

Oracle® Key Vault

Root of Trust HSM Configuration Guide



Release 21.5

F56587-01

October 2022

The Oracle logo, consisting of a solid red square with the word "ORACLE" in white, uppercase, sans-serif font centered within it.

ORACLE®

Oracle Key Vault Root of Trust HSM Configuration Guide, Release 21.5

F56587-01

Copyright © 2014, 2022, Oracle and/or its affiliates.

Primary Authors: Patricia Huey, Monika Sharma

Contributing Authors: Mark Doran

Contributors: Alexis Abell, Bharathi Baskaran, Rahil Mir, Radhika Siravara, Ajay Srivastava, Peter Wahl

This software and related documentation are provided under a license agreement containing restrictions on use and disclosure and are protected by intellectual property laws. Except as expressly permitted in your license agreement or allowed by law, you may not use, copy, reproduce, translate, broadcast, modify, license, transmit, distribute, exhibit, perform, publish, or display any part, in any form, or by any means. Reverse engineering, disassembly, or decompilation of this software, unless required by law for interoperability, is prohibited.

The information contained herein is subject to change without notice and is not warranted to be error-free. If you find any errors, please report them to us in writing.

If this is software, software documentation, data (as defined in the Federal Acquisition Regulation), or related documentation that is delivered to the U.S. Government or anyone licensing it on behalf of the U.S. Government, then the following notice is applicable:

U.S. GOVERNMENT END USERS: Oracle programs (including any operating system, integrated software, any programs embedded, installed, or activated on delivered hardware, and modifications of such programs) and Oracle computer documentation or other Oracle data delivered to or accessed by U.S. Government end users are "commercial computer software," "commercial computer software documentation," or "limited rights data" pursuant to the applicable Federal Acquisition Regulation and agency-specific supplemental regulations. As such, the use, reproduction, duplication, release, display, disclosure, modification, preparation of derivative works, and/or adaptation of i) Oracle programs (including any operating system, integrated software, any programs embedded, installed, or activated on delivered hardware, and modifications of such programs), ii) Oracle computer documentation and/or iii) other Oracle data, is subject to the rights and limitations specified in the license contained in the applicable contract. The terms governing the U.S. Government's use of Oracle cloud services are defined by the applicable contract for such services. No other rights are granted to the U.S. Government.

This software or hardware is developed for general use in a variety of information management applications. It is not developed or intended for use in any inherently dangerous applications, including applications that may create a risk of personal injury. If you use this software or hardware in dangerous applications, then you shall be responsible to take all appropriate fail-safe, backup, redundancy, and other measures to ensure its safe use. Oracle Corporation and its affiliates disclaim any liability for any damages caused by use of this software or hardware in dangerous applications.

Oracle®, Java, and MySQL are registered trademarks of Oracle and/or its affiliates. Other names may be trademarks of their respective owners.

Intel and Intel Inside are trademarks or registered trademarks of Intel Corporation. All SPARC trademarks are used under license and are trademarks or registered trademarks of SPARC International, Inc. AMD, Epyc, and the AMD logo are trademarks or registered trademarks of Advanced Micro Devices. UNIX is a registered trademark of The Open Group.

This software or hardware and documentation may provide access to or information about content, products, and services from third parties. Oracle Corporation and its affiliates are not responsible for and expressly disclaim all warranties of any kind with respect to third-party content, products, and services unless otherwise set forth in an applicable agreement between you and Oracle. Oracle Corporation and its affiliates will not be responsible for any loss, costs, or damages incurred due to your access to or use of third-party content, products, or services, except as set forth in an applicable agreement between you and Oracle.

Contents

Preface

Audience	vii
Documentation Accessibility	vii
Diversity and Inclusion	vii
Related Documents	viii
Conventions	viii

Changes in This Release for Oracle Key Vault

Changes for Oracle Key Vault Release 21.5	ix
Changes for Oracle Key Vault Release 21.3	ix
Changes for Oracle Key Vault Release 21.2	x

1 Getting Started with HSM

1.1 How Oracle Key Vault Works with Hardware Security Modules	1-1
1.2 Installing the HSM Client Software on an Oracle Key Vault Server	1-2
1.3 Enrolling Oracle Key Vault as a Client of the HSM	1-3

2 Configuring an HSM for Oracle Key Vault

2.1 HSM-Enabling in a Standalone Oracle Key Vault Deployment	2-1
2.2 HSMs in a Multi-Master Cluster	2-3
2.2.1 About HSMs in a Multi-Master Cluster	2-3
2.2.2 Configuring an HSM for a Multi-Master Cluster Starting with Single Node (Recommended)	2-4
2.2.3 Configuring an HSM for a Multi-Master Cluster with Multiple Nodes	2-4
2.2.3.1 About Configuring an HSM for a Multi-Master Cluster with Multiple Nodes	2-5
2.2.3.2 Step 1: Create and Copy the Bundle after HSM-Enabling the First Node	2-5
2.2.3.3 Step 2: Configure the Remaining Nodes	2-6
2.3 HSM-Enabling in a Primary-Standby Oracle Key Vault Deployment	2-7
2.4 Backup and Restore Operations in an HSM-Enabled Oracle Key Vault Instance	2-9
2.4.1 Backup Operations in an HSM-Enabled Oracle Key Vault Instance	2-9

2.4.2	Restore Operations in an HSM-Enabled Oracle Key Vault Instance	2-9
2.5	Reverse Migration Operations	2-10
2.5.1	Reverse Migrating a Standalone Deployment	2-11
2.5.2	Reverse Migrating a Multi-Master Cluster	2-12
2.5.3	Reverse Migrating a Primary-Standby Deployment	2-12
2.6	Disabling Reverse Migration on the Management Console	2-14

3 Upgrade Considerations When Using HSMs in Oracle Key Vault

3.1	Upgrades from Oracle Key Vault Release 12.2	3-1
3.1.1	Upgrading from an Oracle Key Vault Release 12.2 Standalone Deployment	3-1
3.1.2	Upgrading from an Oracle Key Vault Release 12.2 Primary-Standby Deployment	3-2
3.2	Upgrade Considerations for Entrust	3-3
3.2.1	Remaking Hardserver Changes While Upgrading Oracle Key Vault	3-4
3.2.2	Overriding Security Assurances for the Oracle Key Vault Upgrade	3-4
3.2.3	Re-installation of Entrust Software While Upgrading Oracle Key Vault from 18.x to 21.x	3-5
3.3	Using a Token Label After Upgrading Oracle Key Vault without Reverse-Migrating	3-5

4 Oracle Key Vault HSM Support Guidance

4.1	General Troubleshooting	4-1
4.1.1	Trace Files for Diagnosing Issues	4-2
4.1.2	HSM Alert	4-2
4.1.3	Could Not Get Slot for HSM Error	4-3
4.1.4	Could Not Load PKCS#11 Library Error	4-3
4.1.5	Oracle Key Vault Management Console Does Not Start After Restarting HSM-Enabled Oracle Key Vault Server	4-3
4.1.6	Primary-Standby Errors	4-4
4.1.7	Errors from HSM-Enabled Oracle Key Vault Backups	4-4
4.1.8	Restoration of a Backed Up HSM-Enabled Oracle Key Vault Server	4-5
4.2	Vendor Specific Notes for Thales	4-5
4.2.1	Installing the HSM Client Software on the Oracle Key Vault Server for Thales	4-5
4.2.2	HSM Credential for Thales	4-6
4.2.3	Token Label for Thales	4-6
4.2.4	Enrolling Oracle Key Vault as a Client of a Thales HSM	4-6
4.2.5	HSM Provider Value for Thales	4-8
4.2.6	HSM Vendor Specific Checks for Thales	4-8
4.3	Vendor Specific Notes for Entrust	4-9
4.3.1	Installing the HSM Client Software on the Oracle Key Vault Server for Entrust	4-9
4.3.2	HSM Credential for Entrust	4-11

4.3.3	Token Label for Entrust	4-11
4.3.4	Enrolling Oracle Key Vault as a Client of an Entrust HSM	4-11
4.3.5	HSM Provider Value for Entrust	4-12
4.4	Vendor Specific Notes for Utimaco	4-12
4.4.1	Installing the HSM Client Software on the Oracle Key Vault Server for Utimaco	4-13
4.4.2	HSM Credential for Utimaco	4-15
4.4.3	Token Label for Utimaco	4-15
4.4.4	HSM Provider Value for Utimaco	4-15
4.4.5	HSM Vendor Specific Checks for Utimaco	4-15
4.5	Vendor Specific Notes for Other HSMs	4-16
4.5.1	About Vendor Specific Notes for Other HSMs	4-16
4.5.2	Installing the HSM Client Software on the Oracle Key Vault Server for Other Vendors	4-17
4.5.3	Configuring the okv_hsm.conf Parameters	4-17
4.5.4	Configuring the okv_hsm_env Environment File	4-18
4.5.5	Configuring the okv_hsm_mid_upgrade Script	4-18
4.5.6	Executing Pre- or Post-Upgrade Validation Scripts	4-18

5 Vendor Instructions for Integrating an HSM as the Root of Trust for Oracle Key Vault

5.1	About Integrating an HSM as a Root of Trust for Oracle Key Vault	5-1
5.2	Requirements Before Starting the Integration	5-2
5.2.1	Requirements for the Vendor's HSM Client Installation Software	5-2
5.2.2	Requirements for the PKCS#11 Library	5-2
5.2.3	Configuration Requirements for Enrolling Oracle Key Vault as the HSM Client	5-3
5.3	Integrating the HSM	5-3
5.3.1	okv_hsm.conf Parameters	5-4
5.3.2	okv_hsm_env Environment File	5-5
5.3.3	okv_hsm_mid_upgrade Script	5-5
5.3.4	Pre- or Post-Upgrade Validation Scripts	5-6
5.4	Confirming the Success of the HSM Configuration	5-6
5.4.1	Enabling the HSM in a Standalone Environment	5-6
5.4.2	Performing an Upgrade of an HSM-Enabled Oracle Key Vault Server	5-7
5.4.3	Performing a Backup of an HSM-Enabled Oracle Key Vault Server	5-8
5.4.4	Performing a Restore of an HSM-Enabled Oracle Key Vault Server	5-8
5.4.5	Confirming the Success of the HSM Configuration in a Multi-Master Cluster	5-9
5.4.5.1	Starting with an HSM-Enabled Single Node	5-9
5.4.5.2	HSM-Enabling a Cluster with Multiple Nodes	5-10
5.4.6	Confirming the Success of the HSM Configuration in a Primary-Standby Environment	5-10
5.4.6.1	Creating an HSM-Enabled Primary Standby Configuration	5-11

5.4.6.2	Performing an HSM-Enabled Primary-Standby Switchover Operation	5-11
5.4.6.3	Performing a Reverse Migration of an HSM-Enabled Primary-Standby Configuration	5-11
5.4.7	Performing a Reverse Migration Operation	5-12
5.5	Validating the HSM as a Root of Trust for Oracle Key Vault	5-12
5.5.1	Test Cases for Standalone Configurations	5-13
5.5.2	Test Cases for Multi-Master Cluster Configurations	5-13
5.5.3	Test Cases for Primary-Standby Configurations	5-14

Preface

Welcome to *Oracle Key Vault Root of Trust HSM Configuration Guide* (formerly *Oracle Key Vault Integration with Hardware Security Module*). This guide explains how to integrate a hardware security module (HSM) with Oracle Key Vault.

- [Audience](#)
- [Documentation Accessibility](#)
- [Diversity and Inclusion](#)
- [Related Documents](#)
- [Conventions](#)

Audience

Oracle Key Vault is meant for users who are responsible for deploying, maintaining, and managing security within the enterprise. These users can be database, system, or security administrators. This guide can be used by any information security personnel who is responsible for protecting enterprise data residing in database servers, application servers, operating systems, and other information systems.

