Integrating PKCS#11 with Azure Cloud HSM

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Summary

PKCS#11 serves as a widely recognized standard for executing cryptographic functions on hardware security modules (HSMs). Azure Cloud HSM provides compliant implementations of the PKCS#11 library, ensuring adherence to the PKCS#11 version 2.40 specifications. To use PKCS#11 with Azure Cloud HSM, the Azure Cloud HSM Client SDK and PKCS#11 library must be installed and configured accordingly.

Prerequisites

System Requirements

- Windows Server (2016, 2019, 2022) or Linux (Ubuntu 20.04, Ubuntu 22.04, RHEL 7, RHEL 8), CBL Mariner 2
- Azure Cloud HSM resource has been deployed, initialized, and configured.
- Azure Cloud HSM Client SDK

PKCS#11 Install Prerequisites

- Copy of partition owner certificate "PO.crt" on application server.
- Known address of your HSM "hsm1.chsm-<resourcename>-<uniquestring>.privatelink.cloudhsm.azure.net".
- Knowledge of Crypto User credentials

Important Note: Customers using any version of Windows Server should install the most recent version of the Visual C++ Redistributable.

Azure Cloud HSM SDK Prerequisites

STEP 1: Create a New Virtual Machine (Application Server)

You will need to create a Virtual Machine in your client VNET. If you choose to use your existing Admin VM you can skip this step. This will serve as your Application VM to run your PKCS#11 application. If you choose to create a New VM for your application, then after provisioning the VM you will download the Azure Cloud HSM SDK from GitHub to this VM to configure your Cloud HSM to use PKCS#11. You can find details on how to deploy a Windows or Linux Virtual Machine using Azure CLI, PowerShell, ARM Template or Azure Portal below.

- Create a Windows Virtual Machine
- Create a Linux Virtual Machine

STEP 2: Download and Install Azure Cloud HSM SDK

Customers can download the Azure Cloud HSM SDK and Client Tools from GitHub:
@ microsoft/MicrosoftAzureCloudHSM: Azure Cloud HSM SDK

a. **Linux Installation:** Customers can copy the Azure Cloud HSM deb or rpm package to their VM, then use dpkg to install it. The Azure Cloud HSM SDK is installed under /opt/azurecloudhsm. This is the directory for all Azure Cloud HSM management and client utilities including shared libraries for PKCS#11 and OpenSSL.

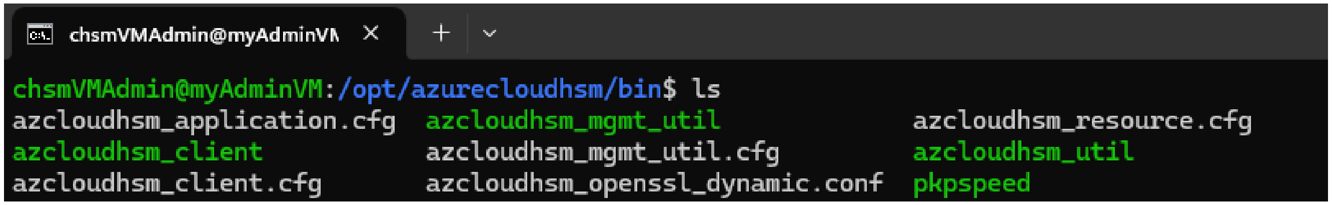
   The example below demonstrates how to download and install the deb package. Please note that rpm packages are also available to customers.

   ○ wget -p ~/ https://github.com/microsoft/MicrosoftAzureCloudHSM/releases/download/AzureCloudHSM-ClientSDK-2.0.1.2/AzureCloudHSM-ClientSDK-2.0.1.2.deb

   ○ sudo dpkg --install ~/AzureCloudHSM-ClientSDK-2.0.1.2.deb

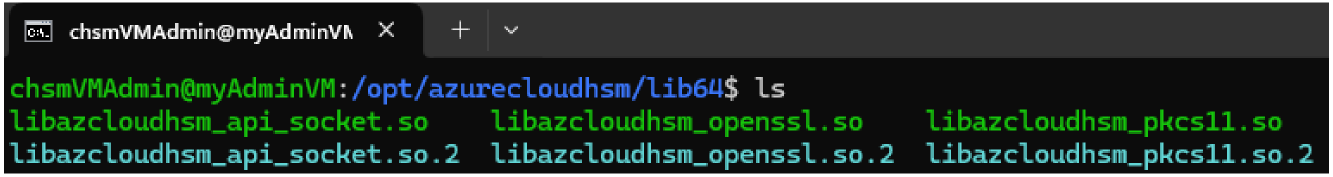
   Directory Example:

   Azure Cloud HSM Management and Client Utilities
   /opt/azurecloudhsm/**bin**



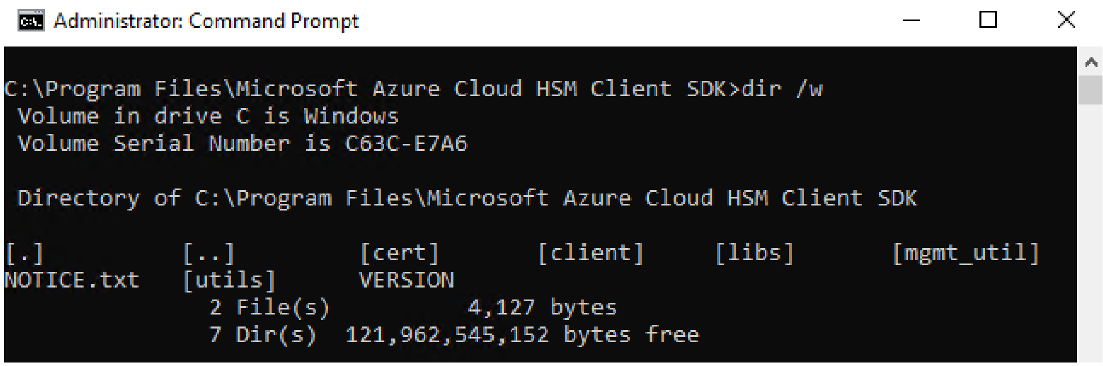
```
chsmVMAdmin@myAdminVM:/opt/azurecloudhsm/bin$ ls
azcloudhsm_application.cfg  azcloudhsm_mgmt_util             azcloudhsm_resource.cfg
azcloudhsm_client           azcloudhsm_mgmt_util.cfg         azcloudhsm_util
azcloudhsm_client.cfg       azcloudhsm_openssl_dynamic.conf  pkpspeed
```

   Azure Cloud HSM Shared Libraries (PKCS#11 & OpenSSL)
   /opt/azurecloudhsm/**lib64**



```
chsmVMAdmin@myAdminVM:/opt/azurecloudhsm/lib64$ ls
libazcloudhsm_api_socket.so    libazcloudhsm_openssl.so    libazcloudhsm_pkcs11.so
libazcloudhsm_api_socket.so.2  libazcloudhsm_openssl.so.2  libazcloudhsm_pkcs11.so.2
```

b. **Windows Installation:** To install the Azure Cloud HSM SDK for Windows, download and run the Azure Cloud HSM SDK MSI (Windows Installer Package). This installer will automatically configure all necessary environment variables and dependencies and set up the Cloud HSM Client to run as a service. In the example below, running the Cloud HSM MSI deploys the SDK to C:\Program Files\Microsoft Azure Cloud HSM Client SDK



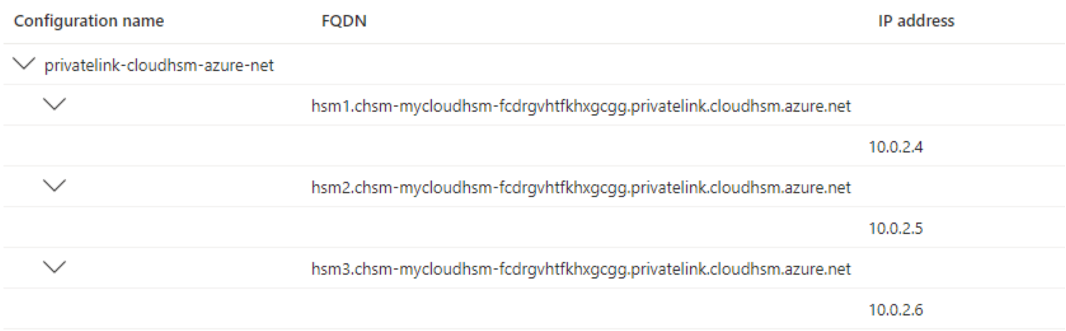
```
C:\Program Files\Microsoft Azure Cloud HSM Client SDK>dir /w
 Volume in drive C is Windows
 Volume Serial Number is C63C-E7A6

 Directory of C:\Program Files\Microsoft Azure Cloud HSM Client SDK

[.]          [..]         [cert]       [client]     [libs]       [mgmt_util]
NOTICE.txt   [utils]      VERSION
               2 File(s)          4,127 bytes
               7 Dir(s)  121,962,545,152 bytes free
```

Azure Cloud HSM Shared Library (PKCS#11)
\Microsoft Azure Cloud HSM Client SDK \libs\pkcs11
\Microsoft Azure Cloud HSM Client SDK \libs\pkcs11\include

STEP 3: Configure the Azure Cloud HSM Client Tools

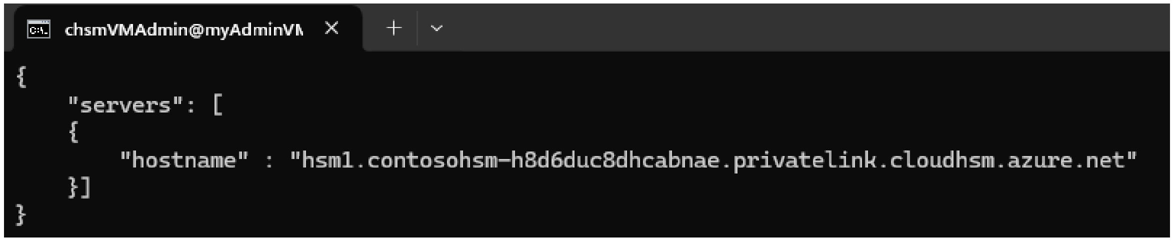
You will need to update the "hostname" property in the \bin\azcloudhsm_resource.cfg file. The azcloudhsm_resource.cfg is used to initialize the Azure Cloud HSM cluster. It must point to the private link FQDN for "hsm1" before the cluster is fully initialized as only hsm1 is currently running.

