient/lib/libCryptoki2_64.so
        label:
        pin:
        filekeystore:
            keystore: msp/keystore
```

> **NOTE:** Use spaces not tabs and pay attention to the indentation. Ensure that the library path points to the correct Thales Cryptoki library when using Thales Luna HSM or Luna Cloud Service.

8. Run the helper script to generate private keys in the HSM, create CSRs for the Peer and Orderer Admin users, and create certificates.

```
# PKCS11_LABEL=fabric-sdk PKCS11_PIN=userpin ./fabric-sdk-
hsm/java/genAdminPkcs11Java.sh
```

> **NOTE:** Where “fabric-sdk” is partition label and “userpin” is partition CO password. The helper script executes configtxgen and generates the genesis block with new certificates.

9. Copy the required java files from fabric-sdk-hsm to fabric-sdk-java.

```
# cp fabric-sdk-hsm/java/End2endHSMIT.java fabric-sdk-java/src/test/java/org/hyperledger/fabric/sdkintegration/

# cp fabric-sdk-hsm/java/SampleHSMStore.java fabric-sdk-java/src/test/java/org/hyperledger/fabric/sdkintegration/
```

10. Open a new terminal and navigate to the fabric-sdk-java directory. Start the fabric docker containers by executing the following commands.

```
# cd ./fabric-sdk-java/src/test/fixture/sdkintegration

# export DOCKER_IMG_TAG=:1.4.0

# docker-compose up
```

11. In the previous terminal, go to the fabric-sdk-java/src/test/java/org/hyperledger/fabric/sdkintegration/End2endHSMIT.java file and configure the constant values for the slot and partition password if needed. Use the following values:

```
private static final String TOKEN_LABEL = "fabric-sdk";

private static final String PARTITION_PASSWORD = "userpin";
```

> **NOTE:** In this context, “fabric-sdk” refers to the partition label and “userpin” refers to the partition CO password.

12. Run the end-to-end HSM integration test.

```
# cd fabric-sdk-java

# mvn failsafe:integration-test -Dtest=End2endHSMIT test
```

The following snippet will appear on your screen when test gets completed successfully:

```
-------------------------------------------------------------------------
That's all folks!

Tests run: 1, Failures: 0, Errors: 0, Skipped: 0, Time elapsed: 40.431 sec - in org.hyperledger.fabric.sdkintegration.End2endHSMIT

Results :

Tests run: 1, Failures: 0, Errors: 0, Skipped: 0

[INFO]

[INFO] --- jacoco-maven-plugin:0.7.9:report (post-unit-test) @ fabric-sdk-java ---

[INFO] Loading execution data file /opt/gopath/src/github.com/hyperledger/fabric-sdk-java/target/coverage-reports/jacoco-ut.exec

[INFO] Analyzed bundle 'fabric-java-sdk' with 231 classes

[INFO] ------------------------------------------------------------------------

[INFO] BUILD SUCCESS

[INFO] ------------------------------------------------------------------------

[INFO] Total time: 1:42.468s
```

```
[INFO] Finished at: Mon Apr 08 13:04:06 IST 2019
[INFO] Final Memory: 30M/188M
[INFO] ------------------------------------------------------------------------
```

13. To clean up the docker containers in the docker-compose terminal, press CTRL-C and run the following commands.

```
# docker rm -f $(docker ps -aq)
# docker-compose up
```

14. Perform step 12 to execute end-to-end HSM integration test again.

    This completes the integration of Luna HSM or Luna Cloud HSM with Hyperledger Fabric Client.

Integrating Thales Luna HSM with Hyperledger Fabric 2.4 on Alpine Linux

In Hyperledger Fabric version 2.4, the Docker images have been updated to use Alpine Linux, which is a lightweight and secure Linux distribution. This change brings several benefits, such as smaller image sizes, faster downloads, quicker startup times, and reduced disk space usage on your system. To integrate Thales Luna HSM with Hyperledger Fabric 2.4, follow these steps:

1. Install the necessary libraries for Hyperledger Fabric 2.4 on Alpine Linux. Use the command below:

```
# apk add --no-cache docker docker-compose go git make curl alien python3 py3-pip libltdl jq build-base bash libc6-compat gcompat
```

2. Ensure that the docker service is running by executing the below command:

```
# service docker start
# service docker status
```

3. Download the Universal Client Minimal Client Package for Alpine Linux and perform the following steps:

```
# mkdir -p /usr/local/lunaclient
# tar xvf LunaClient-Minimal-10.3.0-277.alpinelinux3.13.5.tar --strip 1 -C /usr/local/lunaclient
```

> **NOTE:** The file name for Universal Client 10.3.0 Minimal Client for Alpine Linux 3.13.5 x86_64 is **LunaClient-Minimal-10.3.0-277.alpinelinux3.13.5.tar**. The package is designed to be used with Luna Network HSM 7.

4. Create a working directory:

```
# mkdir -p $HOME/go/src/github.com/hyperledger
# cd $HOME/go/src/github.com/hyperledger
```

5. Clone the Hyperledger Fabric repository and switch to 2.4.7 branch using the following commands:

```
# git clone https://github.com/hyperledger/fabric.git
# cd $HOME/go/src/github.com/hyperledger/fabric
# git checkout -b tag_v2.4.7 v2.4.7
```

NOTE: The instructions were developed for the Hyperledger Fabric release-2.4.7 tag. It is recommended to use the repository checkout from these tags as the instructions may not be compatible with the latest changes in the master branch of Fabric.

6. Build docker images and compile peer and orderer binaries:

```
# make GO_TAGS=pkcs11 docker peer orderer
```

```
# cd $HOME/go/src/github.com/hyperledger
```

7. Clone the Hyperledger Fabric samples repository:

```
# git clone https://github.com/hyperledger/fabric-samples.git
```

8. Download the install script and install Fabric binaries:

```
# curl -sSLO
https://raw.githubusercontent.com/hyperledger/fabric/main/scripts/install-
fabric.sh && chmod +x install-fabric.sh
```

```
# ./install-fabric.sh --fabric-version 2.4.7 binaries
```

9. Copy the sample config from Fabric repository to fabric-samples repository:

```
# cp -r $HOME/go/src/github.com/hyperledger/fabric/sampleconfig/
$HOME/go/src/github.com/hyperledger/fabric-samples/config
```

10. Copy the compiled peer and orderer binaries from the Fabric repository to fabric-samples repository:

```
# cp $HOME/go/src/github.com/hyperledger/fabric/build/bin/peer
$HOME/go/src/github.com/hyperledger/fabric-samples/bin/
```

```
# cp $HOME/go/src/github.com/hyperledger/fabric/build/bin/orderer
$HOME/go/src/github.com/hyperledger/fabric-samples/bin/
```

11. Clone the fabric-ca repository, build the fabric-ca-client, and copy the fabric-ca-client binary to the fabric-samples repository:

```
# git clone https://github.com/hyperledger/fabric-ca.git
```

```
# cd $HOME/go/src/github.com/hyperledger/fabric-ca
```

```
# make fabric-ca-client
```

```
# cp $HOME/go/src/github.com/hyperledger/fabric-ca/bin/fabric-ca-client
$HOME/go/src/github.com/hyperledger/fabric-samples/bin/
```

12. Create a directory to store the Chrystoki.conf files and NTLS certs/keys:

```
# cd $HOME/go/src/github.com/hyperledger/fabric-samples/test-network
```

```
# mkdir -p luna/org1
```

NOTE: The location of Chrystoki.conf for Universal Client 10.3.0 Minimal Client for Alpine Linux is /usr/local/lunaclient/conf/Chrystoki.conf.

13. Copy the Chrystoki.conf file for org1 to the designated directory:

```
# cp /usr/local/lunaclient/conf/Chrystoki.conf luna/org1
```

14. Open the copied Chrystoki.conf inside the luna/org1 directory in previous step and modify the LunaSA Client section for org1 as follows:

```
LunaSA Client = {
ReceiveTimeout = 20000;
SSLConfigFile = /usr/local/lunaclient/bin/openssl.cnf;
ClientPrivKeyFile = ./luna/org1/org1Key.pem;
ClientCertFile = ./luna/org1/org1.pem;
ServerCAFile = ./luna/org1/server.pem;
NetClient = 1;
TCPKeepAlive = 1;
ServerName00 = ;
ServerPort00 = ;
ServerHtl00 = ;
}
```

15. Generate the client certificate and client private key for org1 and copy the generated client certificate to Luna HSM for client registration.