Documentation Accessibility

For information about Oracle's commitment to accessibility, visit the Oracle Accessibility Program website at <http://www.oracle.com/pls/topic/lookup?ctx=acc&id=docacc>.

Access to Oracle Support

Oracle customers that have purchased support have access to electronic support through My Oracle Support. For information, visit <http://www.oracle.com/pls/topic/lookup?ctx=acc&id=info> or visit <http://www.oracle.com/pls/topic/lookup?ctx=acc&id=trs> if you are hearing impaired.

Diversity and Inclusion

Oracle is fully committed to diversity and inclusion. Oracle respects and values having a diverse workforce that increases thought leadership and innovation. As part of our initiative to build a more inclusive culture that positively impacts our employees, customers, and partners, we are working to remove insensitive terms from our products and documentation. We are also mindful of the necessity to maintain compatibility with our customers' existing technologies and the need to ensure continuity of service as Oracle's offerings and industry standards evolve. Because of these technical constraints, our effort to remove insensitive terms is ongoing and will take time and external cooperation.

Related Documents

For more information, see these Oracle resources:

- *Oracle Key Vault Administrator's Guide*
- *Oracle Key Vault RESTful Services Administrator's Guide*
- *Oracle Key Vault Developer's Guide*
- *Oracle Key Vault Licensing Information*
- *Oracle Key Vault Release Notes*
- [Key Management Interoperability Protocol Specification Version 1.1](#)

To download the product data sheet, frequently asked questions, links to the latest product documentation, product download, and other collateral, visit Oracle Technical Resources (formerly Oracle Technology Network). You must register online before using Oracle Technical Services. Registration is free and can be done at

<https://www.oracle.com/technical-resources/>

Conventions

The following text conventions are used in this document:

Convention	Meaning
boldface	Boldface type indicates graphical user interface elements associated with an action, or terms defined in text or the glossary.
<i>italic</i>	Italic type indicates book titles, emphasis, or placeholder variables for which you supply particular values.
monospace	Monospace type indicates commands within a paragraph, URLs, code in examples, text that appears on the screen, or text that you enter.

Changes in This Release for Oracle Key Vault

This Oracle Key Vault release introduces new features that enhance the use of Oracle Key Vault in a large enterprise.

- [Changes for Oracle Key Vault Release 21.5](#)
Oracle Key Vault release 21.5 introduces one new feature that affects this guide.
- [Changes for Oracle Key Vault Release 21.3](#)
Oracle Key Vault release 21.3 introduces one new feature that affects this guide.
- [Changes for Oracle Key Vault Release 21.2](#)
Oracle Key Vault release 21.2 introduces one new feature that affects this guide.

Changes for Oracle Key Vault Release 21.5

Oracle Key Vault release 21.5 introduces one new feature that affects this guide.

- [Reverse Migrate Functionality on the HSM Screen](#)
Starting with Oracle Key Vault release 21.5, reverse migrate functionality is provided on HSM screen.

Reverse Migrate Functionality on the HSM Screen

Starting with Oracle Key Vault release 21.5, reverse migrate functionality is provided on HSM screen.

Using this feature an HSM-enabled Oracle Key Vault server reverts the Key Vault server to using the recovery pass-phrase to protect the TDE wallet.

Related Topics

- [Reverse Migration Operations](#)
Reverse migrating an HSM-enabled Oracle Key Vault server reverts the Key Vault server to using the recovery passphrase to protect the TDE wallet.

Changes for Oracle Key Vault Release 21.3

Oracle Key Vault release 21.3 introduces one new feature that affects this guide.

- [Ability to Configure Other HSMs for Oracle Key Vault](#)
Starting with Oracle Key Vault release 21.3, in addition to the Thales Luna Network HSM version 7000, Entrust nShield Connect + and XC models, and Utimaco's SecurityServer 4.31.1 HSMs, you can configure other HSMs that have been certified to work with Oracle Key Vault.

Ability to Configure Other HSMs for Oracle Key Vault

Starting with Oracle Key Vault release 21.3, in addition to the Thales Luna Network HSM version 7000, Entrust nShield Connect + and XC models, and Utimaco's SecurityServer 4.31.1 HSMs, you can configure other HSMs that have been certified to work with Oracle Key Vault.

Those additional HSMs may or may not be already certified by the HSM vendor.

This feature gives you a much wider range of HSM products that you can use with Oracle Key Vault. The configuration is slightly different from the configuration of the Thales Luna Network HSM version 7000, Entrust nShield Connect + and XC models, and Utimaco's SecurityServer 4.31.1 HSMs in that you will need to work with your HSM vendor with regard to the requirements that they must fulfill in order for their HSM to work with Oracle Key Vault. After you have successfully integrated the HSM with Oracle Key Vault, you will be able to perform all the tasks that you normally perform with the Thales Luna Network HSM version 7000, Entrust nShield Connect + and XC models, and Utimaco's SecurityServer 4.31.1 HSMs, such as upgrade operations, backup and restore operations, and reverse migrations.

Related Topics

- [Vendor Instructions for Integrating an HSM as the Root of Trust for Oracle Key Vault](#)
HSM vendors are responsible for documenting and testing instructions to integrate their HSM with Oracle Key Vault.

Changes for Oracle Key Vault Release 21.2

Oracle Key Vault release 21.2 introduces one new feature that affects this guide.

- [Changes in the Oracle Key Vault Management Console](#)
In Oracle Key Vault release 21.2, the Oracle Key Vault management console user interface has had minor changes throughout.

Changes in the Oracle Key Vault Management Console

In Oracle Key Vault release 21.2, the Oracle Key Vault management console user interface has had minor changes throughout.

These changes are the result of modified terms, updates to the current release, and enhancements for better usability. The overall interface has not had major changes.

1

Getting Started with HSM

To integrate a hardware security module (HSM) with Oracle Key Vault, you must install the HSM client software and enroll Oracle Key Vault as an HSM client.

- [How Oracle Key Vault Works with Hardware Security Modules](#)
This guide explains how to configure Oracle Key Vault to use a supported hardware security module (HSM).
- [Installing the HSM Client Software on an Oracle Key Vault Server](#)
After you install Oracle Key Vault, you can install the HSM client software on the Oracle Key Vault server.
- [Enrolling Oracle Key Vault as a Client of the HSM](#)
You must enroll Oracle Key Vault as a client of HSM and ensure connectivity between the HSM client and the HSM.

1.1 How Oracle Key Vault Works with Hardware Security Modules

This guide explains how to configure Oracle Key Vault to use a supported hardware security module (HSM).

A hardware security module (HSM) contains tamper-resistant, specialized hardware that is designed to protect security objects stored within the HSM. HSMs are physical computing devices that safeguard and manage digital keys, and provide cryptographic processing for clients. HSMs do not usually allow security objects to leave the cryptographic boundary of the HSM.

Oracle Key Vault is a key management platform designed to securely store, manage and share security objects. Unlike an HSM, Oracle Key Vault allows trusted clients to retrieve security objects like decryption keys. Oracle Key Vault is a full-stack software appliance that contains an operating system, database, and key-management application. Oracle Key Vault is designed to help organizations store and manage their keys and credentials.

Your organization may require the use of an HSM to protect encryption keys. Because they are designed to not allow keys to leave the cryptographic boundary of the HSM, in most cases it is not practical to connect databases directly to an HSM. Instead, databases will connect to the Oracle Key Vault which will in turn be protected by the HSM. This configuration establishes a Root-of-Trust (RoT) for Oracle Key Vault in the HSM. When an HSM is deployed with Oracle Key Vault, the RoT remains in the HSM. The HSM RoT protects the Transparent Data Encryption (TDE) wallet password, which protects the TDE master key, which in turn protects all the encryption keys, certificates, and other security artifacts managed by the Oracle Key Vault server. Note that the HSM in this RoT usage scenario does not store any customer encryption keys. The customer keys are stored and managed directly by the Oracle Key Vault server.

Using HSM as a RoT is intended to mitigate attempts to recover keys from an Oracle Key Vault server which has been started in an unauthorized environment. Physical theft of the disk images that represent an Oracle Key Vault server that runs as a virtualization guest is

one example of such a scenario. An unauthorized user attempting to run a stolen Oracle Key Vault server, without authorized access to the HSM, would be prevented from recovering the encryption keys stored on the appliance.

Oracle Key Vault employs a hierarchy of security controls including operating system hardening, database encryption, and data access enforcement using Database Vault. These controls are designed to mitigate the risk of users potentially extracting keys and credentials from systems they can physically access. Administrators do not need to access the internal components of the appliance for normal, day-to-day operations. Therefore, you should disable Secure Shell Protocol (`ssh`) access into Oracle Key Vault at all times, except when you must apply quarterly release upgrades. Oracle Key Vault should be deployed in a secure location, and physical and logical access to the appliance should be controlled and monitored.

If your site uses HSMs from Thales (formerly SafeNet Luna), Entrust (formerly nCipher), or Utimaco, then you can configure these HSMs with Oracle Key Vault in standalone, primary-standby, and multi-master environments. If your site does not use these HSMs and if your HSM vendor meets the requirements, then you and the vendor can configure the vendor's HSM to work with Oracle Key Vault.

This guide assumes that you have installed and configured Oracle Key Vault. It also assumes that you have sufficient knowledge of the HSM that you plan to configure.

The general process that you must follow to configure the HSM with Oracle Key Vault is as follows:

1. Install the HSM client software on the Oracle Key Vault server and perform any necessary configurations that the HSM may need.
2. Enroll Oracle Key Vault as a client of the HSM.
3. Perform further configuration operations, which are as follows:
 - Configure protection for the TDE master encryption key with the HSM.
 - Use an HSM in a primary-standby Oracle Key Vault installation.
 - Use an HSM in an Oracle Key Vault multi-master cluster environment.
 - Perform backup and restore operations in an HSM-enabled Oracle Key Vault instance.
 - When necessary, perform reverse-migration so that the Oracle Key Vault environment is no longer HSM-enabled.

1.2 Installing the HSM Client Software on an Oracle Key Vault Server

After you install Oracle Key Vault, you can install the HSM client software on the Oracle Key Vault server.

1. Ensure that the vendor's software includes a PKCS#11 library.
Refer to the HSM documentation from the HSM vendor for more information.

2. Install the HSM vendor's client software on the Oracle Key Vault server.

You can install HSM products from Thales Luna Network HSM version 7000, Entrust nShield Connect + and XC models, Utimaco's SecurityServer 4.31.1, or

other HSM vendors. If you are installing an HSM from another vendor, then this vendor must provide integration instructions.

Related Topics

- [Installing the HSM Client Software on the Oracle Key Vault Server for Thales](#)
You must use the Luna Universal Client version 6.2.2 for Linux x64 for the installation when integrating Oracle Key Vault with Thales. If you must use a different client version, consult your vendor and use the infrastructure provided to integrate Oracle Key Vault with other HSMs.
- [Installing the HSM Client Software on the Oracle Key Vault Server for Entrust](#)
The Entrust HSM requires a separate non-HSM computer on the network to use as the remote file system.
- [Installing the HSM Client Software on the Oracle Key Vault Server for Utimaco](#)
The setup files for Utimaco are provided in the `SecurityServerEvaluation-V4.31.1.0.zip` file from Utimaco.
- [Vendor Instructions for Integrating an HSM as the Root of Trust for Oracle Key Vault](#)
HSM vendors are responsible for documenting and testing instructions to integrate their HSM with Oracle Key Vault.

1.3 Enrolling Oracle Key Vault as a Client of the HSM

You must enroll Oracle Key Vault as a client of HSM and ensure connectivity between the HSM client and the HSM.