To find the FQDN that includes private link go to your resource group, and select Private Endpoint then select DNS Configuration. You will see configuration name and the FQDN that includes *.privatelink.cloudhsm.azure.net for each HSM instance. Use "hsm1" FQDN as the hostname for the \bin\azcloudhsm_resource.cfg file.



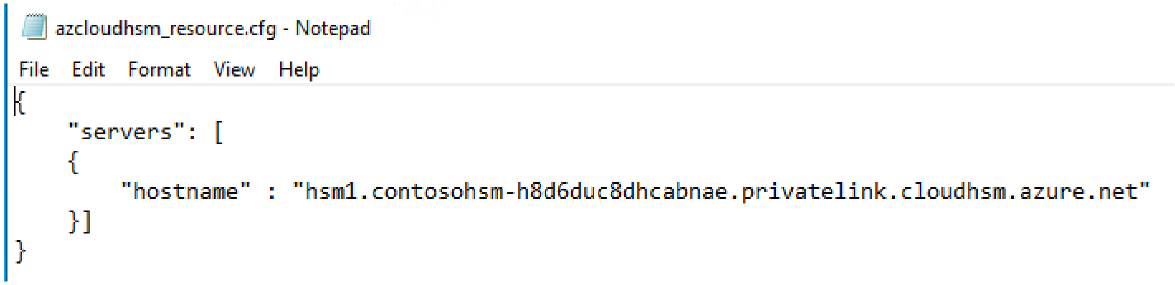
Configuration name	FQDN	IP address
privatelink-cloudhsm-azure-net		
	hsm1.chsm-mycloudhsm-fcdrgvhtfkhxgcgg.privatelink.cloudhsm.azure.net	
		10.0.2.4
	hsm2.chsm-mycloudhsm-fcdrgvhtfkhxgcgg.privatelink.cloudhsm.azure.net	
		10.0.2.5
	hsm3.chsm-mycloudhsm-fcdrgvhtfkhxgcgg.privatelink.cloudhsm.azure.net	
		10.0.2.6

a. **Linux Configuration:**
For Linux, the azcloudhsm_resource.cfg file to be updated is located under /opt/azurecloudhsm/bin



```
{
    "servers": [
    {
        "hostname" : "hsm1.contosohsm-h8d6duc8dhcabnae.privatelink.cloudhsm.azure.net"
    }]
}
```

b. **Windows Configuration:**
For Windows, you will need to update azcloudhsm_resource.cfg in two locations, \mgmt_util\azcloudhsm_resource.cfg and \client\azcloudhsm_resource.cfg



```
{
    "servers": [
    {
        "hostname" : "hsm1.contosohsm-h8d6duc8dhcabnae.privatelink.cloudhsm.azure.net"
    }]
}
```

STEP 4: Running azcloudhsm_client as a service

We recommend running azcloudhsm_client as a service in a production environment since it needs to be continuously operational for the client-server model to establish connections and execute cryptographic operations. Manual execution of the azcloudhsm_client should be for development and testing purposes only.

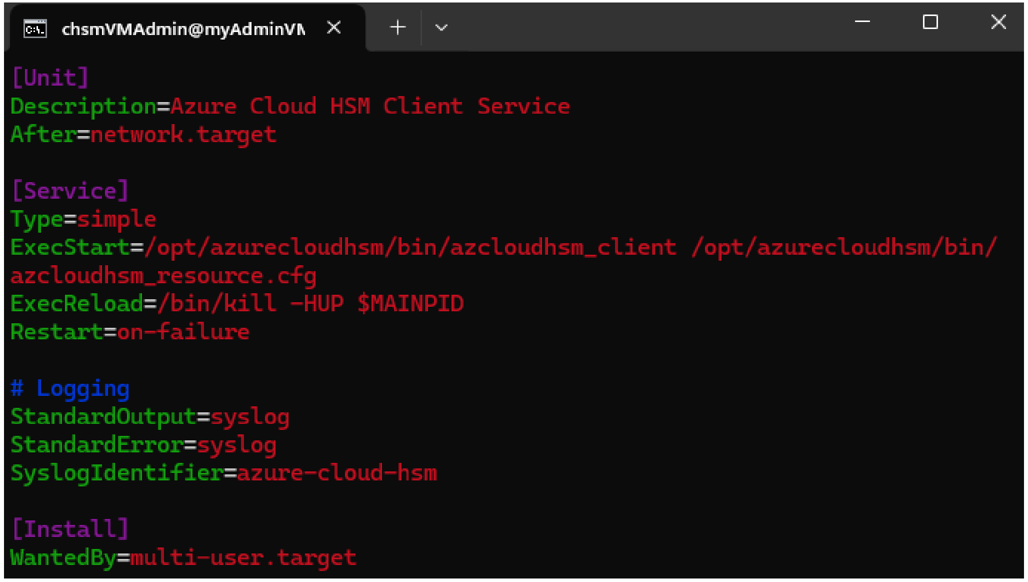
Linux (Recommended):
If you installed the Azure Cloud HSM SDK using deb or rpm, the client is not configured automatically to run as a service. The SDK during installation includes a service unit file under /etc/systemd/system/azure-cloud-hsm.service. To enable *azcloudhsm_client* to run as a service

you will need to use the predefined azure-cloud-hsm.service file. You will then need to reload the Systemd configuration and enable the service to ensure its continuously running by performing the following steps.

1. Open a terminal window and change directory to /etc/systemd/system where the Cloud HSM service unit file is located.

```
cd /etc/systemd/system
```

Example: azure-cloud-hsm.service



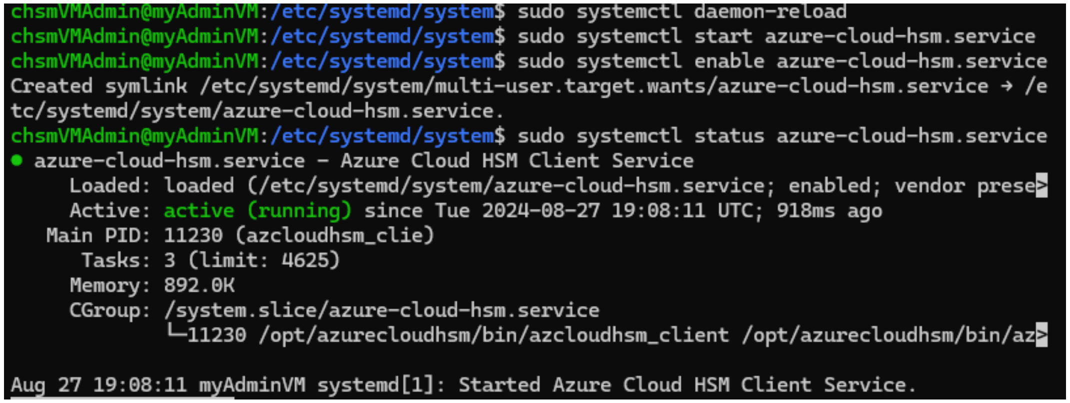
```
[Unit]
Description=Azure Cloud HSM Client Service
After=network.target

[Service]
Type=simple
ExecStart=/opt/azurecloudhsm/bin/azcloudhsm_client /opt/azurecloudhsm/bin/
azcloudhsm_resource.cfg
ExecReload=/bin/kill -HUP $MAINPID
Restart=on-failure

# Logging
StandardOutput=syslog
StandardError=syslog
SyslogIdentifier=azure-cloud-hsm

[Install]
WantedBy=multi-user.target
```

2. Start and Enable the Cloud HSM Client service

```
sudo systemctl start azure-cloud-hsm.service
sudo systemctl enable azure-cloud-hsm.service
```

3. Check status of the Cloud HSM Client service

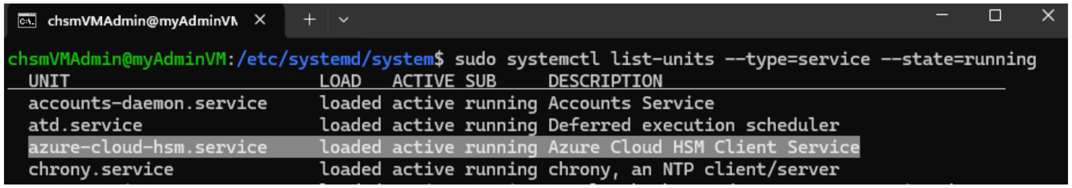
```
sudo systemctl status azure-cloud-hsm.service
```



```
chsmVMAdmin@myAdminVM:/etc/systemd/system$ sudo systemctl daemon-reload
chsmVMAdmin@myAdminVM:/etc/systemd/system$ sudo systemctl start azure-cloud-hsm.service
chsmVMAdmin@myAdminVM:/etc/systemd/system$ sudo systemctl enable azure-cloud-hsm.service
Created symlink /etc/systemd/system/multi-user.target.wants/azure-cloud-hsm.service → /e
tc/systemd/system/azure-cloud-hsm.service.
chsmVMAdmin@myAdminVM:/etc/systemd/system$ sudo systemctl status azure-cloud-hsm.service
● azure-cloud-hsm.service - Azure Cloud HSM Client Service
     Loaded: loaded (/etc/systemd/system/azure-cloud-hsm.service; enabled; vendor prese>
     Active: active (running) since Tue 2024-08-27 19:08:11 UTC; 918ms ago
   Main PID: 11230 (azcloudhsm_clie)
      Tasks: 3 (limit: 4625)
     Memory: 892.0K
     CGroup: /system.slice/azure-cloud-hsm.service
             └─11230 /opt/azurecloudhsm/bin/azcloudhsm_client /opt/azurecloudhsm/bin/az>

Aug 27 19:08:11 myAdminVM systemd[1]: Started Azure Cloud HSM Client Service.
```

4. Reload the Systemd configuration

```
sudo systemctl daemon-reload
sudo systemctl list-units --type=service --state=running
```



```
chsmVMAdmin@myAdminVM:/etc/systemd/system$ sudo systemctl list-units --type=service --state=running
  UNIT                         LOAD   ACTIVE SUB     DESCRIPTION
  accounts-daemon.service      loaded active running Accounts Service
  atd.service                  loaded active running Deferred execution scheduler
  azure-cloud-hsm.service      loaded active running Azure Cloud HSM Client Service
  chrony.service               loaded active running chrony, an NTP client/server
```

Linux (Manual):

Start the client daemon if it is not running.

