Microsoft Authenticode

nShield® HSM Integration Guide

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Chapter 1. Introduction

The Entrust nShield Hardware Security Module (HSM) integrates with Microsoft Authenticode to enable you to identify the publisher of a software component before it is downloaded from the Internet, and to verify that no one has altered the code after it has been signed. Authenticode relies on proven cryptographic techniques and the use of one or more private keys to sign and time-stamp the published software. It is important to maintain the confidentiality of these keys.

The benefits of using an HSM with Microsoft Authenticode include:

- Protection for the organizational credentials of the software publisher.
- Secure storage of the private key.
- FIPS 140 Level 3 validated hardware.
- Provision of a trusted timestamp to Authenticode.

1.1. Product configurations

Entrust has successfully tested nShield HSM integration with Microsoft Authenticode in the following configurations:

Product	Version
Base OS	Windows Server 2025
Microsoft .NET Framework	4.8
Windows SDK	10.0.26100

1.2. Supported nShield features

Entrust has successfully tested nShield HSM integration with the following features:

Feature	Support
Operator Card Set (OCS)	Yes
Softcard Protection	Yes
Module Protection	Yes
nSaaS	Yes

Feature	Support
FIPS 140 level 3	Yes

1.3. Supported nShield hardware and software versions

Entrust has successfully tested with the following nShield hardware and software versions:

Product	Security World Software	Firmware	Image
Connect XC	13.6.16	12.72.4 (FIPS 140-2 certified)	13.6.16
nShield 5C	13.6.16	13.4.5 (FIPS 140-3 certified)	13.6.16

1.4. Requirements

Entrust recommends that you familiarize yourself with the Microsoft Authenticode documentation and setup process, and have the nShield documentation available.

Entrust also recommends that the following aspects of HSM administration are taken into account:

- The Administration Card Set (ACS) K-of-N and management of the card set.
- The type of protection for the application keys, that is, module protection or Operator Card Set (OCS) protection.
- The Operator Card Set K-of-N and management of the card set.
- Any requirement for a FIPS 140 Level 3 Security World.
- Key attributes, such as the key size, persistence, and time-out.

Entrust recommends that you allow only unprivileged connections unless you are performing administrative tasks.

1.5. Preface

This document explains how to set up and configure Microsoft Authenticode with an HSM. The instructions in this document have been tested and provide an integration process. There may be other untested ways to achieve interoperability.

This document may not cover every step in the process of setting up all the software.

Entrust assumes you have read the HSM documentation and that you are familiar with the documentation and setup process for Microsoft Authenticode. For more information about installing Microsoft Authenticode, refer to the Microsoft documentation.

1.6. More information

For more information about OS support, contact your Microsoft sales representative or Entrust nShield Support, https://nshieldsupport.entrust.com.

Chapter 2. Procedures

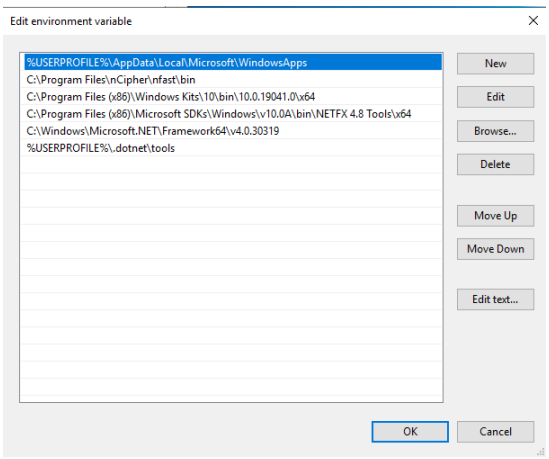
To install and configure Microsoft Authenticode with an HSM:

- Install the Microsoft Windows SDK.
- Install the nShield Security World software and create a Security World.
- Install and register the CNG provider.

The installation procedures outlined here assume, for example purposes, that you are installing an offline root Certificate System. It is also assumed that a new root key is generated during installation, rather than a software key being imported from an existing installation.

2.1. Install the Microsoft tools

1. Install the Microsoft Windows SDK, which contains the Authenticode programs such as `signtool` and `sn` (Strong Name Tool). See the appropriate Microsoft SDK installation documentation.
2. Add the path to the above programs to the Windows Environment Variable, since it might be long.
    - Second line: path to the nShield utilities.
    - Third line: path to the `signtool` utility.
    - Fourth line: path to the `sn` utility.
    - Fifth line: path to the `csc.exe` compiler.



3. Install the PowerShell PKI module:

```
PS C:\Users\Administrator> Get-Command -Module PKI

CommandType     Name                                               Version    Source
```

```
-----------     ----                                            -------    ------
Cmdlet          Add-CertificateEnrollmentPolicyServer           1.0.0.0    PKI
Cmdlet          Export-Certificate                              1.0.0.0    PKI
Cmdlet          Export-PfxCertificate                           1.0.0.0    PKI
Cmdlet          Get-Certificate                                 1.0.0.0    PKI
Cmdlet          Get-CertificateAutoEnrollmentPolicy             1.0.0.0    PKI
Cmdlet          Get-CertificateEnrollmentPolicyServer           1.0.0.0    PKI
Cmdlet          Get-CertificateNotificationTask                 1.0.0.0    PKI
Cmdlet          Get-PfxData                                     1.0.0.0    PKI
Cmdlet          Import-Certificate                              1.0.0.0    PKI
Cmdlet          Import-PfxCertificate                           1.0.0.0    PKI
Cmdlet          New-CertificateNotificationTask                 1.0.0.0    PKI
Cmdlet          New-SelfSignedCertificate                       1.0.0.0    PKI
Cmdlet          Remove-CertificateEnrollmentPolicyServer        1.0.0.0    PKI
Cmdlet          Remove-CertificateNotificationTask              1.0.0.0    PKI
Cmdlet          Set-CertificateAutoEnrollmentPolicy             1.0.0.0    PKI
Cmdlet          Switch-Certificate                              1.0.0.0    PKI
Cmdlet          Test-Certificate                                1.0.0.0    PKI
```

2.2. Install the Security World software and create a Security World

1. Install the Security World software by double-clicking on the `SecWorld_Windows-xx.xx.xx.iso` file. For detailed instructions, see the *Installation Guide* and the *User Guide* for the HSM available from the installation disc.
2. Add the Security World utilities path `C:\Program Files\nCipher\nfast\bin` to the Windows system path.
3. Open the firewall port 9004 for the HSM connections.
4. Install the nShield HSM locally, remotely, or remotely via the serial console. See the following nShield Support articles, and the *Installation Guide* for the HSM:
   - How to locally set up a new or replacement nShield Connect
   - How to remotely set up a new or replacement nShield Connect
   - How to remotely set up a new or replacement nShield Connect XC Serial Console model