If you are enrolling Oracle Key Vault as a client of an HSM from a vendor other than Thales Luna Network HSM version 7000, Entrust nShield Connect + and XC models, or Utimaco's SecurityServer 4.31.1, then ensure that this vendor has provided integration instructions.

1. Install the HSM vendor's client software on the Oracle Key Vault server.
2. Ensure that the HSM client software can communicate from Oracle Key Vault to the HSM.

Related Topics

- [Installing the HSM Client Software on an Oracle Key Vault Server](#)
After you install Oracle Key Vault, you can install the HSM client software on the Oracle Key Vault server.
- [Enrolling Oracle Key Vault as a Client of a Thales HSM](#)
To perform the enrollment, you use the Oracle Key Vault management console and the command-line interface.
- [Enrolling Oracle Key Vault as a Client of an Entrust HSM](#)
You use both the Entrust user interface and the command line to enroll Oracle Key Vault as a client of an Entrust HSM.
- [Installing the HSM Client Software on the Oracle Key Vault Server for Utimaco](#)
The setup files for Utimaco are provided in the `SecurityServerEvaluation-V4.31.1.0.zip` file from Utimaco.

2

Configuring an HSM for Oracle Key Vault

Oracle Key Vault can be configured to use the HSM as the Root of Trust in a standalone, primary-standby, or multi-master cluster environment.

- [HSM-Enabling in a Standalone Oracle Key Vault Deployment](#)
You can use the Oracle Key Vault management console to HSM-enable Oracle Key Vault, which configures additional protection for the TDE master encryption key.
- [HSMs in a Multi-Master Cluster](#)
You can configure HSMs in a multi-master cluster with a single node or multiple nodes.
- [HSM-Enabling in a Primary-Standby Oracle Key Vault Deployment](#)
In an Oracle Key Vault primary-standby deployment, you must perform the HSM-enabling tasks separately on the Oracle Key Vault servers that will become primary and standby servers.
- [Backup and Restore Operations in an HSM-Enabled Oracle Key Vault Instance](#)
You can back up and restore an HSM-enabled Oracle Key Vault instance.
- [Reverse Migration Operations](#)
Reverse migrating an HSM-enabled Oracle Key Vault server reverts the Key Vault server to using the recovery passphrase to protect the TDE wallet.
- [Disabling Reverse Migration on the Management Console](#)
You can disable reverse migration by using the Oracle Key Vault management console.

2.1 HSM-Enabling in a Standalone Oracle Key Vault Deployment

You can use the Oracle Key Vault management console to HSM-enable Oracle Key Vault, which configures additional protection for the TDE master encryption key.

If you plan to use a multi-master cluster, then Oracle recommends that you perform this procedure before you configure the cluster environment. If you plan to use a vendor other than Thales Luna Network HSM version 7000, Entrust nShield Connect + and XC models, or Utimaco's SecurityServer 4.31.1, then check with this vendor to see if there are any additional instructions to follow while doing this operation. Ensure that you complete the following steps on this server before you start these steps on another Oracle Key Vault server.

1. If you have installed the Entrust client software, then run the following command as user `oracle`:

```
oracle$ /opt/nfast/bin/rfs-sync --update
```

2. Log into the Oracle Key Vault management console as a user with the System Administrator role.

If you are using a multi-master cluster environment, then log into the Oracle Key Vault node that you want to HSM-enable.

3. Select the **System** tab, then **Settings** in the left navigation bar.

- In Network Services, click **HSM**.

The Hardware Security Module page appears. The red downward arrow shows the non-initialized **Status**. The **Type** field displays **None**.

- Click **Initialize**.

The Initialize HSM window appears.

- Enter the HSM credential two times: first in **HSM Credential** and second in **Re-enter HSM Credential**.

Consult the documentation that came with your HSM for this credential. The HSM credential for Thales is the Thales partition password. For Entrust, the credential is the password that is associated with the Operator Card Set or Softcard. For Utimaco, the credential is the PIN that was initialized when the token was configured. For other HSM vendors that have been certified, consult the vendor documentation. Oracle currently only supports HSM credentials up to 79 characters in length.

- Enter the **Recovery Passphrase** for Oracle Key Vault.
- If you want Oracle Key Vault to use a specific token to create and use objects in the HSM, then select the **Use Token Label** check box and enter the token label of the token that Oracle Key Vault should use.

Oracle recommends that you select **Use Token Label** if Oracle Key Vault has access to more than one token. Oracle Key Vault does not support using a token that has the same name as one or more other tokens, nor does Oracle Key Vault support the use of tokens that have names with leading spaces.

- Click **Initialize**.

At the end of a successful initialize operation, the **Hardware Security Module** page appears. The initialized **Status** is indicated by an upward green arrow. The **Type** field displays details of the HSM in use.

10. If you are using an Entrust HSM, then run the following command as user `oracle`:

```
oracle$ /opt/nfast/bin/rfs-sync --commit
```

If you do not perform this step after each initialization when using Entrust, then the multiple features will not be usable, including restoring backups and using the primary-standby configuration.

11. Verify that the operation was successful by checking the most recent initialization log files in the `/var/okv/log/hsm/` directory.

If the initialize operation fails, then you will be redirected to the Hardware Security Module page with non-initialized **Status** and **Type** None. You can find detailed information in the log files in the `/var/okv/log/hsm` directory.

Note:

If you change the HSM credential on the HSM after initialization, then you must also update the HSM credential on the Oracle Key Vault server using the **Set Credential** command before the system restarts. Oracle does not recommend that you change the HSM credential after HSM initialization if there are primary-standby Oracle Key Vault deployments using the HSM, because the standby does not have its credential set by the **Set Credential** command on the primary.

2.2 HSMs in a Multi-Master Cluster

You can configure HSMs in a multi-master cluster with a single node or multiple nodes.

- [About HSMs in a Multi-Master Cluster](#)
You can configure each node in the cluster to use an HSM to store each node's Root of Trust (RoT) key.
- [Configuring an HSM for a Multi-Master Cluster Starting with Single Node \(Recommended\)](#)
Oracle recommends that to use an HSM with a multi-master cluster, you start with a single HSM-enabled node and add additional HSM-enabled nodes using the node induction process.
- [Configuring an HSM for a Multi-Master Cluster with Multiple Nodes](#)
You can configure HSM for multiple nodes by copying a bundle from the first HSM-enabled node to the other nodes in the cluster before configuring HSM for the other nodes.

2.2.1 About HSMs in a Multi-Master Cluster

You can configure each node in the cluster to use an HSM to store each node's Root of Trust (RoT) key.

This RoT protects master encryption keys that Oracle Key Vault uses. HSMs are built with specialized tamper-resistant hardware which is harder to access than normal servers. This

protects the RoT and makes it difficult to extract encrypted data, lowering the risk of compromise. In addition, you can use HSMs in FIPS 140-2 level 3 mode, which enables you to meet certain compliance requirements.

In a multi-master Oracle Key Vault installation, any Key Vault node in the cluster can use any HSM. The nodes in the multi-master cluster will use different TDE wallet passwords and RoT keys and may or may not use different HSM credentials, depending on how you choose to configure each cluster node.

**Note:**

To ensure complete security, you must HSM-enable all Oracle Key Vault nodes in the cluster.

2.2.2 Configuring an HSM for a Multi-Master Cluster Starting with Single Node (Recommended)

Oracle recommends that to use an HSM with a multi-master cluster, you start with a single HSM-enabled node and add additional HSM-enabled nodes using the node induction process.

Oracle recommends the following steps to configure an HSM for a multi-master cluster with a single node:

1. Convert an Oracle Key Vault server into the first node of the cluster.
2. HSM-enable the first node before adding any new nodes.
3. HSM-enable the candidate node before adding it to the cluster.
4. Add the HSM-enabled candidate node to the cluster using a controller node that is also HSM-enabled.

Note the following:

- If any node in the cluster is already HSM-enabled, you cannot add a new node that is not HSM-enabled.
- The Add Node to Cluster page on the controller node will require the controller node's HSM credential.

Related Topics

- [Configuring an HSM for a Multi-Master Cluster with Multiple Nodes](#)
You can configure HSM for multiple nodes by copying a bundle from the first HSM-enabled node to the other nodes in the cluster before configuring HSM for the other nodes.
- *Oracle Key Vault Administrator's Guide*

2.2.3 Configuring an HSM for a Multi-Master Cluster with Multiple Nodes

You can configure HSM for multiple nodes by copying a bundle from the first HSM-enabled node to the other nodes in the cluster before configuring HSM for the other nodes.

- [About Configuring an HSM for a Multi-Master Cluster with Multiple Nodes](#)
The general procedure is to perform steps on first on one node of the cluster, then on the other nodes in the cluster.
- [Step 1: Create and Copy the Bundle after HSM-Enabling the First Node](#)
After HSM-enabling the first node in the multi-master cluster, you must create a bundle and copy it to the other nodes in the cluster.
- [Step 2: Configure the Remaining Nodes](#)
After you configure the first node, you are ready to install the bundle on the remaining nodes.

2.2.3.1 About Configuring an HSM for a Multi-Master Cluster with Multiple Nodes

The general procedure is to perform steps on first on one node of the cluster, then on the other nodes in the cluster.

The instructions for configuring an HSM for a multi-master cluster starting with a single node explain how to configure an HSM for a multi-master cluster, starting with a single node of the cluster and is the recommended way to configure a cluster to use HSM(s). However, if you have already configured a multi-master cluster, you can still configure the cluster to use HSMs. However, there are extra steps needed, involving manually copying a bundle from the first HSM-enabled node to all of the other nodes in the cluster and applying it before proceeding to HSM-enable any other node. Note that if the first node that is HSM-enabled has a read-write peer node, then the read-write peer will not be able to decrypt the replicated information from the HSM-enabled node until the bundle is copied and applied successfully to the read-write peer. This could result in data loss if the bundle is not immediately successfully created and applied to the read-write peer, even if the first node that is HSM-enabled is reverse-migrated afterwards.

After you HSM-enable the first node in the cluster, use the following steps to create the bundle on the HSM-enabled node and copy and apply it on all other nodes in the cluster before you proceed to HSM-enable any other node.

Related Topics

- [Configuring an HSM for a Multi-Master Cluster Starting with Single Node \(Recommended\)](#)
Oracle recommends that to use an HSM with a multi-master cluster, you start with a single HSM-enabled node and add additional HSM-enabled nodes using the node induction process.

2.2.3.2 Step 1: Create and Copy the Bundle after HSM-Enabling the First Node

After HSM-enabling the first node in the multi-master cluster, you must create a bundle and copy it to the other nodes in the cluster.

You must HSM-enable the first node in the cluster similar to how you would HSM-enable a standalone Oracle Key Vault deployment, but with the additional steps in this section.

1. Log in to the Oracle Key Vault management console as a user who has the System Administrator role.
2. Select the **System** tab, then **Settings** in the left navigation bar.
3. In Network Services, click **HSM**.
4. On the HSM-enabled node, click **Create Bundle** on the HSM page.
5. In the Create Bundle dialog box, do the following:

- a. In the **HSM Credential** field, enter the HSM credential.
 - b. In the **Recovery Passphrase** field, enter the recovery passphrase.
 - c. Click the **Create Bundle** button.
6. Log in to the HSM-enabled node through SSH as user `support`.

```
$ ssh support@hsm_enabled_node
```

7. Switch to the `root` user.

```
support$ su root
```

8. To copy the bundle to the `/usr/local/okv/hsm` location on each of the other nodes using the IP address, use SCP.

Ensure that you perform this step using the IP address of all other nodes in the cluster.

```
root# scp /usr/local/okv/hsm/hmsbundle support@ip_address:/tmp
```

Related Topics

- [HSM-Enabling in a Standalone Oracle Key Vault Deployment](#)
You can use the Oracle Key Vault management console to HSM-enable Oracle Key Vault, which configures additional protection for the TDE master encryption key.