```
# export ChrystokiConfigurationPath=luna/org1
# /usr/local/lunaclient/bin/vtl createCert -n org1
```

16. Copy the certificate file server.pem from the Luna HSM and then run:

```
# /usr/local/lunaclient/bin/vtl addServer -n <Network_HSM_hostname/IP> -c
server.pem
```

17. Create a partition named **org1.example.com** in the Luna HSM, register the client and initialize the partition along with the CO and CU roles accordingly.

18. Make sure that the Luna partition is visible by running the lunacm utility.

```
localhost:~/go/src/github.com/hyperledger/fabric-samples/test-network#
/usr/local/lunaclient/bin/lunacm
lunacm (64-bit) v10.3.0-277. Copyright (c) 2021 SafeNet. All rights reserved.


        Available HSMs:


        Slot Id ->              0
        Label ->                org1.example.com
        Serial Number ->        1280780175902
        Model ->                LunaSA 7.7.1
        Firmware Version ->     7.7.2
        Bootloader Version ->   1.1.2
```

```
        Configuration ->        Luna User Partition With SO (PW) Key Export
                                With Cloning Mode
        Slot Description ->     Net Token Slot
        FM HW Status ->         Non-FM

        Current Slot Id: 0

lunacm:>
```

19. Repeat the Steps 12-18 for org2/**org2.example.com** and orderer/**orderer.example.com**.

> **NOTE:** Ensure that you use separate partitions for all Peers, Orderers, and Users. For this example make sure to initialize all partitions with the labels provided above to successfully bring up the Fabric network. Set the partition password as per your organization's security policy for a production environment.

20. Modify the **createOrg1** function in the file $HOME/go/src/github.com/hyperledger/fabric-samples/test-network/organizations/fabric-ca/registerEnroll.sh as follows:

    i. After the line containing `export FABRIC_CA_CLIENT_HOME=${PWD}/organizations/peerOrganizations/org2.example.com/`, add the following lines:

    ```
    export ChrystokiConfigurationPath=luna/org1
    export FABRIC_CA_CLIENT_BCCSP_DEFAULT=PKCS11
    export FABRIC_CA_CLIENT_BCCSP_PKCS11_LABEL=org1.example.com
    export FABRIC_CA_CLIENT_BCCSP_PKCS11_PIN=<Partition Password>
    export FABRIC_CA_CLIENT_BCCSP_PKCS11_LIBRARY=<HSM PKCS11 Library>
    fabric-ca-client gencsr -u https://admin:adminpw@localhost:7054
    sed -i 's/bccsp:/bccsp:\n    pkcs11:\n        hash: SHA2\n        security: 384\n        library:\n        label:\n        pin:\n/' ${FABRIC_CA_CLIENT_HOME}/fabric-ca-client-config.yaml
    sed -i 's/size: 256/size: 384/' ${FABRIC_CA_CLIENT_HOME}/fabric-ca-client-config.yaml
    ```

    ii. After the line containing `infoln "Generating the peer0-tls certificates, use --csr.hosts to specify Subject Alternative Names"`, add the following line:

    ```
    export FABRIC_CA_CLIENT_BCCSP_DEFAULT=SW
    ```

    iii. After the line containing `infoln "Generating the user msp"`, add the following line:

    ```
    export FABRIC_CA_CLIENT_BCCSP_DEFAULT=PKCS11
    ```

21. Repeat the above modifications for **createOrg2** and **createOrderer** functions.

22. Copy the HSM PKCS11 library to a new directory, which will be used by the docker containers.