   Access to the Entrust nShield Support Portal is available to customers under maintenance. To request an account, contact nshield.support@entrust.com.
5. Open a command window and run the following to confirm that the HSM is `operational`:

```
>enquiry
Server:
 enquiry reply flags  none
 enquiry reply level  Six
 serial number        530E-02E0-D947 7724-8509-81E3 09AF-0BE9-53AA 9E10-03E0-D947
 mode                 operational
```

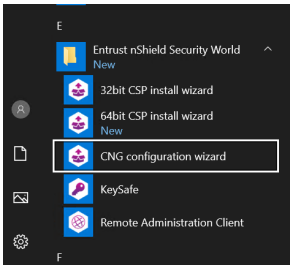
```
...
Module #1:
 enquiry reply flags  none
 enquiry reply level  Six
 serial number        530E-02E0-D947
 mode                 operational
 ...
```

6. Create your Security World if one does not already exist, or copy an existing one. Follow your organization's security policy for this.
7. Confirm that the Security World is `usable`:

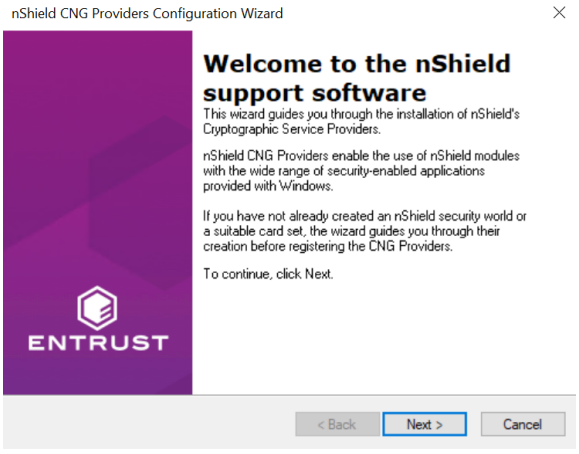
```
>nfkminfoAuthen
 generation  2
 state       0x37270008 Initialised Usable Recovery...
 ...
Module #1
 generation 2
 state      0x2 Usable
 ...
```

2.3. Install and register the CNG provider

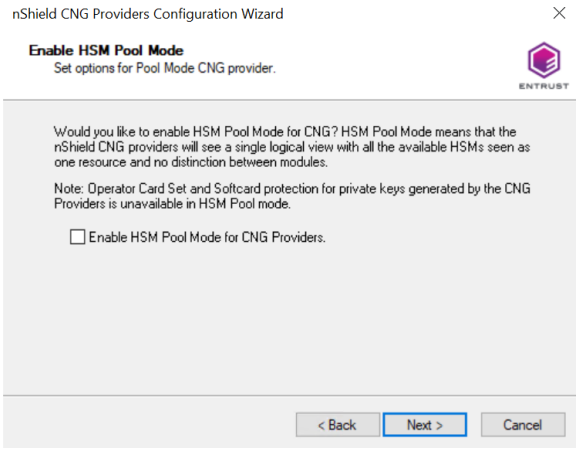
1. Select the **Start** button to access all applications. Look for the recently installed nShield utilities.
2. Double-click the CNG configuration wizard and run it as Administrator.



3. Select **Next** on the **CNG Install** welcome screen.



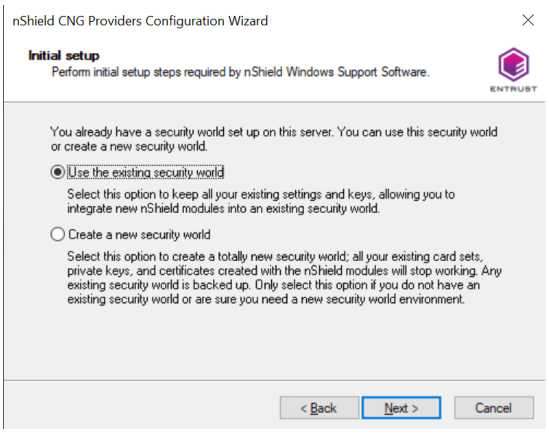
4. Select **Next** on the **Enable HSM Pool Mode** screen. Leave the **Enable HSM Pool Mode for CNG Providers** check box un-checked.



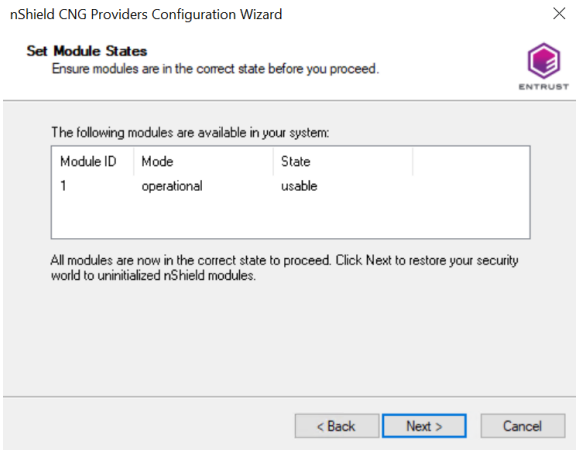
5. At the **Security World** screen, select:
   - **Use the existing security world** if you already have a Security World that you intend to use for this integration. The corresponding `world` and `module_xxxx-xxxx-xxxx` files most be present in the `%NFAST_KMDATA%\local` folder. Be prepared to present the quorum of Administrator cards.
   - **Create a new Security World** if you do not currently have a Security World or would like to create a new Security World.

     For the purposes of this *Integration Guide*, an existing Security World is used. For instructions on how to create and configure a new Security World, see the *Installation Guide* and *User Guide* for your HSM.

   Select **Next**.



6. The **Set Module States** pop-up shows the available HSM(s). Select the desired HSM. The state of the selected HMS should be `operational`. Select **Next**.