2.2.3.3 Step 2: Configure the Remaining Nodes

After you configure the first node, you are ready to install the bundle on the remaining nodes.

Complete this procedure as soon as possible after you have HSM-enabled the first node and copied the bundle to all other nodes.

1. Log in to each node in the cluster using the IP address (except the original HSM-enabled node):.

```
$ ssh support@ip_address
```

2. On each node, switch to the `root` user.

```
support$ su root
```

3. Perform the following steps on each node:

```
root# cp /tmp/hmsbundle /usr/local/okv/hsm/  
root# chown oracle:oinstall /usr/local/okv/hsm/hmsbundle
```

4. On each node except the original HSM-enabled node, click **Apply Bundle** on the **HSM** page, and then follow these steps:
 - a. In the **Recovery Passphrase** field, enter the recovery passphrase.
 - b. Click the **Apply Bundle** button.

You must apply the bundle immediately on all nodes before you reverse-migrate the original HSM-enabled node.

5. Proceed to HSM-enable each of the remaining nodes in the cluster.
6. After you have HSM-enabled all nodes and verified the replication between all nodes, remove the `hsmbundle` file from all of the nodes.

2.3 HSM-Enabling in a Primary-Standby Oracle Key Vault Deployment

In an Oracle Key Vault primary-standby deployment, you must perform the HSM-enabling tasks separately on the Oracle Key Vault servers that will become primary and standby servers.

You must perform this task before pairing these two servers in a primary-standby configuration. If you have already HSM-enabled either the primary or the standby server, or both, but do not follow these steps and then do a primary-standby pairing, then the configuration will fail. If the servers are already paired but neither are HSM-enabled, then you must unpair them, reinstall the standby server, and follow these steps.

1. Install two separate Oracle Key Vault instances.
2. Choose one to be the primary and the other to be the standby server.
3. Install the HSM client software on both the servers that will be used as the primary and the standby servers.
4. Enroll the designated primary and standby servers as clients of the same HSM.
5. HSM-enable the designated primary server.

If you are using Entrust, ensure that you have already executed `/opt/nfast/bin/rfs-sync --commit` on this server as user `oracle` before continuing.

6. Perform the following steps on the primary server:
 - a. Log in to the designated primary server through SSH as user `support`, switch user (`su`) to `root`, then switch user (`su`) to `oracle`.

```
$ ssh support@okv_primary_instance_ip_address
support$ su root
root# su oracle
```

- b. Securely copy the following files to the designated standby server:

```
oracle$ cd /usr/local/okv/hsm/wallet
oracle$ scp cwallet.sso support@okv_standby_instance_ip_address:/tmp
oracle$ scp encdepwd support@okv_standby_instance_ip_address:/tmp
oracle$ cd /usr/local/okv/hsm/restore
oracle$ scp ewallet.p12 support@okv_standby_instance_ip_address:/tmp
```

7. Perform the following steps on the designated standby server:

- a. Log in to the designated standby server through SSH as user `support`, then switch user (`su`) to `root`.

```
$ ssh support@okv_standby_instance_ip_address
support$ su root
```

- b. Set up the HSM-related files and in the `okv_security.conf` file, set the `HSM_ENABLED` and `HSM_PROVIDER` parameters.

Earlier versions of Oracle Key Vault may not contain certain parameters in `okv_security.conf` that are present in later versions.

```
root# cd /usr/local/okv/hsm/wallet
root# mv /tmp/enctdepwd .
root# mv /tmp/cwallet.sso .
root# chown oracle *
root# chgrp oinstall *
root# cd /usr/local/okv/hsm/restore
root# mv /tmp/ewallet.p12 .
root# chown oracle *
root# chgrp oinstall *
root# vi /usr/local/okv/etc/okv_security.conf
    Set HSM_ENABLED="1"
    Set HSM_PROVIDER="provider_value"
    Set HSM_KEY_EXTRACTABLE="extractable_value"
    Set HSM_TOKEN_LABEL="token_label_value"
```

In this specification:

- `HSM_ENABLED` is set in this example to 1 to prepare the designated standby to use the HSM should a switchover or failover occur.
- `HSM_PROVIDER` refers to the HSM provider. For Thales, set this value to 1. For Entrust, set it to 2. For Utimaco, set it to 3. For other HSM vendors that have been certified, enter 4.

The `HSM_PROVIDER` may not be present in the `okv_security.conf` file. If this setting is present, then change it to the setting that is appropriate for the HSM provider. If it is not present, then add the following line. Ensure that the `provider_value` setting is in quotation marks.

```
HSM_PROVIDER="provider_value"
```

- `HSM_KEY_EXTRACTABLE` and `HSM_TOKEN_LABEL` should be set to the same value on the standby that is set on the primary server.

- c. Save and quit by entering the following character:

```
:wq!
```

- d. If you are using Entrust, then execute the following commands:

```
root# su - oracle
oracle$ /opt/nfast/bin/rfs-sync --update
```

8. Without restarting the Oracle Key Vault instances, navigate to the primary and standby Oracle Key Vault management consoles and configure primary-standby environment.

Related Topics

- [Oracle Key Vault Administrator's Guide](#)

2.4 Backup and Restore Operations in an HSM-Enabled Oracle Key Vault Instance

You can back up and restore an HSM-enabled Oracle Key Vault instance.

- [Backup Operations in an HSM-Enabled Oracle Key Vault Instance](#)
The steps to back up Oracle Key Vault data in an HSM-enabled instance are the same as the steps used to back up an instance that has not been HSM-enabled.
- [Restore Operations in an HSM-Enabled Oracle Key Vault Instance](#)
Backups taken from an HSM-enabled Oracle Key Vault instance can only be restored onto a standalone Oracle Key Vault server with access to the same Root of Trust key that was in use when the backup was taken.

2.4.1 Backup Operations in an HSM-Enabled Oracle Key Vault Instance

The steps to back up Oracle Key Vault data in an HSM-enabled instance are the same as the steps used to back up an instance that has not been HSM-enabled.

You can use the Oracle Key Vault management console to perform a backup operation.

Related Topics

- [Oracle Key Vault Administrator's Guide](#)

2.4.2 Restore Operations in an HSM-Enabled Oracle Key Vault Instance

Backups taken from an HSM-enabled Oracle Key Vault instance can only be restored onto a standalone Oracle Key Vault server with access to the same Root of Trust key that was in use when the backup was taken.

Before you restore a backup onto a system, you must ensure that the system can access both the HSM and the Root of Trust (RoT) that was used to make the backup. You must therefore have installed the HSM client software on the Oracle Key Vault server and enrolled the Oracle Key Vault as a client of the HSM before proceeding with this step. If the backup was taken on an HSM-enabled cluster node, then when you restore the backup to a standalone server, you must ensure that the server has access to the same HSM and RoT as the node on which the backup was taken.

1. Log into the Oracle Key Vault management console as a user with the System Administrator role.
The Oracle Key Vault Home page appears.
2. Select the **System** tab, then **Settings** in the left navigation bar.
3. In Network Services, click **HSM**.
The Hardware Security Module page appears. On restore, the **Status** is disabled first, then enabled after the restore completes.
4. Click **Set Credential**.
The Prepare for HSM Restore screen appears.

5. Enter the HSM credential two times: first in **HSM Credential** and second in **Re-enter HSM Credential**.

Consult the documentation that came with your HSM for this credential. The HSM credential for Thales is the Thales partition password. For Entrust, the credential is the password that is associated with the Operator Card Set or Softcard. The HSM-credential if you use an Operator Card Set is the Operator Card Set password. If you use a Softcard, then the password is the Softcard password. For other HSM vendors that have been certified, consult the vendor documentation.

6. If the backup you are restoring was taken while Oracle Key Vault was HSM-enabled and given a specific token to use, select **Use Token Label** and enter the token label of the token that Oracle Key Vault was using when the backup was taken.
7. Click **Set Credential**.

 **Caution:**

If a credential has already successfully been set either via the Set Credential or Initialize operations, if you set an incorrect credential for the HSM, the previous credential, token label, and vendor will continue to be stored and used. If a credential has not been set previously and the Set Credential operation fails, the incorrect credential, token label, and vendor are not stored.

The HSM credential will be stored in the system. It must be stored on the system so that it can be used to perform a backup restore operation because it is not stored in backup itself.

8. If you are using Entrust, then run the following command as user `oracle`:

```
oracle$ /opt/nfast/bin/rfs-sync --update
```

This command is needed for an Entrust backup restore to complete successfully.

9. In the Oracle Key Vault management console, go to the **Restore** page and then restore the backup.

Related Topics

- [Oracle Key Vault Administrator's Guide](#)

2.5 Reverse Migration Operations

Reverse migrating an HSM-enabled Oracle Key Vault server reverts the Key Vault server to using the recovery passphrase to protect the TDE wallet.

This operation is necessary if you no longer want to use the HSM to protect the TDE wallet password (for example, if the HSM must be decommissioned).

- [Reverse Migrating a Standalone Deployment](#)
You can reverse migrate a standalone deployment by using the Oracle Key Vault management console.

- [Reverse Migrating a Multi-Master Cluster](#)
You can reverse migrate a multi-master cluster by using the Oracle Key Vault management console.
- [Reverse Migrating a Primary-Standby Deployment](#)
To reverse migrate a primary-standby deployment, use both the Oracle Key Vault management console and the command line.

2.5.1 Reverse Migrating a Standalone Deployment

You can reverse migrate a standalone deployment by using the Oracle Key Vault management console.

1. Log into the Oracle Key Vault management console as a user with the System Administrator role.

The Oracle Key Vault Home page appears.

2. Select the **System** tab, then **Settings** in the left navigation bar.
3. In Network Services, click **HSM**.

The Hardware Security Module page appears.

4. Click **Reverse Migrate**.

The HSM Reverse Migrate window is displayed.

HSM Reverse Migrate

Cancel Reverse Migrate

HSM Credential

Old Recovery Passphrase

New Recovery Passphrase

Re-enter New Recovery Passphrase

Enter the following details:

- Enter the HSM credential in the **HSM Credential** field. Consult the HSM documentation for this credential. The HSM credential for Thales is the Thales partition password. For Entrust, the credential is the password that is associated with the Operator Card Set or Softcard. For Utimaco, the credential is the PIN that was initialized when the token was configured. For other HSM vendors that have been certified, consult the vendor documentation
- Enter the old recovery passphrase in the **Old Recovery Passphrase** field.
- Enter the new recovery passphrase in the **New Recovery Passphrase** and **Re-enter New Recovery Passphrase** fields. If you do not want to change the recovery passphrase, then enter the same recovery passphrase in the **New Recovery**

Passphrase and **Re-enter New Recovery Passphrase** fields as the one you entered in **Old Recovery Passphrase**.

5. Click **Reverse Migrate**.

The Hardware Security Module page appears. The red downward arrow indicates the **Status**.

2.5.2 Reverse Migrating a Multi-Master Cluster

You can reverse migrate a multi-master cluster by using the Oracle Key Vault management console.

1. Log into the Oracle Key Vault management console as a user with the System Administrator role.

The Oracle Key Vault **Home** page appears.

2. Select the **System** tab, then **Settings** in the left navigation bar.

3. In Network Services, click **HSM**.

The Hardware Security Module page appears.

4. Click **Reverse Migrate**.

The HSM Reverse Migrate window is displayed.