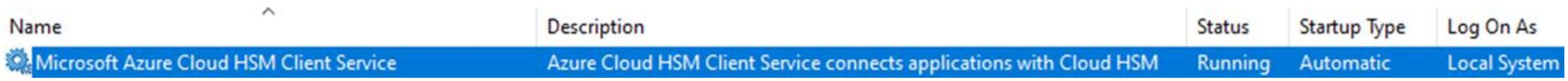
```
cd /opt/azurecloudhsm/bin
sudo ./azcloudhsm_client azcloudhsm_resource.cfg
```

You may also choose as an option with Linux to run the client daemon in the background using the following command.

```
sudo ./azcloudhsm_client azcloudhsm_resource.cfg > /dev/null 2>&1 &
```

Windows (Recommended):

If you installed the Azure Cloud HSM SDK using MSI, the client is already configured to run as a service. If the client is not running, you can open Services.msc, right-click on the Microsoft Azure Cloud HSM Client Service, and select "Start."



Name	Description	Status	Startup Type	Log On As
Microsoft Azure Cloud HSM Client Service	Azure Cloud HSM Client Service connects applications with Cloud HSM	Running	Automatic	Local System

Windows (Manual):
Start the client daemon if it is not running.

```
cd C:\Program Files\Microsoft Azure Cloud HSM Client SDK
.\azcloudhsm_client.exe .\azcloudhsm_resource.cfg
```

STEP 5: Verify crypto user exists

A crypto user account is necessary to configure and run your PKCS#11 application with Azure Cloud HSM, as these applications operate under a crypto user.

a. Use azcloudhsm_util to login to your Azure Cloud HSM as Crypto User by executing the following commands below to validate CU can successfully login. If successful azcloudhsm_util will return SUCCESS.

Linux Installation:

```
./azcloudhsm_util
loginHSM -u CU -s cu1 -p user1234
```

Windows Installation:

```
cd utils\azcloudhsm_util
.\azcloudhsm_util.exe
loginHSM -u CU -s cu1 -p user1234
```

b. If you validated that you have a 'user' with Crypto User role successfully above, you can skip this step (c). If a 'user' with Crypto User roles does not exist, you will need to create a new user to run the PKCS#11 sample applications to validate your configuration. The example shows starting azcloudhsm_mgmt_util and administrator logging on as CO, then proceeds to create 'cu1' user with crypto user role.

Linux Installation:

```
sudo ./azcloudhsm_mgmt_util ./azcloudhsm_resource.cfg
loginHSM CO admin adminpassword
createUser CU cu1 user1234
```

```
logoutHSM
loginHSM CU cu1 user1234
```

Windows Installation:

```
.\azcloudhsm_mgmt_util.exe .\azcloudhsm_resource.cfg
loginHSM CO admin adminpassword
createUser CU cu1 user1234
logoutHSM
loginHSM CU cu1 user1234
```

How to configure and run your PKCS#11 application with Azure Cloud HSM

Linux Installation

Below we created a PKCS#11 custom application example, then compile the program and generate the object file using gcc in the terminal. We then run the generated object file. While the PKCS#11 shared library exists under /opt/azurecloudhsm/**lib64** the .h files for Azure Cloud HSM PKCS#11 exist under /opt/azurecloudhsm/**pkcs11_headers/include**

You can install build essentials using your distribution package manager which is what we will use below to compile our PKCS#11 application.

```
sudo apt install build-essential
```

Copy the PKCS#11 sample application detailed further below and save as a .c file. In this example we saved the file as cust_p11_app.c under /opt/azurecloudhsm. You can then generate the object file by compiling the program using ‘gcc’. The example below is using the custom PKCS#11 sample application template captured below under example.

```
sudo gcc -o cust_p11_app cust_p11_app.c -ldl
```

Ensure that you set the correct pin for your Azure Cloud HSM user credentials. Syntax is username:password. Your PKCS#11 application will use the pin parameter for the C_Login function.

```
char pPin[256] = "cu1:user1234";
```

Execute the custom PKCS#11 application from the example application template below.

```
sudo ./cust_p11_app -s cu1 -p user1234 -l /opt/azurecloudhsm/lib64/libazcloudhsm_pkcs11.so
```

Windows Installation

Below we created a PKCS#11 custom application example, then compile the program and generate the object file using gcc in the terminal. We then run the generated object file. While the PKCS#11 shared library exists under \Microsoft Azure Cloud HSM Client SDK\libs the .h files for Azure Cloud HSM PKCS#11 exist under \Microsoft Azure Cloud HSM Client SDK**\libs\pkcs11\include**

1. Open PowerShell prompt as 'Administrator'
2. Run the following command to Set Execution Policy and Download Chocolatey:

```
Set-ExecutionPolicy Bypass -Scope Process -Force; [System.Net.ServicePointManager]::SecurityProtocol =
[System.Net.ServicePointManager]::SecurityProtocol -bor 3072; iex ((New-Object
System.Net.WebClient).DownloadString('https://community.chocolatey.org/install.ps1'))
```

3. Run the following command for MinGW-w64 Installation:

```
choco install mingw
```

Copy the PKCS#11 sample application detailed further below and save as a .c file. In this example we saved the file as cust_p11_app.c under \Microsoft Azure Cloud HSM Client SDK. You can then generate the object file by compiling the program using 'gcc'. The example below is using the custom PKCS#11 sample application template captured below under example.

```
gcc -o cust_p11_app.exe cust_p11_app.c
```

Ensure that you set the correct pin for your Azure Cloud HSM user credentials. Syntax is username:password. Your PKCS#11 application will use the pin parameter for the C_Login function.

```
char pPin[256] = "cu1:user1234";
```

Execute the custom PKCS#11 application from the example application template below.

```
.\cust_p11_app.exe -s cu1 -p user1234 -l "C:\Program Files\Microsoft Azure Cloud HSM Client SDK\libs\pkcs11\azcloudhsm_pkcs11.dll"
```

Important Note: We've provided two PKCS#11 applications samples, one for Linux customers and the other for Windows customers. The Linux samples makes use dlfcn (dlopen) to load the PKCS#11 library while Windows makes use of LoadLibraryA( ) to load the PKCS#11 library. The dlfcn is a set of functions that allows runtime dynamic library loading. It is standardized in the POSIX. Windows also provide similar routines, but not in a POSIX-compatible way which is why for Windows we've provided a sample using LoadLibraryA( ) which is a standard Windows function.

Important Note: For your PKCS#11 application to execute successfully the azcloudhsm_application.cfg file must exist in the same location as your PKCS#11 application and the azcloudhsm_client must be running. If the azcloudhsm_client is not running, you will receive a failed socket *connection. If the azcloudhsm_client is not running your application will fail and you will not be able to initialize, create sessions, login or perform any Azure Cloud HSM or PKCS#11 functions.*