7. Select the protection method.
   - Module protection:
     a. In **Key Protection Setup**, select **Softcard protection**, then select **Next**.
   - Operator Card Set protection:
     a. In **Key Protection Setup**, select **Operator Card Set**, then select **Next**.
     b. Enter the OCS name, K of N values, select **Persistent** and **Usable remotely**, then select **Next**.
     c. Insert a blank Operator Card in the HSM.
     d. In **Insert Next Card**, enter a name to for the OCS card, enter the passphrase for the OCS card, then select **Next**.
   - Softcard protection:
     a. In **Key Protection Setup**, select **Softcard protection** , then select **Next**.
     b. In **Token for Key Protection**, select **Create a new Softcard named**, enter the name of the Softcard and the passphrase for the Softcard, then select **Next**.
8. In **Software installation**, select **Next**.

   The nShield CNG providers are installed and the key Storage Provider is registered.
9. Select **Finish**.
10. Open a command window as administrator and type the following to confirm that the KSP has been successfully registered. Look for **nCipher Security World Key Storage Provider**.

```
>cnglist.exe --list-providers
Microsoft Key Protection Provider
Microsoft Passport Key Storage Provider
Microsoft Platform Crypto Provider
Microsoft Primitive Provider
Microsoft Smart Card Key Storage Provider
Microsoft Software Key Storage Provider
Microsoft SSL Protocol Provider
Windows Client Key Protection Provider
```

```
nCipher Primitive Provider
nCipher Security World Key Storage Provider
```

11. Check the registry in `CNGRegistry`:

```
HKEY_LOCAL_MACHINE\SYSTEM\ControlSet001\Control\Cryptography\Providers\nCipherSecurityWorldKeyStorageProvid
er
```

2.4. Generate the Authenticode master key

This key will be protected by the HSM.

1. Launch PowerShell as Administrator, and run `Generate_Authenticode_MasterKey.ps1`:

```
> .\Generate_Authenticode_MasterKey.ps1
```

Script:

```
$cngProviderName = "nCipher Security World Key Storage Provider"

$cngAlgorithmName = "RSA"

$cngKeySize = 2048

$cngKeyName = "Authenticode_MasterKey"

$cngProvider = New-Object System.Security.Cryptography.CngProvider($cngProviderName)

$cngKeyParams = New-Object System.Security.Cryptography.CngKeyCreationParameters

$cngKeyParams.provider = $cngProvider

$cngKeyParams.KeyCreationOptions =
[System.Security.Cryptography.CngKeyCreationOptions]::OverwriteExistingKey

$keySizeProperty = New-Object System.Security.Cryptography.CngProperty(
"Length",[System.BitConverter]::GetBytes($cngKeySize),
[System.Security.Cryptography.CngPropertyOptions]::None);

$cngKeyParams.Parameters.Add($keySizeProperty)

$cngAlgorithm = New-Object System.Security.Cryptography.CngAlgorithm($cngAlgorithmName)

$cngKey = [System.Security.Cryptography.CngKey]::Create($cngAlgorithm, $cngKeyName, $cngKeyParams)
```

2. Enter the credentials associated with the protection method:
    - OCS Card Protection:

      The **Create new key** window appears.

        a. Select **Next**.

The **Select a method to protect new key** window appears.

b. Select **Operator Card Set protection**.
c. Insert the OCS card in the HSM and select **Next**.

The **Select token to protect key with** window appears.

Notice that the OCS name appears in the **Current Operator Card Sets** box.

d. Select **Next**.

The **Choose modules you wish to load the key onto** window appears.

e. Add the HSM and select **Finish**.

A credentials window appears.

f. Enter the OCS passphrase and select **Next**.

The **Card reading complete** window appears.

g. Select **Finish**.

- Softcard protection:

The softcard credentials window appears.

a. Enter the Softcard passphrase.
b. Select **Finish**.

- Module protection:

No window appears for module protection.

A 2048-bit RSA key pair, called `Authenticode_MasterKey`, is generated. The key is encrypted in the HSM, and then pushed to the requesting On-Premise Client server, where it is stored as an Application Key Token in the `%NFAST_KMDATA%\local` folder (`C:\ProgramData\nCipher\Key Management Data\local`).

3. Verify the new key:

```
> nfkminfo -k

Key list - 1 keys
 AppName caping              Ident s-1-5-21-3303772969-3979158951-288552622-500--
006507ceb938e7b01e42954ffd4e2238483710eb
```

4. Display the information about the key by copy-pasting the key name. The protection method is displayed according to the type of protection you are using:

For OCS	Cardset
For Softcard	Passphrase
For Module protection	Module

```
> nfkminfo -k caping s-1-5-21-3303772969-3979158951-288552622-500--006507ceb938e7b01e42954ffd4e2238483710eb
Key AppName caping Ident s-1-5-21-3303772969-3979158951-288552622-500--
006507ceb938e7b01e42954ffd4e2238483710eb
 BlobKA length         1128
 BlobPubKA length      484
 BlobRecoveryKA length 1496
 name                  "Authenticode_MasterKey"
 hash                  3e7a6ad6f44bbbd4b01b798d1846427f6f7cf7a7
 recovery              Enabled
 protection            CardSet
 other flags           PublicKey !SEEAppKey !NVMemBlob +0x0
 cardset               1e7c555a529da8dd3a1d41604e83ce2b2b9032f8
 gentime               2021-04-19 20:18:15
 SEE integrity key     NONE

BlobKA
 format                6 Token
 other flags           0x0
 hkm                   2a2e6b22ad6a72673473511d91304efd2f76e197
 hkt                   1e7c555a529da8dd3a1d41604e83ce2b2b9032f8
 hkr                   none

BlobRecoveryKA
 format                9 UserKey
 other flags           0x0
 hkm                   none
 hkt                   none
 hkr                   fc4cbd1a6e88c08dd35912d0aecabf47ff1e0c2a

BlobPubKA
 format                5 Module
 other flags           0x0
 hkm                   c2be99fe1c77f1b75d48e2fd2df8dffc0c969bcb
 hkt                   none
 hkr                   none

Extra entry #1
 typecode              0x10000 65536
 length                96
Not a blob
```

2.5. Generate the Authenticode signing certificate

A self-signed code signing certificate will be generated for the purpose of this *Integration Guide*.

1. Launch PowerShell as Administrator, and run `Generate_Authenticode_SelfCert.ps1`:

```
> .\Generate_Authenticode_SelfCert.ps1
```

Script:

```
$cngProviderName = "nCipher Security World Key Storage Provider"

$subjectName = "Authenticode Code Signing Certificate"

$friendlyName = "Authenticode_SelfCert"

# locationName = "Cert:\LocalMachine\My"
$locationName = "Cert:\CurrentUser\My"

$containerName = "Authenticode_MasterKey"

New-SelfSignedCertificate -Subject $subjectName -FriendlyName $friendlyName -Type CodeSigningCert
-CertStoreLocation $locationName -Provider $cngProviderName -ExistingKey -Container $containerName
```

2. Enter the credentials associated with the protection method:
   - OCS card protection:

     The **Load key** window appears.

     a. Select **Next**.