```
# cd $HOME/go/src/github.com/hyperledger/fabric-samples/test-network

# mkdir docker

# cp <HSM PKCS11 Library> ./docker
```

23. Create a Dockerfile Dockerfile.peer inside the docker directory created in the previous step and add the following contents to it for creating a peer image with the client library:

```
FROM hyperledger/fabric-peer:2.4.7

COPY libCryptoki2_64.so /usr/local/lunaclient/lib/libCryptoki2_64.so

RUN apk add libstdc++
```

> **NOTE:** In the COPY command, **libCryptoki2_64.so** refers to the source HSM PKCS11 Library that was previously copied to the ./docker location, and **/usr/local/lunaclient/lib/libCryptoki2_64.so** indicates the destination path inside the Docker image where the file will be copied.

24. Create the peer image using the Dockerfile created in the previous step, by executing the below command:

```
# cd $HOME/go/src/github.com/hyperledger/fabric-samples/test-network/docker

# docker build -t hsm/fabric-peer:latest -f Dockerfile.peer .
```

25. Similarly, create Dockerfiles for orderer and tools to create an orderer image and a tools image with the client library. For the orderer, create Dockerfile.orderer with the following contents:

```
FROM hyperledger/fabric-orderer:2.4.7

COPY libCryptoki2_64.so /usr/local/lunaclient/lib/libCryptoki2_64.so

RUN apk add libstdc++
```

26. For the tools, create Dockerfile.tools and add the below contents to it:

```
FROM hyperledger/fabric-tools:2.4.7

COPY libCryptoki2_64.so /usr/local/lunaclient/lib/libCryptoki2_64.so

RUN apk add libstdc++
```

27. Create the orderer and tools images using the Dockerfiles created in the previous step by executing the below commands:

    For the orderer image:

```
# docker build -t hsm/fabric-orderer:latest -f Dockerfile.orderer .
```

    For the tools image:

```
# docker build -t hsm/fabric-tools:latest -f Dockerfile.tools .

# cd $HOME/go/src/github.com/hyperledger/fabric-samples/test-network
```

28. Modify the file $HOME/go/src/github.com/hyperledger/fabric-samples/test-network/compose/compose-test-net.yaml as follows:

i. In the **services -> orderer.example.com** section, make the following changes:

- Modify the image to: `image: hsm/fabric-orderer:latest`
- Add the following environment variables under the environment section:

```
- ORDERER_GENERAL_BCCSP_DEFAULT=PKCS11
- ORDERER_GENERAL_BCCSP_PKCS11_LABEL=orderer.example.com
- ORDERER_GENERAL_BCCSP_PKCS11_PIN=<Partition Password>
- ORDERER_GENERAL_BCCSP_PKCS11_LIBRARY=<HSM PKCS11 Library>
- ORDERER_GENERAL_BCCSP_PKCS11_HASH=SHA2
- ORDERER_GENERAL_BCCSP_PKCS11_SECURITY=384
- ChrystokiConfigurationPath=luna/orderer
```

- Add the following entires under the volume section:

```
- /usr/local/lunaclient:/usr/local/lunaclient
- ../luna:/root/luna
```

ii. In **services -> peer0.org1.example.com** section, make the following changes:

- Modify the image to: `image: hsm/fabric-peer:latest`
- Add the following environment variables under the environment section:

```
- CORE_PEER_BCCSP_DEFAULT=PKCS11
- CORE_PEER_BCCSP_PKCS11_LABEL=org1.example.com
- CORE_PEER_BCCSP_PKCS11_PIN=<Partition Password>
- CORE_PEER_BCCSP_PKCS11_LIBRARY=<HSM PKCS11 Library>
- CORE_PEER_BCCSP_PKCS11_HASH=SHA2
- CORE_PEER_BCCSP_PKCS11_SECURITY=384
- ChrystokiConfigurationPath=luna/org1
```

- Add the following under the volume section:

```
- /usr/local/lunaclient:/usr/local/lunaclient
- ../luna:/root/luna
```

iii. In the **services -> peer0.org2.example.com** section, make the following changes:

- Modify the image field to: `image: hsm/fabric-peer:latest`
- Add the following environment variables under the environment section:

```
- CORE_PEER_BCCSP_DEFAULT=PKCS11
- CORE_PEER_BCCSP_PKCS11_LABEL=org2.example.com
- CORE_PEER_BCCSP_PKCS11_PIN=<Partition Password>
- CORE_PEER_BCCSP_PKCS11_LIBRARY=<HSM PKCS11 Library>
```

```
- CORE_PEER_BCCSP_PKCS11_HASH=SHA2
- CORE_PEER_BCCSP_PKCS11_SECURITY=384
- ChrystokiConfigurationPath=luna/org2
```

- Add the following under the volume section:

```
- /usr/local/lunaclient:/usr/local/lunaclient
- ../luna:/root/luna
```

iv. In **services -> cli**, make the following changes:

- Modify the image field to: `image: hsm/fabric-tools:latest`
- Add the following under the volume section:

```
- /usr/local/lunaclient:/usr/local/lunaclient
- ../luna:/opt/gopath/src/github.com/hyperledger/fabric/peer/luna
```

29. Modify the file $HOME/go/src/github.com/hyperledger/fabric-samples/test-network/compose/docker/docker-compose-test-net.yaml as follows:

i. In **services -> peer0.org1.example.com** and in **services -> peer0.org2.example.com**, change the image field to: `image: hsm/fabric-peer:latest`

ii. In the **services -> cli** section, change the image field to: `image: hsm/fabric-tools:latest`

30. Change the bccsp security from 256 to 384 for each of the following configuration files:

- $HOME/go/src/github.com/hyperledger/fabric-samples/test-network/organizations/fabric-ca/org1/fabric-ca-server-config.yaml
- $HOME/go/src/github.com/hyperledger/fabric-samples/test-network/organizations/fabric-ca/org2/fabric-ca-server-config.yaml
- $HOME/go/src/github.com/hyperledger/fabric-samples/test-network/organizations/fabric-ca/ordererOrg/fabric-ca-server-config.yaml

31. Modify the $HOME/go/src/github.com/hyperledger/fabric-samples/test-network/scripts/envVar.sh script:

i. Add the following lines in **if [$USING_ORG -eq 1]; then** block:

```
export ChrystokiConfigurationPath=luna/org1
export CORE_PEER_BCCSP_DEFAULT=PKCS11
export CORE_PEER_BCCSP_PKCS11_SECURITY=384
export CORE_PEER_BCCSP_PKCS11_HASH=SHA2
export CORE_PEER_BCCSP_PKCS11_LABEL=org1.example.com
export CORE_PEER_BCCSP_PKCS11_PIN=<Partition Password>
export CORE_PEER_BCCSP_PKCS11_LIBRARY=<HSM PKCS11 Library>
```

ii. Add the following lines in the **elif [$USING_ORG -eq 2]; then** block:

```
export ChrystokiConfigurationPath=luna/org2
export CORE_PEER_BCCSP_DEFAULT=PKCS11
export CORE_PEER_BCCSP_PKCS11_SECURITY=384
```

```
export CORE_PEER_BCCSP_PKCS11_HASH=SHA2

export CORE_PEER_BCCSP_PKCS11_LABEL=org2.example.com

export CORE_PEER_BCCSP_PKCS11_PIN=<Partition Password>

export CORE_PEER_BCCSP_PKCS11_LIBRARY=<HSM PKCS11 Library>
```

32. Execute the following commands to bring up the Fabric orderer and peer nodes and generate the network crypto material using Certificate Authorities, execute the following command:

```
# cd $HOME/go/src/github.com/hyperledger/fabric-samples/test-network

# ./network.sh up -ca
```

33. This command will create a Fabric network with two peer nodes and one ordering node. The network will use the cryptogen tool to generate the necessary cryptographic material. If the command is successful, you will see the logs indicating the creation of the nodes.