Enter the following details:

- In the **HSM Credential** field, enter the HSM credential. Consult the documentation that came with your HSM for this credential. The HSM credential for Thales is the Thales partition password. For Entrust, the credential is the password that is associated with the Operator Card Set or Softcard. For Utimaco, the credential is the PIN that was initialized when the token was configured. For other HSM vendors that have been certified, consult the vendor documentation
- In the **Recovery Passphrase** field, enter the recovery passphrase.

5. Click **Reverse Migrate**

The **Hardware Security Module** page appears. The red downward arrow indicates the **Status**.

2.5.3 Reverse Migrating a Primary-Standby Deployment

To reverse migrate a primary-standby deployment, use both the Oracle Key Vault management console and the command line.

1. Log into the Oracle Key Vault management console as a user with the System Administrator role.

The Oracle Key Vault **Home** page appears.

2. Select the **System** tab, then **Settings** in the left navigation bar.

3. In Network Services, click **HSM**.

The Hardware Security Module page appears.

4. Click **Reverse Migrate**.

The HSM Reverse Migrate screen is displayed.

HSM Reverse Migrate
ⓧ

Cancel
Reverse Migrate

HSM Credential	<input type="text"/>
Old Recovery Passphrase	<input type="text"/>
New Recovery Passphrase	<input type="text"/>
Re-enter New Recovery Passphrase	<input type="text"/>

On the HSM Reverse Migrate screen, enter the following details:

- Enter the HSM credential in the **HSM Credential** field. Consult the documentation that came with your HSM for this credential. The HSM credential for Thales is the Thales partition password. For Entrust, the credential is the password that is associated with the Operator Card Set or Softcard. For Utimaco, the credential is the PIN that was initialized when the token was configured. For other HSM vendors that have been certified, consult the vendor documentation.
- Enter the old recovery passphrase in the **Old Recovery Passphrase** field.
- Enter the new recovery passphrase in the **New Recovery Passphrase** and **Re-enter New Recovery Passphrase** fields. If you do not want to change the recovery passphrase, then enter the same recovery passphrase in the **New Recovery Passphrase** and re-enter the **New Recovery Passphrase** fields as the one you entered in **Old Recovery Passphrase**.

5. Click **Reverse Migrate**

The **Hardware Security Module** page appears. The red downward arrow indicates the **Status**.

6. On the standby server, log in to the Oracle Key Vault Server through SSH as user `support`, then switch user (`su`) to `root`.

```
$ ssh support@okv_standby_instance
support$ su root
```

7. Modify the `okv_security.conf` file.

```
root# vi /usr/local/okv/etc/okv_security.conf
```

- Delete the line `HSM_PROVIDER="provider_value"`.
- Change the value of the parameter `HSM_ENABLED` to `"0"`.

Save and quit by entering the following character: `:wq!`

8. On the standby server, remove the following files:

```
root# cd /usr/local/okv/hsm/wallet
root# rm -f cwallet.sso enctdepwd
root# cd /usr/local/okv/hsm/restore
root# rm -f cwallet.sso ewallet.p12
root# cd /mnt/okvram
root# rm -f cwallet.sso ewallet.p12
root# cd /mnt/okvram/restore
root# rm -f cwallet.sso ewallet.p12
root# cd /usr/local/okv/tde
root# rm -f cwallet.sso
```

9. Switch user (su) to oracle:

```
root# su oracle
```

10. Run the following command:

```
oracle$ /var/lib/oracle/dbfw/bin/orapki wallet create -wallet /usr/
local/okv/tde -auto_login
```

11. Enter the new recovery passphrase that you specified in Step 4.

The primary-standby deployment is successfully reverse migrated.

2.6 Disabling Reverse Migration on the Management Console

You can disable reverse migration by using the Oracle Key Vault management console.

To disable the reverse migration ability on the management console, you need to edit the `okv_security.conf` file. Once you edit the `okv_security.conf` file as suggested, the Reverse Migrate button is removed from the management console.

1. Log in to the server through SSH as user.

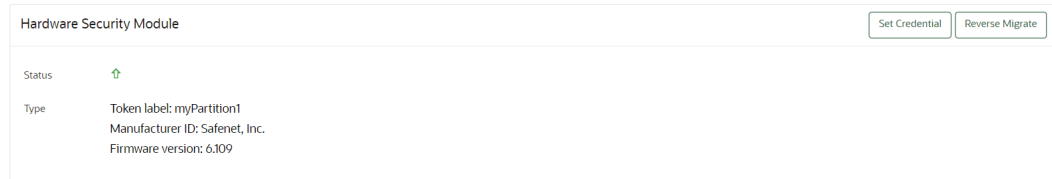
```
ssh support@ip_address
```

2. Switch to the root use.

```
su-root
```

3. Select the **System** tab.
4. Select **Settings** in the left navigation bar.
5. In Network Services, click **HSM**.

The Hardware Security Module page appears with **Reverse Migrate** button.



6. Edit the `okv_security.conf` file to change **HSM_REVERSE_MIGRATE_ENABLED** to

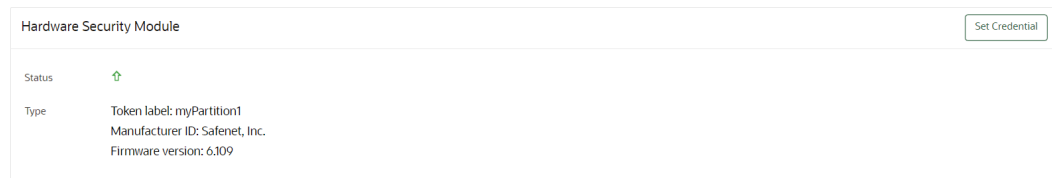
```
"0" root# vi /usr/local/okv/etc/okv_security.conf  
Set HSM_REVERSE_MIGRATE_ENABLED="0"
```

HSM.

7. Save and quit by entering the following sequence of characters:

```
:wq
```

The Hardware Security Module page appears without **Reverse Migrate** button.



Note:

When the parameter `HSM_REVERSE_MIGRATE_ENABLED` is set to "1" the **Reverse Migrate** button is available, when the `HSM_REVERSE_MIGRATE_ENABLED` value is set to "0" **Reverse Migrate** button is not available.

3

Upgrade Considerations When Using HSMs in Oracle Key Vault

When you upgrade an Oracle Key Vault deployment that is integrated with an HSM, consider factors such as the version of Oracle Key Vault.

- [Upgrades from Oracle Key Vault Release 12.2](#)
Upgrading from a standalone or a primary-standby Oracle Key Vault release 12.2 environment has special considerations for HSMs.
- [Upgrade Considerations for Entrust](#)
When you upgrade while HSM-enabled and using an Entrust HSM, you must remake hardware changes and consider changes to overriding security assurances.
- [Using a Token Label After Upgrading Oracle Key Vault without Reverse-Migrating](#)
Starting in release 18.4, Oracle Key Vault can use a token label when you choose a slot while connecting to an HSM.

3.1 Upgrades from Oracle Key Vault Release 12.2

Upgrading from a standalone or a primary-standby Oracle Key Vault release 12.2 environment has special considerations for HSMs.

- [Upgrading from an Oracle Key Vault Release 12.2 Standalone Deployment](#)
You can upgrade from an Oracle Key Vault standalone deployment by reverse-migrating before the upgrade, and after the upgrade completes, re-HSM-enabling Oracle Key Vault.
- [Upgrading from an Oracle Key Vault Release 12.2 Primary-Standby Deployment](#)
You can upgrade from an Oracle Key Vault release 12.2 primary-standby deployment by reverse-migrating before the upgrade, and after the upgrade completes, re-HSM-enabling Oracle Key Vault.

3.1.1 Upgrading from an Oracle Key Vault Release 12.2 Standalone Deployment

You can upgrade from an Oracle Key Vault standalone deployment by reverse-migrating before the upgrade, and after the upgrade completes, re-HSM-enabling Oracle Key Vault.

1. Make a one-time backup of the Oracle Key Vault server to a remote backup destination.
2. Make a copy of the `/mnt/okvram/cwallet.sso` wallet file.

```
$ ssh support@Oracle_Key_Vault_server_IP_address
support$ su - root
root# /bin/cp /mnt/okvram/cwallet.sso /var/lib/oracle/cwallet_hsm_upgrade.sso
```

3. Reverse migrate so that Oracle Key Vault is no longer using an HSM as the RoT.

You can verify the success of this operation by checking the audit record in the audit trail.

If this step fails despite using the correct HSM credential and recovery passphrase, then do not continue with the rest of these steps. Contact Oracle Support.

4. Make another one-time backup of the Oracle Key Vault server to a remote backup destination.
5. Proceed with the rest of the upgrade steps as for a standalone Oracle Key Vault server, including taking a one-time backup after the upgrade completes.
6. After the upgrade successfully completes, optionally HSM-enable your Oracle Key Vault server.
7. Remove the copied wallet in Step 2.

```
$ ssh support@Oracle_Key_Vault_server_IP_address
support$ su - root
root# /bin/rm /var/lib/oracle/cwallet_hsm_upgrade.sso
```

Related Topics

- [HSM-Enabling in a Standalone Oracle Key Vault Deployment](#)
You can use the Oracle Key Vault management console to HSM-enable Oracle Key Vault, which configures additional protection for the TDE master encryption key.
- [Backup Operations in an HSM-Enabled Oracle Key Vault Instance](#)
The steps to back up Oracle Key Vault data in an HSM-enabled instance are the same as the steps used to back up an instance that has not been HSM-enabled.
- [Reverse Migrating a Standalone Deployment](#)
You can reverse migrate a standalone deployment by using the Oracle Key Vault management console.

3.1.2 Upgrading from an Oracle Key Vault Release 12.2 Primary-Standby Deployment

You can upgrade from an Oracle Key Vault release 12.2 primary-standby deployment by reverse-migrating before the upgrade, and after the upgrade completes, re-HSM-enabling Oracle Key Vault.

1. On the current primary, make a one-time backup of the Oracle Key Vault server to a remote backup destination.
2. On the current primary, make a copy of the `/mnt/okvram/cwallet.sso` wallet file.

```
$ ssh support@Oracle_Key_Vault_server_IP_address
support$ su - root
root# /bin/cp /mnt/okvram/cwallet.sso /var/lib/oracle/cwallet_hsm_upgrade.sso
```

3. Unpair the primary and the standby servers.
 - a. Log in to the primary server's management console as a user with the System Administrator role.
 - b. Select the **System** tab, then **Settings** in the left navigation bar.
 - c. In the System Configuration area, click **Primary-Standby**.
 - d. Click **Unpair**.

The unpair operation takes about 10 minutes to complete. After the unpair operation is complete, the standby will no longer be usable.

4. Reverse migrate so that Oracle Key Vault is no longer using an HSM as the RoT.
You can verify the success of this operation by checking the audit record in the audit trail.
If this step fails despite using the correct HSM credential and recovery passphrase, then do not continue with the rest of these steps. Contact Oracle Support.
5. Make another one-time backup of the Oracle Key Vault server to a remote backup destination.
6. Proceed with the rest of the upgrade steps for a primary-standby Oracle Key Vault server, including taking a one-time backup after the upgrade completes.
7. After the upgrade successfully completes, optionally HSM-enable a new primary-standby configuration using the upgraded Oracle Key Vault server as the primary and a fresh installation of the same version as the standby.
8. Remove the copied wallet in Step 2.

```
$ ssh support@Oracle_Key_Vault_server_IP_address
support$ su - root
root# /bin/rm /var/lib/oracle/cwallet_hsm_upgrade.sso
```

Related Topics

- [Backup Operations in an HSM-Enabled Oracle Key Vault Instance](#)
The steps to back up Oracle Key Vault data in an HSM-enabled instance are the same as the steps used to back up an instance that has not been HSM-enabled.
- [Reverse Migrating a Standalone Deployment](#)
You can reverse migrate a standalone deployment by using the Oracle Key Vault management console.
- [HSM-Enabling in a Primary-Standby Oracle Key Vault Deployment](#)
In an Oracle Key Vault primary-standby deployment, you must perform the HSM-enabling tasks separately on the Oracle Key Vault servers that will become primary and standby servers.