        The **Choose modules you wish to load the key onto** window appears.

     b. Add the HSM and select **Finish**.

        A credentials window appears.

     c. Enter the OCS passphrase and select **Next**.

        The **Card reading complete** window appears.

     d. Select **Finish**.
   - Softcard protection:

     The softcard credentials window appears.

     a. Enter the Softcard passphrase.
     b. Select **Finish**.
   - Module protection:

     No pop-up window appears for module protection.
3. When the script completes, the PowerShell command line displays the following information:

```
> PowerShell -ExecutionPolicy Bypass -File Generate_Authenticode_SelfCert.ps1


   PSParentPath: Microsoft.PowerShell.Security\Certificate::CurrentUser\My
```

```
Thumbprint                                Subject
----------                                -------
1974F986D9B8BF32F47FC2AF33D6271DD905C44F  CN=Authenticode Code Signing Certificate
```

4. The self-signed certificate can be viewed at any time in a PowerShell window:

```
> Get-ChildItem -Path Cert:\CurrentUser\My -CodeSigningCert -Recurse


   PSParentPath: Microsoft.PowerShell.Security\Certificate::CurrentUser\My

Thumbprint                                Subject
----------                                -------
1974F986D9B8BF32F47FC2AF33D6271DD905C44F  CN=Authenticode Code Signing Certificate
```

   The certificate can also be viewed with the Windows Certificate Manager.

2.6. Sign and time-stamp the code with Microsoft SDK

The `signtool` utility is used for signing. The Entrust on-line Time Stamp Server (TSS) is used to time stamp.

`signtool` can access the code-signing certificate the following ways:

- Directly from the certificate store with the thumbprint. This is the preferred method.
- By name, for example `Authenticode Code Signing Certificate`.
- By pointing to a `.cer` file that was created by exporting the certificate.

If you plan to access the certificate by pointing to a `.cer` file:

1. Export the certificate to your preferred location in the file system.
2. Launch PowerShell as Administrator, and run `Export_Certificate.ps1`:

```
> .\Export_Certificate.ps1
```

   Script:

```
 $certificate = Get-ChildItem -Path Cert:\CurrentUser\My\ | Where-Object {$_.Subject -eq "CN=Authenticode
Code Signing Certificate"}

 Export-Certificate -FilePath "C:\Users\Administrator\Documents\Authenticode Code Signing Certificate.cer"
-Cert $certificate
```

3. View the exported certificate by right-click on it and selecting **Properties**.
4. An executable called `MyTestApplication.exe` was created for the purpose of this guide.

Sign and time stamp it by running one of the signing scripts provided. There is a script for each protection method. Modify the script as needed.

For all protection methods:

1. Run the required script:
   - OCS card protection:
     a. Run the following script:

```
> .\Sign_with_MS_SDK_OCS.ps1
```

Script:

```
# CNG Provider
#$cngProviderName = "nCipher Security World Key Storage Provider"


# Certificate Key
#$containerName = "Authenticode_MasterKey"


# Certificate Name
#$certName = "Authenticode Code Signing Certificate"
#$certificatePath = "C:\Users\Administrator\Documents\Authenticode Code Signing
Certificate.cer"
$certHash = "9E4748AFB9D8F6C20E3F58C4A308985C5C423BB9"


# OCS Password
#$password = "xxxxxxxxxx"


# Entrust Certificate Services Time Stamp Server
$timestampServer = "http://timestamp.entrust.net/TSS/RFC3161sha2TS"


# File to be Signed
$fileName = "C:\Users\Administrator\Documents\MyTestApplication.exe"


#signtool sign /debug /fd SHA256 /n $certName /td SHA256 /tr $timestampServer $fileName
#signtool sign /debug /fd SHA256 /csp $cngProviderName /kc $containerName /f $certificatePath
/p $password /td SHA256 /tr $timestampServer $fileName
signtool sign /debug /fd SHA256 /sha1 $certHash /td SHA256 /tr $timestampServer $fileName
```

     b. Select the HSM and enter the passphrase when prompted.
   - Softcard protection:
     a. Run the following script:

```
> .\Sign_with_MS_SDK_Softcard.ps1
```

Script:

```
# CNG Provider
$cngProviderName = "nCipher Security World Key Storage Provider"


# Certificate Key
$containerName = "Authenticode_MasterKey"


# Certificate Name
$certName = "Authenticode Code Signing Certificate"
$certificatePath = "C:\Users\Administrator\Documents\Authenticode Code Signing Certificate.cer"

# Softcard Password
$password = "1234"

# Entrust Certificate Services Time Stamp Server
$timestampServer = "http://timestamp.entrust.net/TSS/RFC3161sha2TS"

# File to be Signed
$fileName = "C:\Users\Administrator\Documents\MyTestApplication.exe"

signtool sign /debug /fd SHA256 /csp $cngProviderName /kc $containerName /f $certificatePath /p
$password /td SHA256 /tr $timestampServer $fileName
```

b. Enter the passphrase when prompted.

- Module protection:

a. Run the following script:

```
> .\Sign_with_MS_SDK_Module.ps1
```

Script:

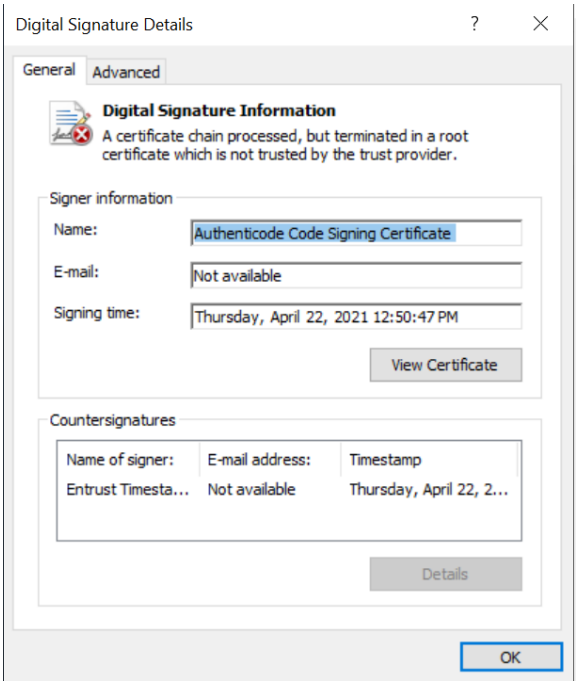
```
# CNG Provider
$cngProviderName = "nCipher Security World Key Storage Provider"


# Certificate Key
$containerName = "Authenticode_MasterKey"


# Certificate Name
$certName = "Authenticode Code Signing Certificate"
$certificatePath = "C:\Users\Administrator\Documents\Authenticode Code Signing Certificate.cer"
#$certHash = "1974f986d9b8bf32f47fc2af33d6271dd905c44f"


# Password
#$password = "123"
#$password = "xxxxxxxxxx"


# Entrust Certificate Services Time Stamp Server
$timestampServer = "http://timestamp.entrust.net/TSS/RFC3161sha2TS"


# File to be Signed
$fileName = "C:\Users\Administrator\Documents\MyTestApplication.exe"
```

```
signtool sign /debug /fd SHA256 /n $certName /td SHA256 /tr $timestampServer $fileName
```

For all protection types, the PowerShell command line displays script output information similar to the following:

```
The following certificates were considered:
    Issued to: Authenticode Code Signing Certificate
    Issued by: Authenticode Code Signing Certificate
    Expires:   Tue Apr 19 17:48:34 2022
    SHA1 hash: 1974F986D9B8BF32F47FC2AF33D6271DD905C44F

After EKU filter, 1 certs were left.
After expiry filter, 1 certs were left.
After Hash filter, 1 certs were left.
After Private Key filter, 1 certs were left.
The following certificate was selected:
    Issued to: Authenticode Code Signing Certificate
    Issued by: Authenticode Code Signing Certificate
    Expires:   Tue Apr 19 17:48:34 2022
    SHA1 hash: 1974F986D9B8BF32F47FC2AF33D6271DD905C44F

Done Adding Additional Store
Successfully signed: C:\Users\Administrator\Documents\MyTestApplication.exe

Number of files successfully Signed: 1
Number of warnings: 0
Number of errors: 0
```

2. Select the **Properties** of the test executable that was signed. Select the **Digital Signatures** tab, and **Details**. The timestamp and other signing parameters are updated.



2.7. nShield and Microsoft Strong Name integration

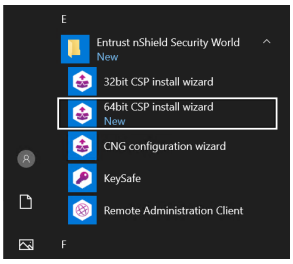
The nShield and Microsoft Strong Name integration is supported in non-FIPS (unrestricted) security worlds.

Strong names prevent spoofing of your code by a third party.

Strong name signing is provided with the Microsoft SDK to give .NET Framework assemblies unique identities. To get a valid strong name, an assembly is strong-name signed during the build process. This is done by using the private key that corresponds to the public key in the strong name.

The strong name signature can then be verified using the public key.

1. Install and register the CAPI provider, which is required for strong name signing with nShield products. Run the **64-bit CSP install wizard** and follow the installation steps. The 32-bit version is not fully supported and may not function as expected. The following shows an example of the 64-bit installer.



Do not place the HSM in `Pre-initialization` mode as descried in Install and register the CNG provider. Name the OCS `MSAuthenticodeCAPI`.

2. Open a command window as **Administrator**.
3. Set the cryptography service provider.

   Notice that the output **nCipher Enhanced Cryptographic Provider** differs from the **nCipher Security World Key Storage Provider** of the CNG.

```
>sn -c "nCipher Enhanced Cryptographic Provider"

Microsoft (R) .NET Framework Strong Name Utility  Version 4.0.30319.0
Copyright (c) Microsoft Corporation.  All rights reserved.

Default CSP set to 'nCipher Enhanced Cryptographic Provider'
```

4. Create the container:

```
>keytst -c StrongNamed_Container
CSP being used: nCipher Enhanced Cryptographic Provider
```

```
Container 'StrongNamed_Container' created
```

5. To create the key in the new container, run the following command:

```
>keytst -cs StrongNamed_Container
CSP being used: nCipher Enhanced Cryptographic Provider
Generating 2048-bit key(s) for the 'StrongNamed_Container' container.

New signature key generated OK.
```

6. List the container and the key that you created:

```
>csputils -U ALL

File ID    Container name       Container owner      DLL name   S X
=========  ===================  ===================  =========  = =
49942fc5f  StrongNamed_Cont...  WIN-G0JD49QMHEV\...  ncsp       *

1 container and 1 key found.
```

7. Show the public half of the key created above. If using an OCS, select the cardset and the HSM. Enter the passphrase as done above.

```
>keytst -p StrongNamed_Container
CSP being used: nCipher Enhanced Cryptographic Provider

Container 'StrongNamed_Container':

Key exchange key not present.
Public half of Signature key is:
06 02 00 00 00 24 00 00 52 53 41 31 00 08 00 00
01 00 01 00 17 F1 63 62 50 41 94 16 90 3F 25 CD
2B 6F FF C5 91 29 74 BA AE 67 EF C4 3D E9 E5 26
10 EE E4 D9 71 1C 0D 7F 2D 71 89 D1 E6 A9 77 A3
AE EB 79 0A 5F D6 E4 3B 41 5A 17 C3 30 B3 8F DF
A0 01 E2 93 8E 6F 6B 5B E2 E5 01 A7 19 25 48 EF
4C 65 29 8D 5E E1 0D 55 E8 93 43 9D 9A 41 EC 93
BD A1 83 11 CF C8 E3 A0 4E AC 78 DC 70 A2 46 56
3F 56 FA 65 C4 4C C1 95 57 CD 40 FE 3A 3F 7B 00
BD BA D5 AB EB 1B A4 06 7A 80 A5 41 27 24 B0 18
45 58 7E B5 7A 5C 80 5D 8C 7D 06 78 2B 3A 7F 36
96 42 D9 29 65 EE 1D 7D 1F E2 15 B6 8C C5 32 66
CB DC C5 54 27 4E D5 76 41 E6 3C FF 00 C0 E6 91
64 FD 4D 2E E8 FD 3D 7A D0 88 CF 0F 14 FA AE 38
70 6D 57 99 31 74 0E B1 29 16 A5 D0 8F FE 1B 08
09 51 AE 7F 76 FC 1F D0 84 7A 4E 76 0C DC E0 D3
2E C9 2F 8F 5E D6 62 7C 38 75 2D AA 47 EF 56 0F
6F 56 78 A7
```