```
Creating orderer.example.com    ... done
Creating peer0.org2.example.com ... done
Creating peer0.org1.example.com ... done
Creating cli                    ... done
CONTAINER ID   IMAGE                               COMMAND                  CREATED              STATUS              PORTS
                  NAMES
a9d1d51b5b22   hsm/fabric-tools:latest             "/bin/bash"              Less than a second ago   Up Less than a second
                  cli
a9dbab889bd6   hsm/fabric-peer:latest              "peer node start"        1 second ago         Up Less than a second   0.0.0.0:7051->7051/tcp,
                  peer0.org1.example.com
5fbddd55d489   hsm/fabric-peer:latest              "peer node start"        1 second ago         Up Less than a second   0.0.0.0:9051->9051/tcp,
                  peer0.org2.example.com
fbc0a9a32232   hsm/fabric-orderer:latest           "orderer"                1 second ago         Up Less than a second   0.0.0.0:7050->7050/tcp,
:9443->9443/tcp   orderer.example.com
214f7e32d066   hyperledger/fabric-ca:latest        "sh -c 'fabric-ca-se…"   10 seconds ago       Up 9 seconds            0.0.0.0:9054->9054/tcp,
                  ca_orderer
1c2f11ffcc17   hyperledger/fabric-ca:latest        "sh -c 'fabric-ca-se…"   10 seconds ago       Up 9 seconds            0.0.0.0:7054->7054/tcp,
                  ca_org1
926b2b8e68e9   hyperledger/fabric-ca:latest        "sh -c 'fabric-ca-se…"   10 seconds ago       Up 9 seconds            0.0.0.0:8054->8054/tcp,
                  ca_org2
```

34. After the Fabric network is created, you can check the ECDSA signing key pairs generated in the Luna HSM partitions for org1, org2 and orderer. For example, to check the contents of the Luna HSM partition org1.example.com, run the following command:

```
localhost:~/go/src/github.com/hyperledger/fabric-samples/test-network# export
ChrystokiConfigurationPath=luna/org1

localhost:~/go/src/github.com/hyperledger/fabric-samples/test-network#
/usr/local/lunaclient/bin/lunacm

lunacm (64-bit) v10.3.0-277. Copyright (c) 2021 SafeNet. All rights reserved.


 Available HSMs:

 Slot Id ->              0

 Label ->                org1.example.com

 Serial Number ->        1280780175902

 Model ->                LunaSA 7.7.1

 Firmware Version ->     7.7.2

 Bootloader Version ->   1.1.2

 Configuration ->        Luna User Partition With SO (PW) Key Export With
                         Cloning Mode
```

```
 Slot Description ->     Net Token Slot
 FM HW Status ->         Non-FM
 Current Slot Id: 0

lunacm:>role login -n co -p <Partition Password>

Command Result : No Error

lunacm:>par con

The 'Crypto Officer' is currently logged in. Looking for objects
accessible to the 'Crypto Officer'.

Object list:

Label:       fef1897158e6b2f60afb79a34868e0938adff228f1c134e12e6a853bbbf9b945
Handle:      224
Object Type: Private Key
Usage Limit: none
Object UID:  420400003e000003cb640800

Label:       fef1897158e6b2f60afb79a34868e0938adff228f1c134e12e6a853bbbf9b945
Handle:      225
Object Type: Public Key
Usage Limit: none
Object UID:  410400003e000003cb640800

Label:       75245626aae524d991b0305e674e4803c6c2231e2976f68959dd9dce24c38ccb
Handle:      230
Object Type: Private Key
Usage Limit: none
Object UID:  400400003e000003cb640800

Label:       75245626aae524d991b0305e674e4803c6c2231e2976f68959dd9dce24c38ccb
```

```
Handle:      236
Object Type: Public Key
Usage Limit: none
Object UID:  3f0400003e000003cb640800

Label:       71bc51e6134a3603ea05ef8837364b9ee0822a36f461fe6fb5cc433ae9be21a7
Handle:      235
Object Type: Private Key
Usage Limit: none
Object UID:  3e0400003e000003cb640800

Label:       71bc51e6134a3603ea05ef8837364b9ee0822a36f461fe6fb5cc433ae9be21a7
Handle:      202
Object Type: Public Key
Usage Limit: none
Object UID:  3d0400003e000003cb640800

Label:       c5930e285c2a570c2aa1ef94478adfe7c1592b5aa34c3d0a76cbee03436888bc
Handle:      205
Object Type: Private Key
Usage Limit: none
Object UID:  3c0400003e000003cb640800