3.2 Upgrade Considerations for Entrust

When you upgrade while HSM-enabled and using an Entrust HSM, you must remake hardserver changes and consider changes to overriding security assurances.

- [Remaking Hardserver Changes While Upgrading Oracle Key Vault](#)
Because HSM configurations can vary, it is your responsibility to run test upgrades on non-production environments to ensure that the upgrade will work with your HSM configuration.
- [Overriding Security Assurances for the Oracle Key Vault Upgrade](#)
You can configure how the Oracle Key Vault security assurance attributes are set for future initialization operations.
- [Re-installation of Entrust Software While Upgrading Oracle Key Vault from 18.x to 21.x](#)
During the upgrade from Oracle Key Vault 18.x to 21.x, the operating system is upgraded from Oracle Linux 6 to Oracle Linux 7.

3.2.1 Remaking Hardserver Changes While Upgrading Oracle Key Vault

Because HSM configurations can vary, it is your responsibility to run test upgrades on non-production environments to ensure that the upgrade will work with your HSM configuration.

Upgrading Oracle Key Vault can undo changes that had been made before the upgrade to accommodate the installed HSM software. After the upgrade, perform the following steps and then ensure that Oracle Key Vault has all of the necessary changes to support integration with your HSM.

1. After you execute the steps to upgrade, and if the upgrade completed successfully, connect to the Oracle Key Vault server as the `root` user.

```
$ ssh support@Oracle_Key_Vault_server_IP_address
support$ su - root
```

2. Execute the following command as the `root` user:

```
root# usermod -a -G nfast oracle
```

3.2.2 Overriding Security Assurances for the Oracle Key Vault Upgrade

You can configure how the Oracle Key Vault security assurance attributes are set for future initialization operations.

As of Oracle Key Vault release 18.4.0.0.0, the Root of Trust (RoT) key that is created will have its `CKA_EXTRACTABLE` attribute set to `CK_FALSE` by default. However, in release 18.3.0.0.0 and earlier, `CKA_EXTRACTABLE` was set to `CK_TRUE`. This meant that the file `/opt/nfast/cknfastrc` used to require the following additional line:

```
CKNFAST_OVERRIDE_SECURITY_ASSURANCES=explicitness;tokenkeys;longterm
```

If you are upgrading Oracle Key Vault from release 18.3.0.0.0 or earlier, then these parameters will continue to be needed until you have reverse-migrated and re-initialized in a higher version, which will create a new RoT key with the `CKA_EXTRACTABLE` attribute set to `CK_FALSE`. If you prefer that future initialize operations continue have `CKA_EXTRACTABLE` set to `CK_TRUE` in release 18.4.0.0.0 and later, then perform the following steps before initializing.

1. Connect to the Oracle Key Vault server as the `root` user.

```
$ ssh support@Oracle_Key_Vault_server_IP_address
support$ su - root
```

2. Open the file `okv_security.conf`:

```
root# vi /usr/local/okv/etc/okv_security.conf
```

3. Set the `HSM_KEY_EXTRACTABLE` parameter in `okv_security.conf` as follows:

```
HSM_KEY_EXTRACTABLE="1"
```

4. Save and exit the `okv_security.conf` file.

```
:wq
```


5. Open the `/opt/nfast/cknfastrc` file.

```
root# vi /opt/nfast/cknfastrc
```

6. Add the following line to `/opt/nfast/cknfastrc`:

```
CKNFAST_OVERRIDE_SECURITY_ASSURANCES=explicitness;tokenkeys;longterm
```

Future initialize operations on this Oracle Key Vault server will now create Root of Trust keys with the `CKA_EXTRACTABLE` attribute set to `CK_TRUE`.

3.2.3 Re-installation of Entrust Software While Upgrading Oracle Key Vault from 18.x to 21.x

During the upgrade from Oracle Key Vault 18.x to 21.x, the operating system is upgraded from Oracle Linux 6 to Oracle Linux 7.

In order to preserve HSM integration functionality after the upgrade, the following steps are performed automatically during the upgrade:

```
/opt/nfast/sbin/install  
/sbin/usermod -a -G nfast oracle  
Edits to the /etc/systemd/system/nc_hardserver.service file
```

No action is required unless these steps are insufficient to set up the Entrust HSM in your environment. Oracle recommends that you run a test upgrade on a non-production environment to ensure that the upgrade will work with your HSM configuration.

3.3 Using a Token Label After Upgrading Oracle Key Vault without Reverse-Migrating

Starting in release 18.4, Oracle Key Vault can use a token label when you choose a slot while connecting to an HSM.

If you are upgrading an HSM-enabled Oracle Key Vault from a previous version, then you can begin using a token label after successfully upgrading without reverse-migrating.

1. Perform the upgrade to Oracle Key Vault release 18.4 or later.
2. Locate the token label of the token that Oracle Key Vault is currently using.
 - a. Log into the Oracle Key Vault management console as a user who has the System Administrator role.
 - b. Select the **System** tab, then **Settings** in the left navigation bar.
 - c. In the Network Services area, click **HSM** to display the Hardware Security Module page.

If the HSM is configured and running, then the **Type** label indicates the token label.

For example:

Token label: myPartition1

Manufacturer ID: Safenet, Inc.

Firmware version: 6.109

- d. Select the **Set Credential** button.

- e. In the Prepare for HSM Restore window, select from the **Vendor** menu, enter the HSM credential in the **HSM Credential** and **Re-enter HSM Credential** fields. Check the **Use Token Label** check box and enter the token label that you found (for example, `myPartition1`) in the **Token Label** field. Then click **Set Credential**.

If this operation is successful, then Oracle Key Vault will begin to use the given token label when choosing a slot. If the operation fails, then your settings (token label, vendor, and HSM credential) are returned to what they were previously.

After this operation completes, if the green status arrow changes to a red arrow, this means that you have entered the wrong HSM credential, token label, vendor, or some combination of the three, and Oracle Key Vault was unable to revert the values to what they were previously. Oracle recommends that you try another set credential operation using the former HSM credential, token label, and vendor settings and do not restart Oracle Key Vault until the status arrow is again green. For more information about why the status arrow is red, check the most recent log files under the `/var/okv/log/hsm` directory.

4

Oracle Key Vault HSM Support Guidance

The Oracle Key Vault HSM support guidance provides information about troubleshooting and vendor specific notes.

- [General Troubleshooting](#)
Oracle Key Vault provides general troubleshooting help. Vendor-specific notes cover vendor-specific troubleshooting.
- [Vendor Specific Notes for Thales](#)
Oracle Key Vault supports integration with Thales (formerly Safenet Luna) NetworkHSM version 7000, but does not support Host Trust Link (HTL) for Thales HSM.
- [Vendor Specific Notes for Entrust](#)
You can integrate Oracle Key Vault release 12.2 BP 3 and later with the HSM from Entrust nShield Connect + and XC models.
- [Vendor Specific Notes for Utimaco](#)
Oracle Key Vault supports Oracle Key Vault integration with Utimaco SecurityServer 4.31.1.
- [Vendor Specific Notes for Other HSMs](#)
For HSMs other than Thales Luna Network HSM version 7000, Entrust nShield Connect + and XC models, or Utimaco's SecurityServer 4.31.1, Oracle Key Vault supports an integration with HSM vendors that meet the Oracle Key Vault requirements.

4.1 General Troubleshooting

Oracle Key Vault provides general troubleshooting help. Vendor-specific notes cover vendor-specific troubleshooting.

- [Trace Files for Diagnosing Issues](#)
Oracle Key Vault provides trace files so that you can better diagnose issues that may arise.
- [HSM Alert](#)
Oracle Key Vault provides an alert mechanism that periodically monitors the HSM configuration to check for Root of Trust key availability and file health.
- [Could Not Get Slot for HSM Error](#)
The `Could Not Get Slot for HSM` error indicates that Oracle Key Vault could not get a slot from the HSM.
- [Could Not Load PKCS#11 Library Error](#)
The `Could Not Load PKCS#11 Library` error indicates that Oracle Key Vault could not load the PKCS#11 library.
- [Oracle Key Vault Management Console Does Not Start After Restarting HSM-Enabled Oracle Key Vault Server](#)
The Oracle Key Vault management console may not appear after you restart the HSM-enabled Oracle Key Vault server.

- [Primary-Standby Errors](#)
The `okv_security.conf` file contains settings that can help you diagnose primary-standby errors.
- [Errors from HSM-Enabled Oracle Key Vault Backups](#)
You can use the `cwallet.sso` file to diagnose HSM-enabled Oracle Key Vault backup errors.
- [Restoration of a Backed Up HSM-Enabled Oracle Key Vault Server](#)
Before you restore a backup that was taken on an HSM-enabled Oracle Key Vault server, ensure that you have set the same HSM credential and token label that were used when the backup was taken.

4.1.1 Trace Files for Diagnosing Issues

Oracle Key Vault provides trace files so that you can better diagnose issues that may arise.

Use these trace files to more finely diagnose issues when you attempt hardware security module operations. These trace files are located in the `/var/okv/log/hsm/` directory on the Oracle Key Vault server. To see the most recently failed operation, you can sort the trace files by their last modified time. For example, `ls -ltr /var/okv/log/hsm` lists the most recently modified trace files at the bottom of the list.

4.1.2 HSM Alert

Oracle Key Vault provides an alert mechanism that periodically monitors the HSM configuration to check for Root of Trust key availability and file health.

When an Oracle Key Vault server is HSM-enabled, Oracle Key Vault contacts the HSM every five minutes (or whatever you have set the monitoring interval to on the Configure Alerts page) to ensure that the Root of Trust key is available and the TDE wallet password can be decrypted. When a problem in the HSM configuration arises (for example, the HSM cannot be reached or if there are conflicting keys in the HSM with the same ID), then the up arrow on the **Hardware Security Module** page (accessed by selecting the **System** tab, then **Settings**, then in the Network Services area, clicking **HSM**) switches to a down arrow and an alert is raised. The down arrow signifies that the HSM is not configured or the HSM configuration has a problem.

When an alert has been raised, the following error message appears: HSM configuration error. Please refer to the HSM Alert section in the Oracle Key Vault Root of Trust HSM Configuration Guide.

If this alert appears, then follow these steps:

1. Log in as root as follows:

```
$ ssh support@okv_instance_ip_address
support$ su - root
```

2. Back up the SSO wallet. For example:

```
root# cp /mnt/okvram/cwallet.sso /var/lib/oracle/cwallet_hsm_backup.sso
```

3. Diagnose the source of the alert.

The following `verify` command should show why the alert was raised. The `ls -ltrh` command shows the most recent log file at the bottom of the output.

```
root# su - oracle
oracle$ /usr/local/okv/hsm/bin/hsmclient verify
oracle$ cd /var/okv/log/hsm
oracle$ ls -ltrh
```

4. If you cannot resolve this problem, then contact Oracle Support.

4.1.3 Could Not Get Slot for HSM Error

The `Could Not Get Slot for HSM` error indicates that Oracle Key Vault could not get a slot from the HSM.

Consult the most recent trace files for more details. Possible causes include providing an invalid or nonexistent token label and the HSM failing to return a list of slots.

4.1.4 Could Not Load PKCS#11 Library Error

The `Could Not Load PKCS#11 Library` error indicates that Oracle Key Vault could not load the PKCS#11 library.