8. Extract the public half of the key to a file:

```
>sn -pc StrongNamed_Container C:\Users\Administrator\Documents\StrongNamed_Container.snk

Microsoft (R) .NET Framework Strong Name Utility Version 4.0.30319.33440
Copyright (c) Microsoft Corporation. All rights reserved.
```

```
Public key written to StrongNamed_Container.snk
```

a. If the extraction command fails, it may be because the key containers are machine-based, and not user-based. Execute the following command to change your configuration, then re-run the extract command:

```
>sn -m n

Microsoft (R) .NET Framework Strong Name Utility  Version 4.0.30319.0
Copyright (c) Microsoft Corporation.  All rights reserved.

Key containers are user based
```

9. The executable `MyTestProgram.cs` was created for the purpose of this guide.

   Compile `MyTestProgram.cs` with the public key part of `StrongNamed_Container`:

```
>csc /delaysign+ /keyfile:"C:\Users\Administrator\Documents\StrongNamed_Container.snk"
/out:C:\Users\Administrator\Documents\MyTestProgram.exe C:\Users\Administrator\Documents\MyTestProgram.cs

Microsoft (R) Visual C# Compiler version 4.8.9221.0
for C# 5
Copyright (C) Microsoft Corporation. All rights reserved.
```

10. Re-sign the signed `MyTestProgram.exe` executable with `StrongNamed_Container`:

```
>sn -Rc C:\Users\Administrator\Documents\MyTestProgram.exe StrongNamed_Container

Microsoft (R) .NET Framework Strong Name Utility  Version 4.0.30319.0
Copyright (c) Microsoft Corporation.  All rights reserved.

Assembly 'C:\Users\Administrator\Documents\MyTestProgram.exe' successfully re-signed
```

11. Verify the self-consistency of the strong name signature:

```
>sn -v C:\Users\Administrator\Documents\MyTestProgram.exe

Microsoft (R) .NET Framework Strong Name Utility  Version 4.0.30319.0
Copyright (c) Microsoft Corporation.  All rights reserved.

Assembly 'C:\Users\Administrator\Documents\MyTestProgram.exe' is valid
```

12. Disassemble `MyTestProgram.exe`:

```
>ildasm C:\Users\Administrator\Documents\MyTestProgram.exe
```

Chapter 3. Post-Quantum Cryptography Testing

This section outlines the nShield product configuration requirements and the specific testing procedures needed to integrate post-quantum key generation and certificate signing with Microsoft Authenticode.

3.1. Product configurations

Entrust has successfully tested nShield HSM integration with Microsoft Authenticode in Microsoft Windows Server 2025 in the following configurations, with OCS, softcard, and module protection:

Product	Version
Base OS	Windows Server 2025, OS-build 26100.32995
Microsoft .NET Framework	4.8
Windows SDK	10.0.26100

3.2. Supported nShield features

Entrust has successfully tested nShield HSM integration with the following features:

Feature	Support
Operator Card Set (OCS)	Yes
Softcard Protection	Yes
Module Protection	Yes
nSaaS	Yes

3.3. Supported nShield hardware and software versions

Product	Security World Software	Firmware	Image
Connect XC	13.9.5	13.8.3	13.9.5
nShield 5C	13.9.5	13.8.4	13.9.5

3.4. Overview

The testing procedures documented here are similar to the procedures used in non-PQC environments, with key differences in a few areas. This section of the guide assumes that the environment is set up according to the directions outlined earlier in this document within Install the Microsoft tools. The following steps highlight the variations required for post-quantum testing; all other aspects follow the standard process.

Ensure you are installing a Security World software version that supports post-quantum cryptography, as described in Supported nShield hardware and software versions. For detailed instructions, see the *Installation Guide* and the *User Guide* for the HSM available from the installation disc.

3.5. Generate the Authenticode master key

This key will be protected by the HSM.

1. Launch PowerShell as Administrator, and run the following script:

   ```
   > .\Generate_ML-DSA_Authenticode_MasterKey.ps1
   ```

   You can run this script with the following options:

   - `-ParameterSet`: Changes the type of the ML-DSA key (ML-DSA 44, 65, 87)
   - `-KeyName`: Changes the name of the key

   For example, to generate an ML-DSA 87 key with the default name, you would run the script as follows:

   ```
   > .\Generate_ML-DSA_Authenticode_MasterKey.ps1 -ParameterSet 87
   ```

   ▼ *Generate_ML-DSA_Authenticode_MasterKey.ps1*

   ```
   param(
   ```

```
    [ValidateSet("44", "65", "87")]
    [string]$ParameterSet = "87",

    [string]$KeyName = ""
)

if ([string]::IsNullOrWhiteSpace($KeyName)) {
    $KeyName = "Authenticode_MLDSA${ParameterSet}_MasterKey"
}


$cngProviderName = "nCipher Security World Key Storage Provider"
$cngAlgorithmName = "ML-DSA"

$cngProvider = New-Object System.Security.Cryptography.CngProvider($cngProviderName)

$cngKeyParams = New-Object System.Security.Cryptography.CngKeyCreationParameters
$cngKeyParams.Provider = $cngProvider
$cngKeyParams.KeyCreationOptions =
[System.Security.Cryptography.CngKeyCreationOptions]::OverwriteExistingKey

$paramSetBytes = [System.Text.Encoding]::Unicode.GetBytes("$ParameterSet`0")

$parameterSetProperty = New-Object System.Security.Cryptography.CngProperty(
    "ParameterSetName",
    $paramSetBytes,
    [System.Security.Cryptography.CngPropertyOptions]::None
)

$cngKeyParams.Parameters.Add($parameterSetProperty)

$cngAlgorithm = New-Object System.Security.Cryptography.CngAlgorithm($cngAlgorithmName)

$cngKey = [System.Security.Cryptography.CngKey]::Create(
    $cngAlgorithm,
    $KeyName,
    $cngKeyParams
)

Write-Host "Key successfully created."
Write-Host "Provider: $cngProviderName"
Write-Host "Algorithm: $cngAlgorithmName"
Write-Host "Parameter Set: $ParameterSet"
Write-Host "Key Name: $KeyName"

$cngKey
```

2. Enter the credentials associated with the protection method you selected when you installed the CNG provider.

   An ML-DSA key pair called `Authenticode_MLDSA_MasterKey` is generated (the name may vary depending on the key size or on the name you specified). The key is encrypted in the HSM, and then pushed to the requesting On-Premise Client server, where it is stored as an Application Key Token in the `%NFAST_KMDATA%\local` folder (`C:\ProgramData\nCipher\Key Management Data\local`).