Linux Example: Custom PKCS#11 Sample Application Template

```
#include <stdio.h>
#include <stdlib.h>
#include <unistd.h>
#include <string.h>
#include <pthread.h>
#include <ctype.h>
#include <getopt.h>
#include "dlfcn.h"
#include "pkcs11_headers/include/cryptoki.h"
#include "pkcs11_headers/include/pkcs11t.h"

CK_FUNCTION_LIST_PTR func_list = NULL;
static void *module = NULL;

#define CAVIUM_SLOT 1
unsigned long int Private = 0;
unsigned long int Public = 0;

/* This section contains the standard .h files and user credentials. "cu1:user1234" represents the username and password that are initialized to log in to Azure Cloud HSM. */

char pPin[256] = "cu1:user1234";

/* This function loads the library; here dlOpen is used. */
static int inline load_lib(const char *libpath)
{
    CK_RV rv = -1;
    CK_C_GetFunctionList get_function_list;

    /* loads the PKCS#11 library present in libpath */
    printf("[INFO] Azure Cloud HSM - Loading PKCS#11 library.\n");
    module = dlopen(libpath, RTLD_NOW);

    if (!module) {
        printf("couldn't open library: %s: %s", libpath, dlerror());
        return -1;
    }

    /* Look up the appropriate function in library */
    printf("[INFO] Azure Cloud HSM – C_GetFunctionList\n");
    get_function_list = (CK_C_GetFunctionList) dlsym(module, "C_GetFunctionList");
    if (!get_function_list) {
        printf("couldn't find function 'C_GetFunctionList' in library: %s: %s", libpath, dlerror());
        return -1;
    }

    /* Makes all PKCS#11 functions available in the form of a function list by returning func_list */
    rv = (get_function_list) (&func_list);
    if (rv != CKR_OK || !func_list) {
        printf("couldn't get function list: %d", (int) rv);
        return -1;
    }
    return rv;
}

/* This function closes the object opened by the previous application. */
static int inline lib_close()
{
    if (module)
        dlclose(module);
        return 0;
}

/* Main function */
```

```
CK_RV main_func()
{
    CK_SESSION_HANDLE session_rw = 0;
    CK_SLOT_ID slot = CAVIUM_SLOT;
    CK_FUNCTION_LIST_PTR list;
    CK_INFO info = { };
    CK_TOKEN_INFO token_info = { };
    CK_RV rv = CKR_OK;
    int n_pin = strlen(pPin);
    int s_done = 0;

    rv = (func_list->C_GetFunctionList) (&list);
    if (CKR_OK != rv) {
        printf("\nCall through function list %08lx\n", rv);
        goto clean_up;
    }

    if (memcmp(list, func_list, sizeof(*list)) != 0)
        printf("\nCall doesn't return same data as library C_GetFunctionList entry point\n");

    printf("[INFO] Azure Cloud HSM – C_Initialize\n");
    rv = (func_list->C_Initialize) (NULL);
    if (CKR_OK != rv) {
        printf("\nC_Initialize() failed with %08lx\n", rv);
        goto clean_up;
    }

    printf("[INFO] Azure Cloud HSM – C_GetInfo\n");
    rv = (func_list->C_GetInfo) (&info);
    if (CKR_OK != rv) {
        printf("\nCall through function list %08lx\n", rv);
        goto clean_up;
    }
```

```
printf("[INFO] Azure Cloud HSM – Retrieve access token, C_GetTokenInfo\n");
rv = (func_list->C_GetTokenInfo) (slot, &token_info);
if (CKR_OK != rv) {
    printf("\nCall through function list %08lx\n", rv);
    goto clean_up;
}

printf("[INFO] Azure Cloud HSM – Start session with specified token, C_OpenSession\n");
rv = (func_list->C_OpenSession) (slot, CKF_SERIAL_SESSION | CKF_RW_SESSION, NULL, NULL, &session_rw);
if (CKR_OK != rv) {
    printf("\nC_OpenSession() failed with %08lx\n", rv);
    goto clean_up;
}
s_done = 1;

printf("[INFO] Azure Cloud HSM – Login with PIN, C_Login\n");
rv = (func_list->C_Login) (session_rw, CKU_USER, (CK_UTF8CHAR_PTR) pPin, n_pin);
if (CKR_OK != rv) {
    printf("[ERROR] Failed C_Login\n");
    goto clean_up;
}

/**********[INSERT CUSTOM P11 APP CODE HERE]**********/

printf("Add Your PKCS#11 Code Here\n");

/**********[END OF CUSTOM P11 APP CODE]**********/

/* Clean Up */
clean_up:
#ifndef USE_FIND_KEY
    if (s_done) {
        if (Private)
            (func_list->C_DestroyObject) (session_rw, Private);
            if (Public)
                (func_list->C_DestroyObject) (session_rw, Public);
            Public = Private = 0;
        }
    #endif

    if (s_done) {
        /* logout */
        rv = func_list->C_Logout(session_rw);
        if (CKR_OK != rv) {
            printf("\nC_Logout() failed with %08lx\n", rv);
        }

        /* close session */
        rv = func_list->C_CloseSession(session_rw);
        if (CKR_OK != rv) {
            printf("\nC_CloseSession() failed with %08lx\n", rv);
        }
    }

    /* Application Shutdown */
    rv = func_list->C_Finalize(NULL);
    if (CKR_OK != rv) {
        printf("\nC_Finalize() failed with %08lx\n", rv);
    }
    return rv;
}

int main(int argc, char *argv[])
{
    CK_RV rv = 0;
    char *username = NULL;
    char *password = NULL;
    char *libname = NULL;
char buName = FALSE;
char bPassword = FALSE;
char bLibray = FALSE;
int cmd_options = 0;

if (argc < 7) {
    printf("\nMissing arguments: The format is %s -s <username> -p <password> -l <pkcs-lib> \n\n", argv[0]);
    return 0;
}

if (argc > 7) {
    printf("\nToo many arguments: The format is %s -s <username> -p <password> -l <pkcs-lib>\n\n", argv[0]);
    return 0;
}

while ((cmd_options = getopt(argc, argv,"s:p:l:")) != -1) {
    switch (cmd_options) {
        case 's' : username = optarg;
            buName = TRUE;
            break;
        case 'p' : password = optarg;
            bPassword = TRUE;
            break;
        case 'l' : libname = optarg;
            bLibray = TRUE;
            break;
        default: printf("\nWrong arguments: The format is %s -s <username> -p <password> -l <pkcs-lib>\n\n",argv[0]);
            return 0;
    }
}

if (!buName || !bPassword || !bLibray) {
    printf("\nWrong arguments: The format is %s -s <username> -p <password> -l <pkcs-lib>> \n\n", argv[0]);
    return 0;
    }

    if (load_lib(libname)) {
        printf("\n Error: loading library %s\n ", libname);
        rv = 0;
        goto end;
    }

    if (!module) {
        printf("\n Error: module loading failure %s\n ", libname);
        rv = 0;
        goto end;
    }

    /* prepare the pPin with given username and password */
    printf("[INFO] Azure Cloud HSM – Preparing PIN with given username and password.\n");
    snprintf(pPin, sizeof(pPin), "%s:%s", username, password);

    rv = main_func();
    if (rv != CKR_OK) {
        printf("Error while running the tests\n");
    }

    end:
        lib_close();
        exit(0);
}
```

Windows Example: Custom PKCS#11 Sample Application Template

```
#include <windows.h>
#include <stdio.h>
#include <stdlib.h>
```

```
#include <unistd.h>
#include <string.h>
#include <pthread.h>
#include <ctype.h>
#include <getopt.h>
#include "libs\pkcs11\include\cryptoki.h"
#include "libs\pkcs11\include\pkcs11t.h"

CK_FUNCTION_LIST_PTR func_list = NULL;
static void *module = NULL;

#define CAVIUM_SLOT 1
unsigned long int Private = 0;
unsigned long int Public = 0;

/* This section contains the standard .h files and user credentials. "cu1:user1234" represents the username and password that are initialized to
log in to Azure Cloud HSM. */

char pPin[256] = "cu1:user1234";

/* This function loads the library; here LoadLibraryA is used. */
static int inline load_lib(const char *libpath)
{
    CK_RV rv = -1;
    CK_C_GetFunctionList get_function_list;

    /* loads the PKCS#11 library present in libpath */
    printf("[INFO] Azure Cloud HSM - Loading PKCS#11 library.\n");
    module = LoadLibraryA(libpath);

    if (!module) {
        printf("couldn't open library");
        return -1;
    }
    /* Look up the appropriate function in library */
    printf("[INFO] Azure Cloud HSM – C_GetFunctionList\n");
    get_function_list = (CK_C_GetFunctionList)GetProcAddress(module,"C_GetFunctionList");
    if (!get_function_list) {
        printf("couldn't find function 'C_GetFunctionList' in library");
        return -1;
    }

    /* Makes all PKCS#11 functions available in the form of a function list by returning func_list */
    rv = (get_function_list) (&func_list);
    if (rv != CKR_OK || !func_list) {
        printf("couldn't get function list: %d", (int) rv);
        return -1;
    }
    return rv;
}

/* This function closes the object opened by the previous application. */
static int inline lib_close()
{
    if (module)
            FreeLibrary(module);
        return 0;
}

/* Main function */
CK_RV main_func()
{
    CK_SESSION_HANDLE session_rw = 0;
    CK_SLOT_ID slot = CAVIUM_SLOT;
    CK_FUNCTION_LIST_PTR list;
    CK_INFO info = { };
    CK_TOKEN_INFO token_info = { };
```

```
CK_RV rv = CKR_OK;
int n_pin = strlen(pPin);
int s_done = 0;

rv = (func_list->C_GetFunctionList) (&list);
if (CKR_OK != rv) {
    printf("\nCall through function list %08lx\n", rv);
    goto clean_up;
}

if (memcmp(list, func_list, sizeof(*list)) != 0)
    printf("\nCall doesn't return same data as library C_GetFunctionList entry point\n");

printf("[INFO] Azure Cloud HSM – C_Initialize\n");
rv = (func_list->C_Initialize) (NULL);
if (CKR_OK != rv) {
    printf("\nC_Initialize() failed with %08lx\n", rv);
    goto clean_up;
}

printf("[INFO] Azure Cloud HSM – C_GetInfo\n");
rv = (func_list->C_GetInfo) (&info);
if (CKR_OK != rv) {
    printf("\nCall through function list %08lx\n", rv);
    goto clean_up;
}

printf("[INFO] Azure Cloud HSM – Retrieve access token, C_GetTokenInfo\n");
rv = (func_list->C_GetTokenInfo) (slot, &token_info);
if (CKR_OK != rv) {
    printf("\nCall through function list %08lx\n", rv);
    goto clean_up;
}
```

```
printf("[INFO] Azure Cloud HSM – Start session with specified token, C_OpenSession\n");
rv = (func_list->C_OpenSession) (slot, CKF_SERIAL_SESSION | CKF_RW_SESSION, NULL, NULL, &session_rw);
if (CKR_OK != rv) {
    printf("\nC_OpenSession() failed with %08lx\n", rv);
    goto clean_up;
}
s_done = 1;

printf("[INFO] Azure Cloud HSM – Login with PIN, C_Login\n");
rv = (func_list->C_Login) (session_rw, CKU_USER, (CK_UTF8CHAR_PTR) pPin, n_pin);
if (CKR_OK != rv) {
    printf("[ERROR] Failed C_Login\n");
    goto clean_up;
}

/**********[INSERT CUSTOM P11 APP CODE HERE]**********/

printf("Add Your PKCS#11 Code Here\n");

/**********[END OF CUSTOM P11 APP CODE]**********/

/* Clean Up */
clean_up:
#ifndef USE_FIND_KEY
    if (s_done) {
        if (Private)
            (func_list->C_DestroyObject) (session_rw, Private);
        if (Public)
            (func_list->C_DestroyObject) (session_rw, Public);
        Public = Private = 0;
    }
#endif

if (s_done) {
        /* logout */
        rv = func_list->C_Logout(session_rw);
        if (CKR_OK != rv) {
            printf("\nC_Logout() failed with %08lx\n", rv);
        }

        /* close session */
        rv = func_list->C_CloseSession(session_rw);
        if (CKR_OK != rv) {
            printf("\nC_CloseSession() failed with %08lx\n", rv);
        }
    }

    /* Application Shutdown */
    rv = func_list->C_Finalize(NULL);
    if (CKR_OK != rv) {
        printf("\nC_Finalize() failed with %08lx\n", rv);
    }
    return rv;
}

int main(int argc, char *argv[])
{
    CK_RV rv = 0;
    char *username = NULL;
    char *password = NULL;
    char *libname = NULL;
    char buName = FALSE;
    char bPassword = FALSE;
    char bLibray = FALSE;
    int cmd_options = 0;

    if (argc < 7) {
        printf("\nMissing arguments: The format is %s -s <username> -p <password> -l <pkcs-lib> \n\n", argv[0]);
    return 0;
}

if (argc > 7) {
    printf("\nToo many arguments: The format is %s -s <username> -p <password> -l <pkcs-lib>\n\n", argv[0]);
    return 0;
}

while ((cmd_options = getopt(argc, argv,"s:p:l:")) != -1) {
    switch (cmd_options) {
        case 's' : username = optarg;
            buName = TRUE;
            break;
        case 'p' : password = optarg;
            bPassword = TRUE;
            break;
        case 'l' : libname = optarg;
            bLibray = TRUE;
            break;
        default: printf("\nWrong arguments: The format is %s -s <username> -p <password> -l <pkcs-lib>\n\n",argv[0]);
            return 0;
    }
}

if (!buName || !bPassword || !bLibray) {
    printf("\nWrong arguments: The format is %s -s <username> -p <password> -l <pkcs-lib>> \n\n", argv[0]);
    return 0;
}

if (load_lib(libname)) {
    printf("\n Error: loading library %s\n ", libname);
    rv = 0;
    goto end;
}
```

```
  if (!module) {
    printf("\n Error: module loading failure %s\n ", libname);
    rv = 0;
    goto end;
  }

  /* prepare the pPin with given username and password */
  printf("[INFO] Azure Cloud HSM – Preparing PIN with given username and password.\n");
  snprintf(pPin, sizeof(pPin), "%s:%s", username, password);

  rv = main_func();
  if (rv != CKR_OK) {
    printf("Error while running the tests\n");
  }

  end:
    lib_close();
    exit(0);
}
```