Possible reasons for this error could be due to file permission issues or failing to properly deploy the HSM client software on Oracle Key Vault. More details can be found in recent trace files. Oracle looks for the PKCS#11 library at the following locations, depending on the vendor:

- For Thales, `/usr/safenet/lunaclient/lib/libCryptoki2_64.so`
- For Entrust, `/opt/nfast/toolkits/pkcs11/libcknfast.so`
- For Utimaco, `/opt/utimaco/lib/libcs_pkcs11_R2.so`

4.1.5 Oracle Key Vault Management Console Does Not Start After Restarting HSM-Enabled Oracle Key Vault Server

The Oracle Key Vault management console may not appear after you restart the HSM-enabled Oracle Key Vault server.

If this happens, then log into the Oracle Key Vault server using SSH as user `support` and try manually opening the wallet as follows:

```
$ ssh support@okv_instance_ip_address
support$ su root
root# su oracle
oracle$ cd /usr/local/okv/hsm/bin
oracle$ ./hsmclient open_wallet
```

If the `open_wallet` command succeeds, the database will open and the management console will appear, unless there is another non-HSM problem. If the command does not succeed, then check the recent log files under `/var/okv/log/hsm` and check for vendor-specific instructions.

4.1.6 Primary-Standby Errors

The `okv_security.conf` file contains settings that can help you diagnose primary-standby errors.

- Check that the files have been transported to the standby server.

Execute the command `ls -l` as root on the standby server:

```
root# ls -l /usr/local/okv/hsm/wallet
-rw----- 1 oracle oinstall 324 May 16 22:57 cwallet.sso
-rw----- 1 oracle oinstall 176 May 16 22:57 enctdepwd
root# ls -l /usr/local/okv/hsm/restore
-rw----- 1 oracle oinstall 320 May 16 22:57 ewallet.p12
```

You should see `cwallet.sso` and `enctdepwd` in the `/usr/local/okv/hsm/wallet` directory and `ewallet.p12` in the `/usr/local/okv/hsm/restore` directory.

- Check that the mode is set to HSM on the standby server:

Open the file `okv_security.conf` as root on the standby server:

```
root# cat /usr/local/okv/etc/okv_security.conf
Look for the line:
HSM_ENABLED="1"
```

You should see the number within double quotes.

- Check the vendor-specific instructions.

4.1.7 Errors from HSM-Enabled Oracle Key Vault Backups

You can use the `cwallet.sso` file to diagnose HSM-enabled Oracle Key Vault backup errors.

You should check that the `pre_restore` command has been run on the target as follows:

Execute the command `ls -l` as root on the Oracle Key Vault server to which you are restoring the backup:

```
root# ls -l /usr/local/okv/hsm/wallet
-rw----- 1 oracle oinstall 324 May 16 22:57 cwallet.sso
```

You should see the wallet file `cwallet.sso`, which indicates that the credential has successfully been set and stored on Oracle Key Vault.

You should also check that you have followed the instructions from the HSM vendor. In addition, check the most recent log files generated by the recent backup restore, which are in the `/var/okv/log/db` directory.

4.1.8 Restoration of a Backed Up HSM-Enabled Oracle Key Vault Server

Before you restore a backup that was taken on an HSM-enabled Oracle Key Vault server, ensure that you have set the same HSM credential and token label that were used when the backup was taken.

The HSM credential for Thales is the Thales partition password. For Entrust, the credential is the password that is associated with the Operator Card Set or Softcard. For Utimaco, the credential is the PIN that was initialized when the token was configured.

When using the Set Credential operation, if you enter an incorrect credential or token label, or if Oracle Key Vault is unable to connect to the HSM, then the operation will not succeed and the credential, token label, and vendor provided will not be stored. Ensure that Oracle Key Vault has been enrolled as a client of the HSM and then ensure that the correct credential and token label are entered such that Oracle Key Vault will be able to access the same Root of Trust key that was in use when the backup was taken.

For more information about enrolling Oracle Key Vault as a client of the HSM, see [Enrolling Oracle Key Vault as a Client of the HSM](#).

4.2 Vendor Specific Notes for Thales

Oracle Key Vault supports integration with Thales (formerly Safenet Luna) NetworkHSM version 7000, but does not support Host Trust Link (HTL) for Thales HSM.

- [Installing the HSM Client Software on the Oracle Key Vault Server for Thales](#)
You must use the Luna Universal Client version 6.2.2 for Linux x64 for the installation when integrating Oracle Key Vault with Thales. If you must use a different client version, consult your vendor and use the infrastructure provided to integrate Oracle Key Vault with other HSMs.
- [HSM Credential for Thales](#)
The HSM credential is the Thales partition password.
- [Token Label for Thales](#)
The token label for Thales is the name of the partition.
- [Enrolling Oracle Key Vault as a Client of a Thales HSM](#)
To perform the enrollment, you use the Oracle Key Vault management console and the command-line interface.
- [HSM Provider Value for Thales](#)
For Thales, the provider value is 1.
- [HSM Vendor Specific Checks for Thales](#)
You should check the Thales vendor-specific settings.

4.2.1 Installing the HSM Client Software on the Oracle Key Vault Server for Thales

You must use the Luna Universal Client version 6.2.2 for Linux x64 for the installation when integrating Oracle Key Vault with Thales. If you must use a different client version, consult your vendor and use the infrastructure provided to integrate Oracle Key Vault with other HSMs.

1. Obtain the latest Luna Universal client software package for Linux x64.

2. Transport the Thales client software package to the Oracle Key Vault machine. Oracle recommends using SCP. For example, assuming the Thales client software packages is called `safenet.tar`:

```
$ scp safenet.tar support@okv_instance_ip_address:/tmp
```

3. Install the Thales client software on Oracle Key Vault.
4. Log in to the Oracle Key Vault Server through SSH as user `support`, and switch user (`su`) to `root`:

```
$ ssh support@okv_instance_ip_address
support$ su root
root# cd /usr/local/okv/hsm
```

5. Find the Linux 64-bit packages:

```
root# tar -tvf /tmp/safenet.tar | grep 'linux/64/'; Output:
"SafeNet_package_version/linux/64/"
```

6. Only extract the Linux 64-bit packages:

```
root# tar -xvf /tmp/safenet.tar SafeNet_package_version/linux/64/
root# cd SafeNet_package_version/linux/64
root# ./install.sh
```

7. Accept the Thales license by typing `y` at the prompt.
8. Install the Luna SA by entering `1, n, i` at the successive prompts.
This installs the Thales software in the directory `/usr/safenet/lunaclient`.
9. Delete the `safenet.tar` file from `/tmp` directory.

```
root# rm -f /tmp/safenet.tar
```

4.2.2 HSM Credential for Thales

The HSM credential is the Thales partition password.

If you are using Thales as your HSM, then you can use the Thales `assignPassword` command to assign a password for a partition. However, do not do this when a partition is currently in use by an Oracle Key Vault server, because Oracle Key Vault will no longer be able to access the Root of Trust key as its stored credential will no longer be correct.

4.2.3 Token Label for Thales

The token label for Thales is the name of the partition.

4.2.4 Enrolling Oracle Key Vault as a Client of a Thales HSM

To perform the enrollment, you use the Oracle Key Vault management console and the command-line interface.

1. Log in to the Oracle Key Vault management console as a user who has the System Administrator role.
2. Set up the DNS servers.

When enrolling Oracle Key Vault as a client of a Thales HSM, if the HSM will be registered using a host name, you should first set up DNS using the Oracle Key Vault the management console. To access the DNS settings, select the **System** tab, and then from the left navigation bar, select **Settings**. In Network Services, click **DNS**.

You must configure the DNS servers on each Oracle Key Vault server that you plan to register as a client of the HSM. In a primary-standby environment, configure the DNS servers on both primary and standby server before pairing. For a multi-master cluster, configure DNS on each node in the cluster that will be registered as a client of the HSM.

3. Exchange certificates between Oracle Key Vault and the Thales SA HSM.

Log in to the Oracle Key Vault Server through SSH as user `support`, and switch user (`su`) to `root`:

```
$ ssh support@okv_instance_ip_address
support$ su root
root# cd /usr/safenet/lunaclient/bin
root# scp admin@hsm_hostname:server.pem .
root# ./vtl addServer -n hsm_hostname -c server.pem
root# ./vtl createCert -n okv_hostname
root# scp /usr/safenet/lunaclient/cert/client/okv_hostname.pem
admin@hsm_hostname:
```

You must enter the HSM administrative password when using SCP with the HSM.

4. Register Oracle Key Vault as a client of the Thales SA.

This assumes that you have a partition set up on the Thales SA HSM. You can use any client name that is not yet taken. Oracle recommends using a descriptive name that will identify the Oracle Key Vault instance.

Access the HSM administrative console by using SSH to `admin@hsm_hostname` and providing the administrative password:

```
$ client register -client client_name -hostname okv_hostname
$ client hostip map -c client_name -i okv_ip_address
$ client assignPartition -client client_name -partition partition_name
```

5. Verify the enrollment as follows:

Log in to Oracle Key Vault as the support user using SSH:

```
$ ssh support@okv_instance_ip_address
support$ su root
root# cd /usr/safenet/lunaclient/bin
root# ./vtl verify
```

The following output appears:

The following Luna SA Slots/Partitions were found:

Slot	Serial #	Label
------	----------	-------

```
====      =====      =====
1         serial_number  partition_name
```

4.2.5 HSM Provider Value for Thales

For Thales, the provider value is 1.

If you are setting this value manually for a primary-standby configuration, then set `HSM_PROVIDER="1"` in the `okv_security.conf` file. For more information about enabling HSM in a primary-standby deployment, see [Enabling HSM in a High Availability Deployment](#).

4.2.6 HSM Vendor Specific Checks for Thales

You should check the Thales vendor-specific settings.

1. Log in to the Oracle Key Vault server as user `support` using SSH:

```
$ ssh support@okv_instance_ip_address
support$ su root
```

2. Execute the `vtl verify` command.

```
root# cd /usr/safenet/lunaclient/bin
root# ./vtl verify
```

The following output appears when the HSM is set up properly:

The following Luna SA Slots/Partitions were found:

```
Slot      Serial #      Label
====      =====      =====
1         [serial #]    [partition name]
```

If you do not see this output, then it means that the HSM is not set up properly. You can diagnose further by completing the remaining steps in this procedure.

3. Log into the Thales SA administrative console.
4. Enter the following command:

```
client show -client client_name
```

5. Verify that the expected client exists and is assigned a partition.
6. If it does not exist, then register the client with the command:

```
client register -client client_name-hostname host_name
```

7. If no partition is assigned, assign a partition with the command:

```
client assignPartition -client client_name -partition partition_name
```

8. Verify that all client IP addresses are mapped correctly. If entries are missing, run the command:

```
client hostip map -c client_name -i ip_address
```

9. Verify that Oracle Key Vault can reach the HSM using the `vtl verify` command:

```
$ su root
root# cd /usr/safenet/lunaclient/bin
root# ./vtl verify
```

The output should look similar to the following output:

The following Luna SA Slots/Partitions were found:

Slot	Serial #	Label
====	=====	=====
1	[serial #]	[partition name]

If the command fails, then it means that the Oracle Key Vault server is unable to contact the HSM. Check the vendor's other troubleshooting sections for instructions to restore `vtl verify` functionality. Contact your HSM administrator and confirm that Oracle Key Vault's access to the HSM has not been revoked. If you are unable to resolve the problem, then contact Oracle Support.

4.3 Vendor Specific Notes for Entrust

You can integrate Oracle Key Vault release 12.2 BP 3 and later with the HSM from Entrust nShield Connect + and XC models.