3. Verify the new key with `nfkminfo -k`:

```
> nfkminfo -k
```

```
Key list - 1 keys
AppName caping              Ident s-1-5-21-1456163111-1567960500-3523019067-500--
b15c34b0ee3ef43bb6405bd4946f86190b60a7a5
```

4. Display the key information by running `nfkminfo -k` again, this time with the `AppName` and `Ident` from the output in the previous step:

```
nfkminfo -k <AppName> <Ident>
```

The protection method is displayed according to the type of protection you are using:

For OCS	Cardset
For Softcard	Passphrase
For Module protection	Module

You can check the actual key name in the `name` line.

For example:

```
> nfkminfo -k caping  s-1-5-21-1456163111-1567960500-3523019067-500--
b15c34b0ee3ef43bb6405bd4946f86190b60a7a5
Key AppName caping Ident s-1-5-21-1456163111-1567960500-3523019067-500--
b15c34b0ee3ef43bb6405bd4946f86190b60a7a5
BlobKA length         5316
BlobPubKA length      2820
BlobRecoveryKA length 5704
name                  "Authenticode_MLDSA87_MasterKey"
hash                  1984db66564a85596531ef4fe1e1178cf2525d4f
recovery              Enabled
protection            Module
other flags           PublicKey !SEEAppKey !NVMemBlob +0x0
gentime               2026-07-27 16:16:48
SEE integrity key     NONE

BlobKA
format                5 Module
other flags           0x0
hkm                   417f6e05283d8abad40ee3ee49db304c70027535
hkt                   none
hkr                   none

BlobRecoveryKA
format                9 UserKey
other flags           0x0
hkm                   none
hkt                   none
hkr                   ff6ec9c6c1a13a37d30c3a29ae56a51cbfd107ca

BlobPubKA
format                5 Module
other flags           0x0
hkm                   c2be99fe1c77f1b75d48e2fd2df8dffc0c969bcb
hkt                   none
hkr                   none

Extra entry #1
```

```
typecode              0x10000 65536
length                132
Not a blob
```

3.6. Generate the Authenticode signing certificate

A self-signed code signing certificate will be generated for the purpose of this *Integration Guide*.

1. Launch PowerShell as Administrator, and run the following script:

   ```
   > .\Generate_ML-DSA_Authenticode_SelfCert.ps1
   ```

   Ensure you provide the same `-ParameterSet` value you used when generating the key in the previous step, for example:

   ```
   > .\Generate_ML-DSA_Authenticode_SelfCert.ps1 -ParameterSet 87
   ```

   ▼ *Generate_ML-DSA_Authenticode_SelfCert.ps1*

   ```
   param(
       [ValidateSet("44","65","87")]
       [string]$ParameterSet = "87"
   )

   $cngProviderName = "nCipher Security World Key Storage Provider"

   $subjectName = "Authenticode ML-DSA-$ParameterSet Code Signing Certificate"

   $friendlyName = "Authenticode_MLDSA${ParameterSet}_SelfCert"

   $locationName = "Cert:\CurrentUser\My"

   $containerName = "Authenticode_MLDSA${ParameterSet}_MasterKey"

   New-SelfSignedCertificate `
       -Subject $subjectName `
       -FriendlyName $friendlyName `
       -Type CodeSigningCert `
       -CertStoreLocation $locationName `
       -Provider $cngProviderName `
       -ExistingKey `
       -Container $containerName
   ```

2. Enter the credentials associated with your selected protection method.

   When the script completes, the PowerShell command line displays the following information:

   ```
   PSParentPath: Microsoft.PowerShell.Security\Certificate::CurrentUser\My

   Thumbprint                                Subject
   ```

```
----------                                -------
5B27B1E51D12161A5EC994DF65ECB262E93BEAEA  CN=Authenticode ML-DSA-87 Code Signing Certificate
```

3. To view the self-signed certificate, run the following command in a PowerShell window:

```
> Get-ChildItem Cert:\CurrentUser\My | Format-Table Subject,FriendlyName,Thumbprint,HasPrivateKey

Subject                                          FriendlyName                Thumbprint
-------                                          ------------                ----------
CN=Authenticode ML-DSA-87 Code Signing Certificate Authenticode_MLDSA87_SelfCert
5B27B1E51D12161A5EC994DF65ECB262E93...
```

   You can also view it with the Windows Certificate Manager.

3.7. Sign and timestamp the code with Microsoft SDK

The `signtool` utility is used for signing. The Entrust online Time Stamp Server (TSS) is used to timestamp.

`signtool` can access the code-signing certificate the following ways:

- Directly, from the certificate store with the thumbprint. This is the preferred method.
- By name, for example, `Authenticode Code Signing Certificate`.
- By pointing to a `.cer` file that was created by exporting the certificate.

If you plan to access the certificate by pointing to a `.cer` file, perform the following steps first:

1. Export the certificate to your preferred location in the file system.

```
> Export-Certificate -FilePath "Place_Output_Certificate_Path_Here" -Cert (Get-ChildItem
Cert:\CurrentUser\My | Where-Object { $_.FriendlyName -eq "Place_Friendly_Name_Here" } | Select-Object
-First 1)
```

   For example:

```
> Export-Certificate -FilePath "C:\Users\Administrator\Documents\Authenticode_MLDSA87_SelfCert.cer" -Cert
(Get-ChildItem Cert:\CurrentUser\My | Where-Object { $_.FriendlyName -eq "Authenticode_MLDSA87_SelfCert" }
| Select-Object -First 1)

Directory: C:\Users\Administrator\Documents

Mode                 LastWriteTime         Length Name
----                 -------------         ------ ----
-a----         7/27/2026  12:38 PM           7527 Authenticode_MLDSA87_SelfCert.cer
```

2. View the exported certificate by navigating to it in File Explorer, right-clicking it, and selecting **Properties**.

An executable called `MyTestApplication.exe` was created for the purpose of this guide. Sign and timestamp it by running one of the signing scripts provided. There is a script for each protection method.

To sign and timestamp the test executable, run the appropriate script based on your protection method. You might need to modify the `$fileName` line in the script before you run it to update the filepath for the executable.