Appendix

Frequently Asked Questions

- **C_Login failed with error code: 0xa3.**
    - Encountering (0xa3) indicates a login failure that the issue might be related to the format of the PIN parameter you’re passing or incorrect PIN (password).

        - The PIN should be provided in the following format: char pPin[256] = "crypto_user:user123"; The pPin value should follow the structure of "<username>:<password>". Please verify that you are providing the pPin in this format, as any deviation might result in a login failure.

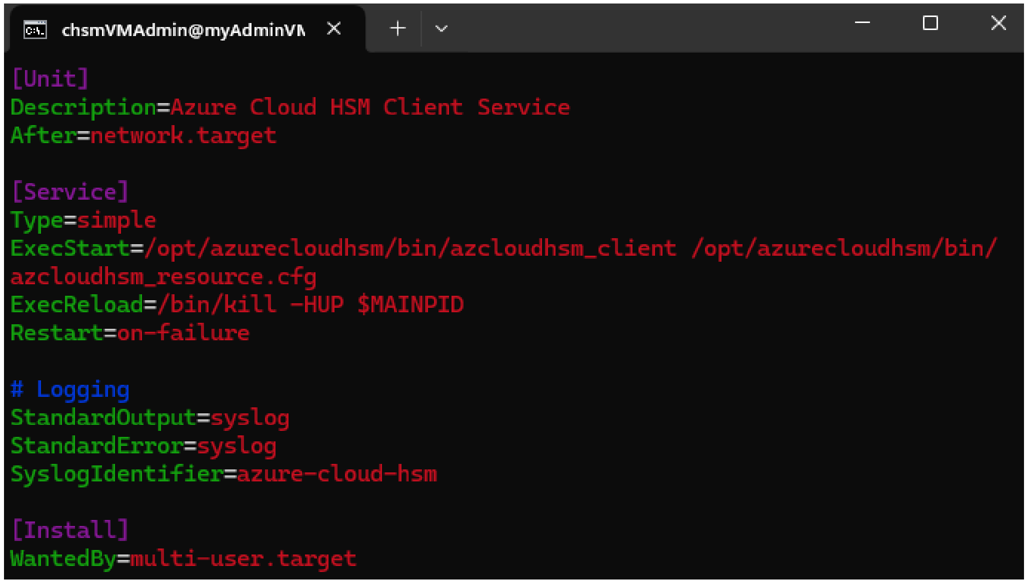
- **C_Initialize() failed with 00000005 (Failed to connect socket).**
    - Encountering a failed socket connection during C_Initialize might be related to the azcloudhsm_client not running on your system. For your PKCS#11 applications to execute successfully the azcloudhsm_client must be running. You can start the azcloudhsm_client by ensuring its running as a service or by manually running the following command in a separate terminal.

      Linux (Recommended):
      If you installed the Azure Cloud HSM SDK using deb or rpm, the client is not configured automatically to run as a service. The SDK during installation includes a service unit file under /etc/systemd/system/azure-cloud-hsm.service. To enable *azcloudhsm_client* to run as a service you will need to use the predefined azure-cloud-hsm.service file. You will then need to reload the Systemd configuration and enable the service to ensure its continuously running by performing the following steps.

      1. Open a terminal window and change directory to /etc/systemd/system where the Cloud HSM service unit file is located.

         ```
         cd /etc/systemd/system
         ```

         Example: azure-cloud-hsm.service



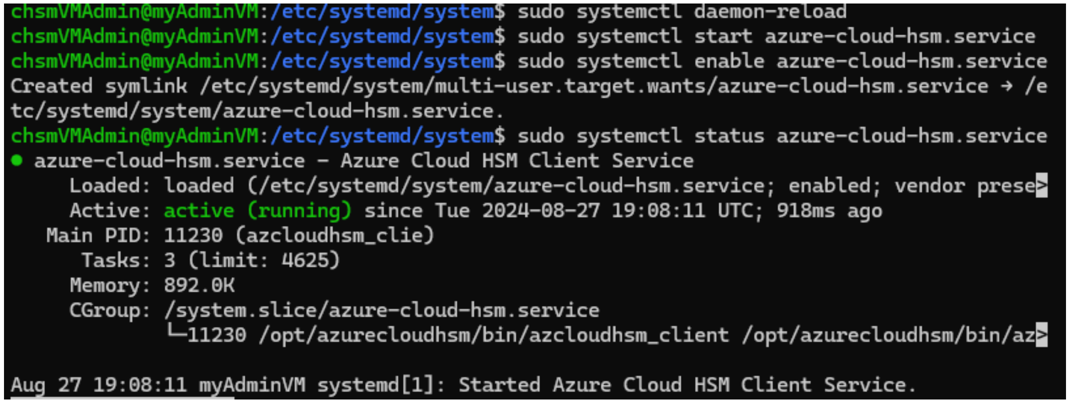
```
[Unit]
Description=Azure Cloud HSM Client Service
After=network.target

[Service]
Type=simple
ExecStart=/opt/azurecloudhsm/bin/azcloudhsm_client /opt/azurecloudhsm/bin/
azcloudhsm_resource.cfg
ExecReload=/bin/kill -HUP $MAINPID
Restart=on-failure

# Logging
StandardOutput=syslog
StandardError=syslog
SyslogIdentifier=azure-cloud-hsm

[Install]
WantedBy=multi-user.target
```

2. Start and Enable the Cloud HSM Client service

```
sudo systemctl start azure-cloud-hsm.service
sudo systemctl enable azure-cloud-hsm.service
```

3. Check status of the Cloud HSM Client service

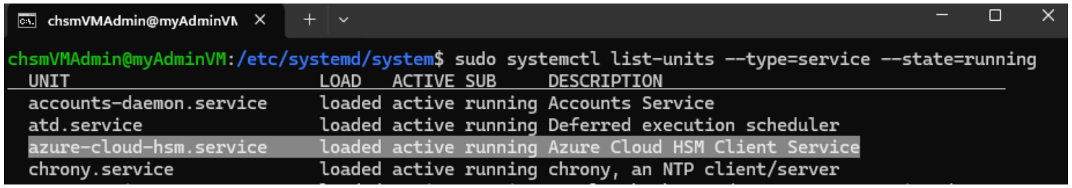
```
sudo systemctl status azure-cloud-hsm.service
```



```
chsmVMAdmin@myAdminVM:/etc/systemd/system$ sudo systemctl daemon-reload
chsmVMAdmin@myAdminVM:/etc/systemd/system$ sudo systemctl start azure-cloud-hsm.service
chsmVMAdmin@myAdminVM:/etc/systemd/system$ sudo systemctl enable azure-cloud-hsm.service
Created symlink /etc/systemd/system/multi-user.target.wants/azure-cloud-hsm.service → /e
tc/systemd/system/azure-cloud-hsm.service.
chsmVMAdmin@myAdminVM:/etc/systemd/system$ sudo systemctl status azure-cloud-hsm.service
● azure-cloud-hsm.service - Azure Cloud HSM Client Service
     Loaded: loaded (/etc/systemd/system/azure-cloud-hsm.service; enabled; vendor prese>
     Active: active (running) since Tue 2024-08-27 19:08:11 UTC; 918ms ago
   Main PID: 11230 (azcloudhsm_clie)
      Tasks: 3 (limit: 4625)
     Memory: 892.0K
     CGroup: /system.slice/azure-cloud-hsm.service
             └─11230 /opt/azurecloudhsm/bin/azcloudhsm_client /opt/azurecloudhsm/bin/az>

Aug 27 19:08:11 myAdminVM systemd[1]: Started Azure Cloud HSM Client Service.
```

4. Reload the Systemd configuration

```
sudo systemctl daemon-reload
sudo systemctl list-units --type=service --state=running
```



```
chsmVMAdmin@myAdminVM:/etc/systemd/system$ sudo systemctl list-units --type=service --state=running
  UNIT                       LOAD   ACTIVE SUB     DESCRIPTION
  accounts-daemon.service    loaded active running Accounts Service
  atd.service                loaded active running Deferred execution scheduler
  azure-cloud-hsm.service    loaded active running Azure Cloud HSM Client Service
  chrony.service             loaded active running chrony, an NTP client/server
```

Linux (Manual):

Start the client daemon if it is not running.