Label:       c5930e285c2a570c2aa1ef94478adfe7c1592b5aa34c3d0a76cbee03436888bc
Handle:      203
Object Type: Public Key
Usage Limit: none
Object UID:  3b0400003e000003cb640800

Number of objects:  8

Command Result : No Error

lunacm:>
```

35. Similarly, you can check the contents of the org2 and orderer partitions.
36. After creating the network, use the following command to create and join the channel:

```
# ./network.sh createChannel
```

If the command is successful, you will see the following message printed in the logs:

```
Channel 'mychannel' joined
```

37. Deploy the Chaincode to the created channel by executing the following command:

```
# ./network.sh deployCC -ccn basic -ccp ../asset-transfer-basic/chaincode-go -ccl go
```

38. To interact with the network using the peer CLI, ensure you are in the test-network directory and add the peer binaries to your CLI Path with the following commands:

```
# cd $HOME/go/src/github.com/hyperledger/fabric-samples/test-network
```

```
# export PATH=${PWD}/../bin:$PATH
```

> **NOTE:** By executing these commands, you will be able to use the peer CLI for various operations such as invoking smart contracts, updating channels, or installing and deploying new smart contracts directly from the command line.

39. Set the FABRIC_CFG_PATH environment variable to point to the core.yaml file in the fabric-samples repository:

```
# export FABRIC_CFG_PATH=$PWD/../config/
```

40. Set the environment variables to operate the peer CLI as Org1:

```
# export CORE_PEER_TLS_ENABLED=true
```

```
# export CORE_PEER_LOCALMSPID="Org1MSP"
```

```
# export
CORE_PEER_TLS_ROOTCERT_FILE=${PWD}/organizations/peerOrganizations/org1.example
.com/peers/peer0.org1.example.com/tls/ca.crt
```

```
# export
CORE_PEER_MSPCONFIGPATH=${PWD}/organizations/peerOrganizations/org1.example.com
/users/Admin@org1.example.com/msp
```

```
# export CORE_PEER_ADDRESS=localhost:7051
```

```
# export ChrystokiConfigurationPath=luna/org1
```

```
# export CORE_PEER_BCCSP_DEFAULT=PKCS11
```

```
# export CORE_PEER_BCCSP_PKCS11_SECURITY=384
```

```
# export CORE_PEER_BCCSP_PKCS11_HASH=SHA2
```

```
# export CORE_PEER_BCCSP_PKCS11_LABEL=org1.example.com
```

```
# export CORE_PEER_BCCSP_PKCS11_PIN=<Partition Password>
```

```
# export CORE_PEER_BCCSP_PKCS11_LIBRARY=<HSM PKCS11 Library>
```

41. Initialize the ledger with assets using the following command:

```
# peer chaincode invoke -o localhost:7050 --ordererTLSHostnameOverride
orderer.example.com --tls --cafile
"${PWD}/organizations/ordererOrganizations/example.com/orderers/orderer.example
.com/msp/tlscacerts/tlsca.example.com-cert.pem" -C mychannel -n basic --
peerAddresses localhost:7051 --tlsRootCertFiles
"${PWD}/organizations/peerOrganizations/org1.example.com/peers/peer0.org1.examp
le.com/tls/ca.crt" --peerAddresses localhost:9051 --tlsRootCertFiles
"${PWD}/organizations/peerOrganizations/org2.example.com/peers/peer0.org2.examp
le.com/tls/ca.crt" -c '{"function":"InitLedger","Args":[]}'
```

If the above command is successful, you will see the output similar to the following example:

```
INFO [chaincodeCmd] chaincodeInvokeOrQuery -> Chaincode invoke successful.
result: status:200
```

42. Query the ledger to get the list of assets that were added to the channel ledger:

```
# peer chaincode query -C mychannel -n basic -c '{"Args":["GetAllAssets"]}'
```

If the above command is successful, you will see the following output:

```
[{"AppraisedValue":300,"Color":"blue","ID":"asset1","Owner":"Tomoko","Size":5},
{"AppraisedValue":400,"Color":"red","ID":"asset2","Owner":"Brad","Size":5},{"Ap
praisedValue":500,"Color":"green","ID":"asset3","Owner":"Jin
Soo","Size":10},{"AppraisedValue":600,"Color":"yellow","ID":"asset4","Owner":"M
ax","Size":10},{"AppraisedValue":700,"Color":"black","ID":"asset5","Owner":"Adr
iana","Size":15},{"AppraisedValue":800,"Color":"white","ID":"asset6","Owner":"M
ichel","Size":15}]
```

43. Change the owner of an asset by invoking the asset-transfer (basic) chaincode:

```
# peer chaincode invoke -o localhost:7050 --ordererTLSHostnameOverride
orderer.example.com --tls --cafile
"${PWD}/organizations/ordererOrganizations/example.com/orderers/orderer.example
.com/msp/tlscacerts/tlsca.example.com-cert.pem" -C mychannel -n basic --
peerAddresses localhost:7051 --tlsRootCertFiles
"${PWD}/organizations/peerOrganizations/org1.example.com/peers/peer0.org1.examp
le.com/tls/ca.crt" --peerAddresses localhost:9051 --tlsRootCertFiles
"${PWD}/organizations/peerOrganizations/org2.example.com/peers/peer0.org2.examp
le.com/tls/ca.crt" -c
'{"function":"TransferAsset","Args":["asset6","Christopher"]}'
```

If the command is successful, you will see the following output:

```
INFO [chaincodeCmd] chaincodeInvokeOrQuery -> Chaincode invoke successful.
result: status:200
```

44. Set the following variables to query the chaincode running on the Org2peer:

```
# export CORE_PEER_TLS_ENABLED=true

# export CORE_PEER_LOCALMSPID="Org2MSP"

# export
CORE_PEER_TLS_ROOTCERT_FILE=${PWD}/organizations/peerOrganizations/org2.example
.com/peers/peer0.org2.example.com/tls/ca.crt
```

```
# export
CORE_PEER_MSPCONFIGPATH=${PWD}/organizations/peerOrganizations/org2.example.com
/users/Admin@org2.example.com/msp

# export CORE_PEER_ADDRESS=localhost:9051

# export ChrystokiConfigurationPath=luna/org2

# export CORE_PEER_BCCSP_DEFAULT=PKCS11

# export CORE_PEER_BCCSP_PKCS11_SECURITY=384

# export CORE_PEER_BCCSP_PKCS11_HASH=SHA2

# export CORE_PEER_BCCSP_PKCS11_LABEL=org2.example.com

# export CORE_PEER_BCCSP_PKCS11_PIN=<Partition Password>

# export CORE_PEER_BCCSP_PKCS11_LIBRARY=<HSM PKCS11 Library>
```

45. You can now query the asset-transfer (basic) chaincode running on peer0.org2.example.com:

```
# peer chaincode query -C mychannel -n basic -c
'{"Args":["ReadAsset","asset6"]}'
```

The result will show that asset6 was transferred to Christopher:

```
{"AppraisedValue":800,"Color":"white","ID":"asset6","Owner":"Christopher","Size
":15}
```

With these steps, you have successfully integrated Luna HSM with Hyperledger Fabric 2.4 on Alpine Linux OS.

Contacting Customer Support

If you encounter a problem during this integration, contact your supplier or Thales Customer Support. Thales Customer Support operates 24 hours a day, 7 days a week. Your level of access to this service is governed by the support plan arrangements made between Thales and your organization. Please consult this support plan for further information about your entitlements, including the hours when telephone support is available to you.

Customer Support Portal

The Customer Support Portal, at https://supportportal.thalesgroup.com, is a database where you can find solutions for most common problems. The Customer Support Portal is a comprehensive, fully searchable repository of support resources, including software and firmware downloads, release notes listing known problems and workarounds, a knowledge base, FAQs, product documentation, technical notes, and more. You can also use the portal to create and manage support cases.

> **NOTE:** You require an account to access the Customer Support Portal. To create a new account, go to the portal and click on the **REGISTER** link.

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If you have an urgent problem, or cannot access the Customer Support Portal, you can contact Thales Customer Support by telephone at +1 410-931-7520. Additional local telephone support numbers are listed on the support portal.