- OCS card protection:

```
> .\Sign_with_MS_SDK_PQC_OCS.ps1 -ParameterSet 87
```

When prompted, select the HSM and enter the passphrase.

▼ *Sign_with_MS_SDK_PQC_OCS.ps1*

```
param(
    [ValidateSet("44","65","87")]
    [string]$ParameterSet = "87"
)

$friendlyName = "Authenticode_MLDSA${ParameterSet}_SelfCert"

$certHash = (Get-ChildItem Cert:\CurrentUser\My |
    Where-Object { $_.FriendlyName -eq $friendlyName } |
    Select-Object -First 1 -ExpandProperty Thumbprint)

if (-not $certHash) {
    throw "Certificate '$friendlyName' not found."
}

$timestampServer = "http://timestamp.entrust.net/TSS/RFC3161sha2TS"

$fileName = "C:\Users\Administrator\Documents\MyTestApplication.exe"

signtool sign `
    /debug `
    /fd SHA256 `
    /sha1 $certHash `
    /td SHA256 `
    /tr $timestampServer `
    $fileName
```

- Softcard protection:

```
> .\Sign_with_MS_SDK_PQC_Softcard.ps1 -ParameterSet 87
```

When prompted, enter the passphrase.

▼ *Sign_with_MS_SDK_PQC_Softcard.ps1*

```
param(
    [ValidateSet("44","65","87")]
    [string]$ParameterSet = "87"
)

$cngProviderName = "nCipher Security World Key Storage Provider"

$containerName = "Authenticode_MLDSA${ParameterSet}_MasterKey"

$certificatePath = "C:\Users\Administrator\Documents\Authenticode_MLDSA${ParameterSet}_SelfCert.cer"

$password = "1234"

$timestampServer = "http://timestamp.entrust.net/TSS/RFC3161sha2TS"

$fileName = "C:\Users\Administrator\Documents\MyTestApplication.exe"

signtool sign `
    /debug `
    /fd SHA256 `
    /csp $cngProviderName `
    /kc $containerName `
    /f $certificatePath `
    /p $password `
    /td SHA256 `
    /tr $timestampServer `
    $fileName
```

- Module protection:

```
> .\Sign_with_MS_SDK_PQC_Module.ps1 -ParameterSet 87
```

▼ *Sign_with_MS_SDK_PQC_Module.ps1*

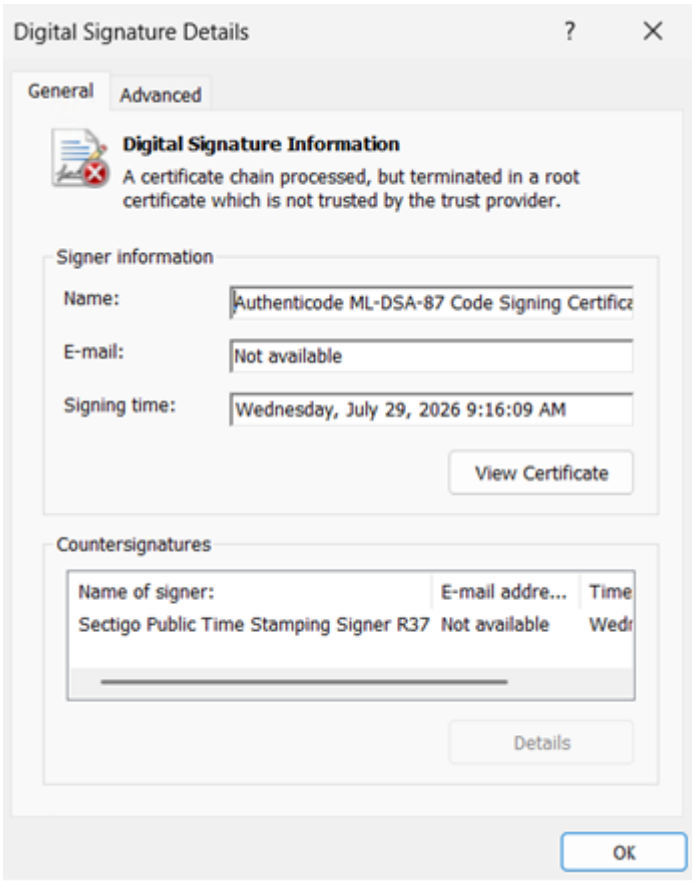
```
param(
    [ValidateSet("44","65","87")]
    [string]$ParameterSet = "87"
)

$friendlyName = "Authenticode_MLDSA${ParameterSet}_SelfCert"

$certHash = (
    Get-ChildItem Cert:\CurrentUser\My |
    Where-Object { $_.FriendlyName -eq $friendlyName } |
    Select-Object -First 1 -ExpandProperty Thumbprint
)

$timestampServer = "http://timestamp.entrust.net/TSS/RFC3161sha2TS"
$fileName = "C:\Users\Administrator\Documents\MyTestApplication.exe"

signtool sign `
    /debug `
    /fd SHA256 `
    /sha1 $certHash `
    /td SHA256 `
    /tr $timestampServer `
    $fileName
```

For all protection types, the PowerShell command line displays script output information similar to the following:

```
The following certificates were considered:
    Issued to: Authenticode ML-DSA-87 Code Signing Certificate
    Issued by: Authenticode ML-DSA-87 Code Signing Certificate
    Expires:   Wed Jul 14 10:36:15 2027
    SHA1 hash: 7D5F95A9CF17893EE17425AB9CCBD3486745E7BC

After EKU filter, 1 certs were left.
After expiry filter, 1 certs were left.
After Subject Name filter, 1 certs were left.
After Private Key filter, 1 certs were left.
The following certificate was selected:
    Issued to: Authenticode ML-DSA-87 Code Signing Certificate
    Issued by: Authenticode ML-DSA-87 Code Signing Certificate
    Expires:   Wed Jul 14 10:36:15 2027
    SHA1 hash: 7D5F95A9CF17893EE17425AB9CCBD3486745E7BC

Done Adding Additional Store
Successfully signed: C:\Users\Administrator\MyTestApplication.exe

Number of files successfully Signed: 1
Number of warnings: 0
Number of errors: 0
```

To view the update timestamp and signing parameters:

1. Select the **Properties** of the test executable that was signed.
2. On the **Digital Signatures** tab, select **Details**.



Chapter 4. Additional resources and related products

4.1. nShield HSMs

4.2. nShield as a Service

4.3. Entrust products

4.4. nShield product documentation