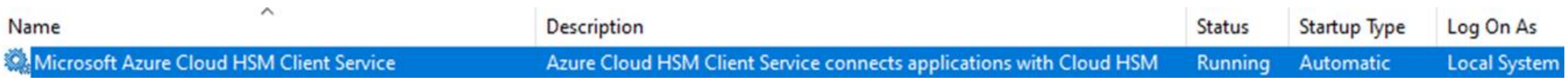
```
cd /opt/azurecloudhsm/bin
sudo ./azcloudhsm_client azcloudhsm_resource.cfg
```

You may also choose as an option with Linux to run the client daemon in the background using the following command.

```
sudo ./azcloudhsm_client azcloudhsm_resource.cfg > /dev/null 2>&1 &
```

Windows (Recommended):

If you installed the Azure Cloud HSM SDK using MSI, the client is already configured to run as a service. If the client is not running, you can open Services.msc, right-click on the Microsoft Azure Cloud HSM Client Service, and select "Start."



Name	Description	Status	Startup Type	Log On As
Microsoft Azure Cloud HSM Client Service	Azure Cloud HSM Client Service connects applications with Cloud HSM	Running	Automatic	Local System

Windows (Manual):

Start the client daemon if it is not running.

```
cd C:\Program Files\Microsoft Azure Cloud HSM Client SDK
.\azcloudhsm_client.exe .\azcloudhsm_resource.cfg
```

- **azcloudhsm_application.cfg is not present (Cannot find file).**
  - The file location of the azcloudhsm_application.cfg is different for Linux and Windows. You may need to copy the azcloudhsm_application.cfg file from the default location below to the location of the PKCS#11 application you are running. They should both exist in the same directly.
    - **Linux File Location:** /opt/azurecloudhsm/bin
    - **Windows File Location:** C:\Program Files\Microsoft Azure Cloud HSM Client SDK\utils\azcloudhsm_util\azcloudhsm_application.cfg

- **How does the PKCS#11 library know how to find the client configuration for Linux.**
  - The PKCS#11 library knows how to find the client configuration as you must have a copy of your partition owner certificate "PO.crt" on the application server that is running your application and using the PKCS#11 library. In addition to PO certificate you have to update azcloudhsm_resource.cfg on your application server that has the SDK installed to point to your Azure Cloud HSM (i.e hsm1.chsm-<resourcename>-<uniquestring>.privatelink.cloudhsm.azure.net). The azcloudhsm_client must be running on your application server which connects to your Azure Cloud HSM. Finally, you must specify a PIN within your PKCS#11 application using syntax <username>:<password> which is used when calling C_Login to your Azure Cloud HSM.

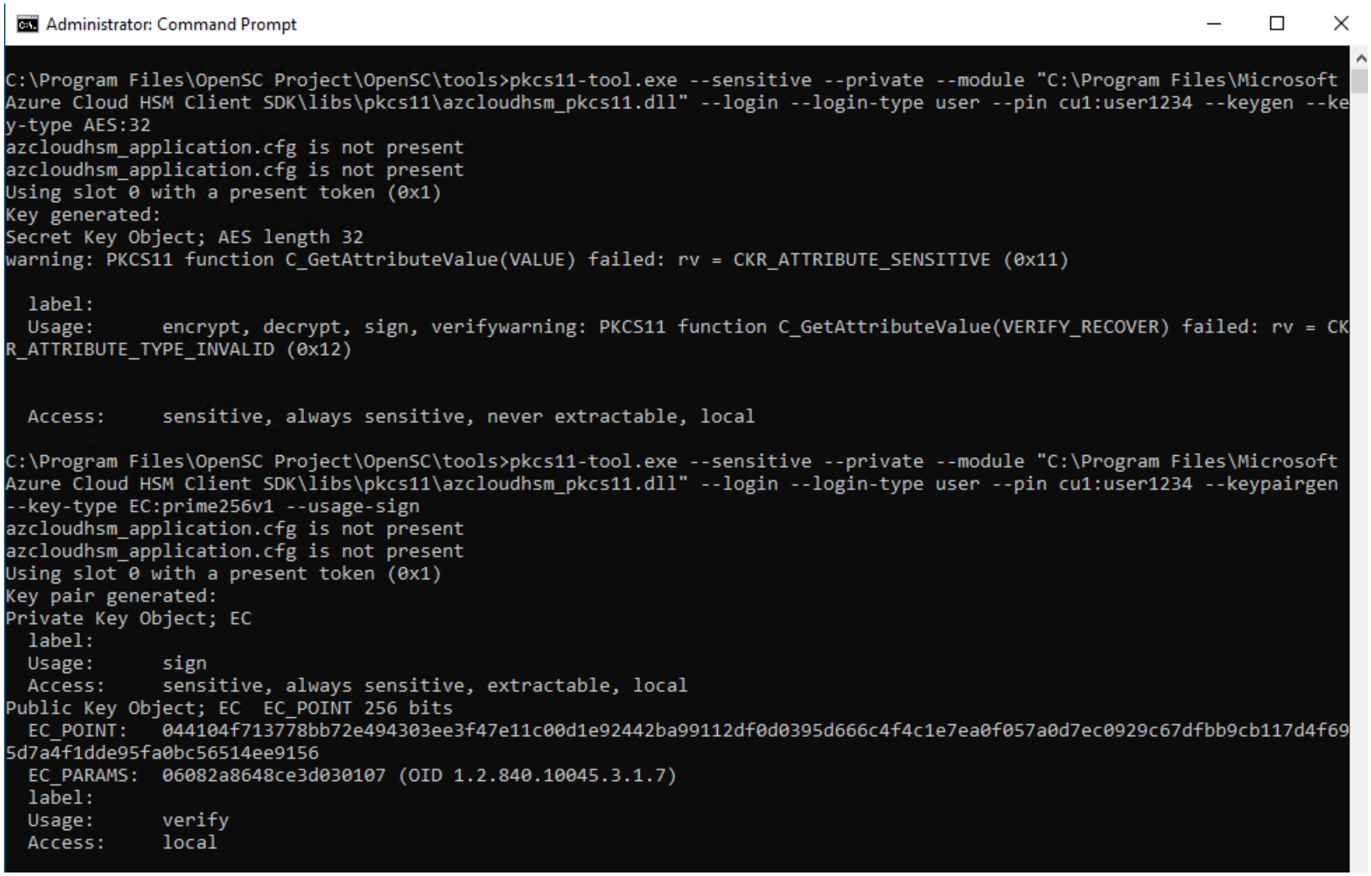
  - You will need to #include pkcs11_headers/include/cryptoki.h and pkcs11_headers/include/pkcs11t.h in your PKCS#11 application to use the Azure Cloud HSM PKCS#11 library.

- **How does the PKCS#11 library (azcloudhsm_pkcs11.dll) for Windows know how to find the client configuration?**
  - The azcloudhsm_pkcs11.dll under Azure Cloud HSM Windows SDK knows how to find the client configuration as you must have a copy of your partition owner certificate "PO.crt" on the application server that is running your application and using the PKCS#11 library. In addition to PO certificate you have to update azcloudhsm_resource.cfg on your application server that has the SDK installed to point to your Azure Cloud HSM (i.e hsm1.chsm-<resourcename>-<uniquestring>.privatelink.cloudhsm.azure.net). The azcloudhsm_client must run on your application server which connects to

your Azure Cloud HSM. Finally, you must specify a PIN within your PKCS#11 application using syntax <username>:<password> which is used when calling C_Login to your Azure Cloud HSM.

  - You will need to #include pkcs11_headers\include\cryptoki.h and pkcs11_headers\include\pkcs11t.h in your PKCS#11 application to use the Azure Cloud HSM PKCS#11 library.

- **How does the PKCS#11 library (azcloudhsm_pkcs11.dll) integrate with OpenSC (Open-Source Smart Card Tools)?**
  Download OpenSC MSI for Windows: OpenSC: Open source smart card tools and middleware. PKCS#11/MiniDriver/Tokend (github.com)
  - Customers must use the “--sensitive" and "--private" arguments when using OpenSC tools as the sensitive and private attributes are not allowed to be 0. Without using those arguments, the sensitive and private attributes are set to 0 by OpenSC tooling and will cause an exception as Azure Cloud HSM always imposes sensitive and private behavior.
    - *AES Wrapping Example: pkcs11-tool.exe --sensitive --private --module "C:\Program Files\Microsoft Azure Cloud HSM Client SDK\libs\pkcs11\azcloudhsm_pkcs11.dll" --login --login-type user --pin cu1:user1234 --keygen --key-type AES:32*
    - *ECC P521 Example: pkcs11-tool.exe --sensitive --private --module "C:\Program Files\Microsoft Azure Cloud HSM Client SDK\libs\pkcs11\azcloudhsm_pkcs11.dll" --login --login-type user --pin cu1:user1234 --keypairgen --key-type EC:prime256v1 --usage-sign*



```
C:\Program Files\OpenSC Project\OpenSC\tools>pkcs11-tool.exe --sensitive --private --module "C:\Program Files\Microsoft
Azure Cloud HSM Client SDK\libs\pkcs11\azcloudhsm_pkcs11.dll" --login --login-type user --pin cu1:user1234 --keygen --ke
y-type AES:32
azcloudhsm_application.cfg is not present
azcloudhsm_application.cfg is not present
Using slot 0 with a present token (0x1)
Key generated:
Secret Key Object; AES length 32
warning: PKCS11 function C_GetAttributeValue(VALUE) failed: rv = CKR_ATTRIBUTE_SENSITIVE (0x11)

  label:
  Usage:      encrypt, decrypt, sign, verifywarning: PKCS11 function C_GetAttributeValue(VERIFY_RECOVER) failed: rv = CK
R_ATTRIBUTE_TYPE_INVALID (0x12)


  Access:     sensitive, always sensitive, never extractable, local

C:\Program Files\OpenSC Project\OpenSC\tools>pkcs11-tool.exe --sensitive --private --module "C:\Program Files\Microsoft
Azure Cloud HSM Client SDK\libs\pkcs11\azcloudhsm_pkcs11.dll" --login --login-type user --pin cu1:user1234 --keypairgen
--key-type EC:prime256v1 --usage-sign
azcloudhsm_application.cfg is not present
azcloudhsm_application.cfg is not present
Using slot 0 with a present token (0x1)
Key pair generated:
Private Key Object; EC
  label:
  Usage:      sign
  Access:     sensitive, always sensitive, extractable, local
Public Key Object; EC  EC_POINT 256 bits
  EC_POINT:   044104f713778bb72e494303ee3f47e11c00d1e92442ba99112df0d0395d666c4f4c1e7ea0f057a0d7ec0929c67dfbb9cb117d4f69
5d7a4f1dde95fa0bc56514ee9156
  EC_PARAMS:  06082a8648ce3d030107 (OID 1.2.840.10045.3.1.7)
  label:
  Usage:      verify
  Access:     local
```

PKCS#11 Specifications

Unsupported Key Types and Mechanisms

- Sign Recover and Verify Recover functions are not supported.
- CKM_RSA_X_509 is not supported currently for Azure Cloud HSM.

Supported Key Types

The Azure Cloud HSM PKCS#11 library supports the following key types and sizes.

Key Type	Description
RSA	1024 - 4096-bit modulus in steps of 256 bits. • Key generation of 1024 modulus size key is supported only in non-FIPS mode of operation.
ECDSA	Curves supported: secp192r1 (P-192), secp224r1 (P-224), secp256r1 (P-256), secp256k1 (blockchain), secp384r1 (P-384), and secp521r1 (P-521) for key generation. • Only Curves P-256 and P-384 are supported for sign/verify. • P-192 and P-521 for ECDH key derivation are supported only in non-FIPS mode of operation.
AES	128, 192, and 256 bits.
Triple DES (3DES)	192 bits
DES	64 bits • Supported only in non-FIPS mode of operation.
RC4	1 - 256 bytes • Supported only in non-FIPS mode of operation.
GENERIC_SECRET	1 – 3072 bytes

Supported Mechanisms

To invoke a cryptographic feature using PKCS#11, call a function with a given mechanism. The following sections summarize the combinations of functions and mechanisms supported by Azure Cloud HSM.

The Azure Cloud HSM PKCS#11 library supports the following algorithms:

- **Encryption and decryption –** AES-CBC, AES-CTR, AES-ECB, AES-GCM, DES3-CBC, DES3-ECB, RSA-OAEP, and RSA-PKCS
- **Sign and verify –** RSA, HMAC, and ECDSA, with and without hashing.
- **Hash/digest –** SHA1, SHA224, SHA256, SHA384, and SHA512
- **Key wrap –** AES Key Wrap, AES-GCM, RSA-AES, and RSA-OAEP

Supported Key Generation Mechanisms

Mechanism	Min Key Length	Max Key Length	Algorithm	Mode
CKM_RC4_KEY_GEN	1 byte	256 bytes	RC4	STREAM
CKM_GENERIC_SECRET_KEY_GEN	1 byte	800 bytes	None	None
CKM_DES3_KEY_GEN	192 bits	192 bits	DES3	None
CKM_AES_KEY_GEN	128 bits	256 bits	AES	None
CKM_RSA_X9_31_KEY_PAIR_GEN	2048 bits	4098 bits	RSA	None
CKM_RSA_PKCS_KEY_PAIR_GEN	2048 bits	4098 bits	RSA	None
CKM_EC_KEY_PAIR_GEN	256 bits	521 bits	ECDSA	None

** The mechanism CKM_EC_KEY_PAIR_GEN must be used to generate Ed25519 and X25519 key pairs*

Supported Key Encryption/Decryption Mechanisms

Mechanism	Min Key Length	Max Key Length	Algorithm	Mode
CKM_DES_CBC	64 bits	64 bits	DES	CBC
CKM_DES_CBC_PAD	64 bits	64 bits	DES	CBC_PAD
CKM_DES3_CBC	192 bits	192 bits	DES3	CBC
CKM_DES3_CBC_PAD	192 bits	192 bits	DES3	CBC_PAD
CKM_DES3_ECB	192 bits	192 bits	DES3	ECB
CKM_RC4	8 bits	2048 bits	RC4	None
CKM_AES_CBC	128 bits	256 bits	AES	CBC
CKM_AES_CBC_PAD	128 bits	256 bits	AES	CBC_PAD
CKM_AES_ECB	128 bits	256 bits	AES	ECB
CKM_AES_CTR	128 bits	256 bits	AES	CTR
CKM_AES_GCM	128 bits	256 bits	AES	GCM
CKM_CLOUDHSM_AES_GCM	128 bits	256 bits	*	GCM
CKM_RSA_PKCS	2048 bits	4098 bits	RSA	None
CKM_RSA_PKCS_OAEP	2048 bits	4098 bits	RSA	None
CKM_AES_KEY_WRAP	128 bits	256 bits	AES	None
CKM_AES_KEY_WRAP_PAD	128 bits	256 bits	AES	None
CKM_AES_KEY_WRAP_NO_PAD	128 bits	256 bits	AES	None

CKM_AES_KEY_WRAP_PKCS5_PAD	128 bits	256 bits	AES	None

* The mechanism CKM_DES_CBC, CKM_DES_CBC_PAD and CKM_RC4 are supported in non-FIPS mode only. CKM_CLOUDHSM_AES_GCM is a proprietary mechanism and programmatically safer alternative to the standard CKM_AES_GCM.

Supported Sign/Verify Mechanisms

Mechanism	**Min Key Length**	**Max Key Length**	**Algorithm**	**Mode**
CKM_MD5_RSA_PKCS	1024 bits	4098 bits	RSA	None
CKM_SHA1_RSA_PKCS	2048 bits	4098 bits	RSA	SHA1
CKM_SHA224_RSA_PKCS	2048 bits	4098 bits	RSA	SHA224
CKM_SHA256_RSA_PKCS	2048 bits	4098 bits	RSA	SHA256
CKM_SHA384_RSA_PKCS	2048 bits	4098 bits	RSA	SHA384
CKM_SHA512_RSA_PKCS	2048 bits	4098 bits	RSA	SHA512
CKM_RSA_PKCS_PSS	2048 bits	4098 bits	RSA	None
CKM_SHA1_RSA_PKCS_PSS	2048 bits	4098 bits	RSA	SHA1
CKM_SHA224_RSA_PKCS_PSS	2048 bits	4098 bits	RSA	SHA224
CKM_SHA256_RSA_PKCS_PSS	2048 bits	4098 bits	RSA	SHA256
CKM_SHA384_RSA_PKCS_PSS	2048 bits	4098 bits	RSA	SHA384
CKM_SHA512_RSA_PKCS_PSS	2048 bits	4098 bits	RSA	SHA512
CKM_ECDSA	256 bits	384 bits	ECDSA	None
CKM_ECDSA_SHA224	256 bits	384 bits	ECDSA	SHA224
CKM_ECDSA_SHA256	256 bits	384 bits	ECDSA	SHA256
CKM_ECDSA_SHA384	256 bits	384 bits	ECDSA	SHA384
CKM_ECDSA_SHA512	256 bits	384 bits	ECDSA	SHA512
CKM_SHA_1_HMAC	8 bits	800 bits	SHA1	HMAC
CKM_SHA224_HMAC	8 bits	800 bits	SHA224	HMAC
CKM_SHA256_HMAC	8 bits	800 bits	SHA256	HMAC
CKM_SHA384_HMAC	8 bits	800 bits	SHA384	HMAC
CKM_SHA512_HMAC	8 bits	800 bits	SHA512	HMAC

* The mechanism CKM_MD5_RSA_PKCS is supported in non-FIPS mode only.

Supported Key Hash/Digest Mechanisms

Mechanism	Min Key Length	Max Key Length	Algorithm	Supported Functions
CKM_SHA_1	N/A	N/A	SHA	Digest
CKM_SHA224	N/A	N/A	SHA224	Digest
CKM_SHA256	N/A	N/A	SHA256	Digest
CKM_SHA384	N/A	N/A	SHA384	Digest
CKM_SHA512	N/A	N/A	SHA512	Digest

Supported Key Wrap Mechanisms

Mechanism	Min Key Length	Max Key Length	Algorithm	Mode
CKM_AES_CBC	128 bits	256 bits	AES	Keywrap
CKM_AES_CBC_PAD	128 bits	256 bits	AES	Keywrap
CKM_AES_GCM	128 bits	256 bits	AES	Keywrap
CKM_AES_KEY_WRAP	128 bits	256 bits	AES	Keywrap
CKM_AES_KEY_WRAP_PAD	128 bits	256 bits	AES	Keywrap_pad
CKM_AES_KEY_WRAP_NO_PAD	128 bits	256 bits	AES	Keywrap
CKM_AES_KEY_WRAP_PKCS5_PAD	128 bits	256 bits	AES	Keywrap
CKM_RSA_AES_KEY_WRAP	2048 bits	4098 bits	RSA	Keywrap
CKM_DES3_NIST_WRAP	192 bits	192 bits	DES	None
CKM_RSA_PKCS	2048 bits	4096 bits	AES	Keywrap
CKM_RSA_PKCS_OAEP	2048 bits	4096 bits	AES	Keywrap

** The mechanism CKM_AES_CBC and CKM_AES_CBC_PAD support Unwrap in FIPS mode, and Wrap/Unwrap in non-FIPS mode.*

Supported Key Derivation Mechanisms

The Azure Cloud HSM PKCS#11 library allows you to use the following mechanisms for Derive functions.

- CKM_ECDH1_DERIVE
- CKM_SP800_108_COUNTER_KDF

Supported API Operations

The Azure Cloud HSM PKCS#11 library supports the following PKCS#11 API operations.

Function	PKCS#11 API	Description
General Purpose	C_Initialize	Initializes the key
	C_finalize	Cleans up miscellaneous Cryptoki-associated resources.
	C_GetInfo	Obtains general information about Cryptoki.
	C_GetFunctionList	Obtains the entry point.
Slot and Token Management	C_GetSlotInfo	Obtains information about a particular slot.
	C_GetTokenInfo	Obtains information about a particular token.
	C_GetMechanismList	Obtains a list of mechanisms supported by a token.
	C_GetMechanismInfo	Obtains information about a particular mechanism.
Session Management	C_OpenSession	Opens a connection between an application and a particular token or set up an application call azcloudhsm_client.
	C_CloseSession	Close a session
	C_CloseAllSessions	Close all sessions with a token.
	C_Login	Logs in to a token.
	C_Logout	Logs out from a token.
	C_GetSessionInfo	Gets session information.
Object Management	C_CreateObject	Creates an object.
	C_CopyObject	Copies an object.
	C_DestroyObject	Destroys an object.
	C_GetAttributeValue	Obtains an attribute value of an object.
	C_FindObjectsInit	Initializes an object search operation.
	C_FindObjects	Continues an object search operation.
	C_FindObjectsFinal	Finishes an object search operation.
Encryption	C_EncryptInit	Initializes an encryption operation
	C_Encrypt	Encrypts single-part data.
	C_EncryptUpdate	Continues a multiple-part encryption operation
	C_EncryptFinal	Finishes a multiple-part encryption operation.
Decryption	C_DecryptInit	Initializes a decryption operation.
	C_Decrypt	Decrypts single-part data.

	C_DecryptUpdate	Continues a multiple-part decryption operation.
	C_DecryptFinal	Finishes a multiple-part decryption operation.
Message Digest	C_DigestInit	Initializes a message-digesting operation.
	C_Digest	Digests single-part data.
	C_DigestUpdate	Continues a multiple-part digesting operation.
	C_DigestFinal	Finishes a multiple-part digesting operation.
Signing and MAC	C_SignInit	Initializes a signature operation.
	C_Sign	Signs single-part data.
	C_SignUpdate	Continues a multiple-part signature operation.
	C_SignFinal	Finishes a multiple-part signature operation.
	C_SignRecoverInit	Initializes a signature operation, where the data can be recovered from the signature.
	C_SignRecover	Signs single-part data, where the data can be recovered from the signature.
Verifying Signatures and MAC	C_VerifyInit	Initializes a verify operation.
	C_Verify	Verifies a signature on single-part data.
	C_VerifyUpdate	Continues a multiple part verify operation
	C_VerifyFinal	Finishes a multiple-part verification operation.
	C_VerifyRecoverInit	Initializes a verification operation where the data is recovered from the signature
	C_VerifyRecover	Verifies a signature on single-part data, where the data is recovered from the signature.
Random Number Generators	C_SeedRandom	Mixes in additional seed material to the random number generator.
	C_GenerateRandom	Generates random data.
Parallel Functions	C_GetFunctionStatus	Obtains updated status of a function running in parallel with an application.
	C_CancelFunction	Cancels a function running in parallel.
Key Management	C_GenerateKey	Generates a secret key.
	C_GenerateKeyPair	Generates a public-key/private-key pair.
	C_WrapKey	Wraps (encrypts) a key.
	C_UnwrapKey	Unwarps (decrypts) a key.
	C_DeriveKey	Derives a key from a base key.

Supported Attributes

A key object can be a public, private, or secret key. Actions permitted on a key object are specified through attributes. Attributes are defined when the key object is created. When you use the Azure Cloud HSM PKCS#11 library, we assign default values as specified by the PKCS#11 standard.

Azure Cloud HSM does not support all attributes listed in the PKCS#11 specification. We are compliant with the specification for all attributes we support. These attributes are listed in the respective tables.

The PKCS#11 library table contains a list of attributes that differ by key types. It indicates whether a given attribute is supported for a particular key type when using a specific cryptographic function with Azure Cloud HSM.

Attribute	Firmware Stores	Description	Can be changed after object creation.	Default Value
CKA_SIGN	Yes	Boolean type CK_TRUE if key supports signatures	Yes	FALSE
CKA_SIGN_RECOVER	Yes	CK_TRUE if key supports signatures where the data can be recovered from the signature. Only applicable to private keys. If ND (Not Defined), value is inherited from CKA_SIGN	Yes	FALSE
CKA_VERIFY	Yes	Boolean type CK_True if key supports verification.	Yes	FALSE
CKA_VERIFY_RECOVER	Yes	CK_TRUE if key supports verification where data is recovered from the signature. Only applicable to public keys. If ND, value is inherited from CKA_SIGN	Yes	FALSE
CKA_ENCRYPT	Yes	Boolean type. CK_TRUE if key supports encryption.	Yes	FALSE
CKA_DECRYPT	Yes	Boolean type. CK_TRUE if key supports decryption.	Yes	FALSE
CKA_WRAP	Yes	Boolean type. CK_TRUE if key supports wrapping.	Yes	FALSE

CKA_UNWRAP	Yes	Boolean type. CK_TRUE if key supports unwrapping.	Yes	FALSE
CKA_LABEL	Yes	Description of the object.	Yes	NA
CKA_ID	Yes	Byte array; key identifier for key.	No	NA
CKA_CHECK_VALUE	Yes	Byte array; KeyChecksum	No	NA
CKA_CLASS	Yes	Object class	No	NA
CKA_LOCAL	Yes	Boolean type. TRUE is key was generated locally.	No	Derived
CKA_EXTRACTABLE	Yes	Boolean type. TRUE if key is extractable and can be wrapped.	No	TRUE
CKA_EC_PARAMS	Yes		No	NA
CKA_EC_POINT	Yes	Supported only for create public key.	No	NA
CKA_PRIVATE_ EXPONENT	Yes	Private exponent d. Supported only for create private object.	No	NA
CKA_SENSITIVE	Yes	TRUE if key is sensitive.	Yes	TRUE (returns the value from firmware)
CKA_DERIVE	Yes	CK_TRUE if key supports key derivation. This attribute is used to derive another key from the input key. This attribute must be FALSE for all public keys and cannot be set to TRUE. For secret and EC private keys, this can be TRUE or FALSE	Yes	From firmware TRUE, but from PKCS#11 FALSE
CKA_TRUSTED	Yes	Can be set to TRUE or FALSE by CO only. The key can be trusted for the application that it was created.	Yes	FALSE
CKA_NEVER_EXTRACTABLE	Yes	Returns the value set by the firmware.	No	TRUE for private and secret keys FALSE for public keys

CKA_ALWAYS_SENSITIVE	Yes	CK_TRUE if key has always had the CKA_SENSITIVE attribute set to CK_TRUE.	No	TRUE
CKA_WRAP_WITH_TRUSTED	Yes	Can be set from FALSE to TRUE but cannot be changed after set to TRUE. CK_TRUE if the key can only be wrapped with a wrapping key that has CKA_TRUSTED set to CK_TRUE.	Depends on initial value.	FALSE
CKA_DESTROYABLE	Yes	Can be set to TRUE or FALSE. CK_TRUE if the object can be destroyed using C_DestroyObject. Note this attribute is not applied to session keys. This is a deviation from the specification.	Yes	TRUE
CKA_WRAP_TEMPLATE	Yes	his attribute is not applied to session keys. This is a deviation from the specification.	Yes	Not defined (returns the value from firmware)
CKA_UNWRAP_TEMPLATE	Yes	For wrapping keys. The attribute template to apply to any keys unwrapped using this wrapping key. Any user-supplied template is applied after this template as if the object has already been created.	Yes	Not defined (returns the value from firmware)
CKA_SUBJECT	No	DER-encoding of the certificate subject name.	No	NA
CKA_OBJECT_ID	No	DER-encoding of the object identifier indicating the data object type.	No	NA
CKA_APPLICATION	No	Description of the application that manages the object.	No	NA
CKA_START_DATE	No	Start date for the key.	No	NA
CKA_END_DATE	No	End date for the key.	No	NA
CKA_KEY_GEN_MECHANISM	No	Identifier for the mechanism used to generate the key material.	No	NA

CKA_ALLOWED_MECHANISMS	No	A list of mechanisms allowed to be used with this key	No	NA
CKA_ALWAYS_AUTHENTICATE	No	If CK_TRUE, the user must supply the PIN for each use (sign or decrypt) with the key.	No	NA
CKA_MODIFIABLE	No	CK_TRUE if object can be modified; default is CK_TRUE	No	NA
CKA_PUBLIC_KEY_ INFO	Yes	DER-encoding of the SubjectPublicKeyInfo for the public key contained in this certificate.	No	NA
CKA_COPYABLE	No	CK_TRUE if object can be copied using C_CopyObject. Defaults to CK_TRUE	No	NA
CKA_PRIME_1	No	Prime p.	No	NA
CKA_PRIME_2	No	Prime q.	No	NA
CKA_EXPONENT_1	No	Private exponent d modulo p-1.	No	NA
CKA_EXPONENT_2	No	Private exponent d modulo q-1.	No	NA
CKA_PRIME	No		No	NA
CKA_SUBPRIME	No		No	NA
CKA_BASE	No		No	NA
CKA_PRIME_BITS	No		No	NA
CKA_SUBPRIME_BITS	No		No	NA
CKA_SUB_PRIME_BIT	No		No	NA
CKA_TOKEN	No	CK_TRUE if object is a token object; CK_FALSE if object is a session object	No	FALSE
CKA_VALUE_BITS	No		No	NA
CKA_VALUE_LEN	No		No	NA
CKA_DERIVE_TEMPLATE	No		No	NA
CKA_MECHANISM_TYPE	No		No	NA