- [Installing the HSM Client Software on the Oracle Key Vault Server for Entrust](#)
The Entrust HSM requires a separate non-HSM computer on the network to use as the remote file system.
- [HSM Credential for Entrust](#)
The HSM credential for Entrust is the password that is associated with the Operator Card Set or Softcard.
- [Token Label for Entrust](#)
The token label for Entrust is the name of the Operator Card Set or Softcard.
- [Enrolling Oracle Key Vault as a Client of an Entrust HSM](#)
You use both the Entrust user interface and the command line to enroll Oracle Key Vault as a client of an Entrust HSM.
- [HSM Provider Value for Entrust](#)
For Entrust, the provider value is 2.

4.3.1 Installing the HSM Client Software on the Oracle Key Vault Server for Entrust

The Entrust HSM requires a separate non-HSM computer on the network to use as the remote file system.

1. Set up the remote file system.

2. Log in to the Oracle Key Vault server as support user using SSH:

```
$ ssh support@okv_instance_ip_address
```

3. Switch to root:

```
support$ su root
```

4. Go to the root directory and create the directories ctls, hwsp, and pkcs11:

```
root# cd /root
root# mkdir ctls
root# mkdir hwsp
root# mkdir pkcs11
```

5. Transfer the Entrust software installation files using the Secure Copy (SCP) protocol as follows:

For example:

```
root# scp user@remote_file_system_computer:/source_directory/ncipher/nfast/
ctls/agg.tar ctls
root# scp user@remote_file_system_computer:/source_directory/ncipher/nfast/
hwsp/agg.tar hwsp
root# scp user@remote_file_system_computer:/source_directory/ncipher/nfast/
pkcs11/user.tar pkcs11
```

6. Install these files as follows:

```
root# cd /
root# tar xvf /root/ctls/agg.tar
root# tar xvf /root/hwsp/agg.tar
root# tar xvf /root/pkcs11/user.tar
root# /opt/nfast/sbin/install
```

7. As root, perform additional edits to the groups and service file on the Oracle Key Vault server:

```
root# usermod -a -G nfast oracle
root# vi /etc/systemd/system/nc_hardserver.service
```

Inside the vi editor, edit the file so that the line `Before=dbfwdb.service` is added after the line that starts with `After=`.

For example, before the change:

```
[Unit]
Description=nFast hardserver service
Wants=remote-fs.target rsyslog.service nc_drivers.service
nc_exard.service
After=remote-fs.target rsyslog.service nc_drivers.service
nc_exard.service
```

After the change, it looks like this:

```
[Unit]
Description=nFast hardserver service
Wants=remote-fs.target rsyslog.service nc_drivers.service
nc_exard.service
After=remote-fs.target rsyslog.service nc_drivers.service
```

```
nc_exard.service
Before=dbfwdb.service
```

8. Switch to user `oracle` and verify the installation:

```
root# su oracle
oracle$ PATH=/opt/nfast/bin:$PATH
oracle$ export PATH
oracle$ enquiry
```

The state should say `operational` in the output.

9. Restart Oracle Key Vault for the group change to take effect.

In the Oracle Key Vault management console, log in as a user with the System Administrator role. Select the **System** tab, and then select **Status** in the left navigation bar. Then click the **Reboot** button.

4.3.2 HSM Credential for Entrust

The HSM credential for Entrust is the password that is associated with the Operator Card Set or Softcard.

The HSM-credential if they use an Operator Card Set is the Operator Card Set password. If they use a Softcard, then the password is the Softcard password.

4.3.3 Token Label for Entrust

The token label for Entrust is the name of the Operator Card Set or Softcard.

4.3.4 Enrolling Oracle Key Vault as a Client of an Entrust HSM

You use both the Entrust user interface and the command line to enroll Oracle Key Vault as a client of an Entrust HSM.

1. Add the Oracle Key Vault server IP address to the client list on the HSM using the front panel. Select privileged on any port.
 - In a primary-standby environment, register both the primary server and the standby server to use the Entrust HSM.
 - In a multi-master cluster environment, register each Oracle Key Vault node that will use the Entrust HSM.
2. Switch to user `oracle`:

```
root# su oracle
oracle$ PATH=/opt/nfast/bin:$PATH
oracle$ export PATH
```

3. On the Oracle Key Vault server, enroll with the HSM:

```
oracle$ nethsmenroll hsm_ip_address hsm_esn hsm_keyhash
```

4. Configure the TCP sockets:

```
oracle$ config-serverstartup --enable-tcp --enable-privileged-tcp
```

5. Switch back to `root` from `oracle` by entering `exit`.

```
oracle$ exit
```

6. In `root`, restart the `hardserver` (Entrust client process that communicates with the HSM):

```
root# /opt/nfast/sbin/init.d-ncipher restart
```

7. On the remote file system computer, run the following command:

```
$ /opt/nfast/bin/rfs-setup --gang-client --write-noauth okv_server_ip_address
```

8. On the Oracle Key Vault server as user `oracle`, run the following commands:

```
oracle$ /opt/nfast/bin/rfs-sync --setup --no-authenticate
remote_file_system_ip_address
oracle$ /opt/nfast/bin/rfs-sync --update
```

A prompt appears listing the module. You can confirm or exit.

9. Test PKCS#11 access as follows:

```
root# /opt/nfast/bin/ckcheckinst
```

10. Create the configuration file `/opt/nfast/cknfastrc` as user `root`. Write the following lines to the file:

```
CKNFAST_NO_ACCELERATOR_SLOTS=1
CKNFAST_OVERRIDE_SECURITY_ASSURANCES=none
```

11. Perform the steps described in [HSM-Enabling in a Standalone Oracle Key Vault Deployment](#).

12. On the Oracle Key Vault server as user `oracle` run the command:

```
oracle$ /opt/nfast/bin/rfs-sync --commit
```

If you do not run this command after each HSM initialize operation, then the Root of Trust key may not be available for other operations such as restoring backups and setting up a primary-standby configuration.

4.3.5 HSM Provider Value for Entrust

For Entrust, the provider value is 2.

If you are setting this value manually for the primary-standby, then set `HSM_PROVIDER="2"`. For more information about enabling HSM in a primary-standby deployment, see [Enabling HSM in a High Availability Deployment](#).

4.4 Vendor Specific Notes for Utimaco

Oracle Key Vault supports Oracle Key Vault integration with Utimaco SecurityServer 4.31.1.

- [Installing the HSM Client Software on the Oracle Key Vault Server for Utimaco](#)
The setup files for Utimaco are provided in the `SecurityServerEvaluation-V4.31.1.0.zip` file from Utimaco.
- [HSM Credential for Utimaco](#)
The HSM credential for Utimaco is the PIN that was initialized when the token was configured.
- [Token Label for Utimaco](#)
The token label for Utimaco is the name of the token that was set up for the HSM.

- [HSM Provider Value for Utimaco](#)
For Utimaco, the provider value is 3.
- [HSM Vendor Specific Checks for Utimaco](#)
You should check the Utimaco vendor-specific settings.

4.4.1 Installing the HSM Client Software on the Oracle Key Vault Server for Utimaco

The setup files for Utimaco are provided in the `SecurityServerEvaluation-V4.31.1.0.zip` file from Utimaco.

1. Locate the necessary setup files provided in the `SecurityServerEvaluation-V4.31.1.0.zip` file from Utimaco.
2. After unzipping the Utimaco zip file, transport the necessary files to the Oracle Key Vault machine. Oracle recommends using SCP. For example:

```
$ scp unzip_directory/Software/Linux/x86-64/Crypto_APIs/PKCS11_R2/sample/cs_pkcs11_R2.cfg support@okv_instance_ip_address:/tmp
$ scp unzip_directory/Software/Linux/x86-64/Crypto_APIs/PKCS11_R2/lib/libcs_pkcs11_R2.so support@okv_instance_ip_address:/tmp
$ scp unzip_directory/Software/Linux/x86-64/Administration/p11tool2 support@okv_instance_ip_address:/tmp
$ scp unzip_directory/Software/Linux/x86-64/Administration/cxtool support@okv_instance_ip_address:/tmp
$ scp unzip_directory/Software/Linux/x86-64/Administration/csadm support@okv_instance_ip_address:/tmp
```

3. Log in to the Oracle Key Vault server as user `support`, and switch user (`su`) to `root`:

```
$ ssh support@okv_instance_ip_address
support$ su - root
```

4. Create the appropriate directories for the Utimaco files:

```
root# mkdir -p /opt/utimaco/lib
root# mkdir /opt/utimaco/bin
root# mkdir /etc/utimaco
```

5. Move the Utimaco files to the correct directories:

```
root# mv /tmp/cs_pkcs11_R2.cfg /etc/utimaco
root# mv /tmp/p11tool2 /opt/utimaco/bin
root# mv /tmp/cxtool /opt/utimaco/bin
root# mv /tmp/csadm /opt/utimaco/bin
root# mv /tmp/libcs_pkcs11_R2.so /opt/utimaco/lib
```

6. Change the configuration file permissions:

```
root# /bin/chmod 640 /etc/utimaco/cs_pkcs11_R2.cfg
root# /bin/chown oracle:oinstall /etc/utimaco/cs_pkcs11_R2.cfg
```

7. Change the executable file permissions:

```
root# /bin/chmod 550 /opt/utimaco/bin/*
root# /bin/chown oracle:oinstall /opt/utimaco/bin/*
```

8. Change the library file permissions:

```
root# /bin/chmod 440 /opt/utimaco/lib/libcs_pkcs11_R2.so
root# /bin/chown oracle:oinstall /opt/utimaco/lib/libcs_pkcs11_R2.so
```

9. Modify the configuration file `/etc/utimaco/cs_pkcs11_R2.cfg` so that **Device** is set to the Utimaco HSM's IP address.

```
Device = utimaco_ip_address
```

If you are testing with an Utimaco HSM simulator, the line should be in the format:

```
Device = 3001@utimaco_ip_address
```

Oracle does not recommend that you use the simulator in a production environment.

10. To verify that you have set up your Utimaco HSM and the client files correctly, you can use `p11tool2`. The `p11tool2` command call can be used to verify that the PKCS11 token has been configured:

```
root# /opt/utimaco/bin/p11tool2 GetSlotInfo
```

The output should look similar to the following output:

```
CK_SLOT_INFO (slot ID: 0x00000000):

  slotDescription      33303031 4031302e 3234302e 3131382e |
3001@10.240.118.|
                      32333120 2d20534c 4f545f30 30303020 |231 -
SLOT_0000 |
                      20202020 20202020 20202020 20202020
|                |
                      20202020 20202020 20202020 20202020
|                |
  manufacturerID      5574696d 61636f20 49532047 6d624820 |Utimaco
IS GmbH |
                      20202020 20202020 20202020 20202020
|                |

  flags: 0x00000005
  CKF_TOKEN_PRESENT   : CK_TRUE
  CKF_REMOVABLE_DEVICE : CK_FALSE
  CKF_HW_SLOT         : CK_TRUE
```



```
hardwareVersion      : 5.01
firmwareVersion      : 2.03
```

11. The `csadm` command call can be used to confirm that the PKCS11 users have been defined:

```
root# /opt/utimaco/bin/csadm Dev=utimaco_ip_address ListUsers
```

The output should look similar to the following output:

Name	Permission	Mechanism	Attributes
ADMIN	22000000	RSA sign	Z[0]
SO_0000	00000200	HMAC passwd	Z[0]A[CXI_GROUP=SLOT_0000]
USR_0000	00000002	HMAC passwd	Z[0]A[CXI_GROUP=SLOT_0000]

4.4.2 HSM Credential for Utimaco

The HSM credential for Utimaco is the PIN that was initialized when the token was configured.

See the Utimaco documentation for more details.

4.4.3 Token Label for Utimaco

The token label for Utimaco is the name of the token that was set up for the HSM.

4.4.4 HSM Provider Value for Utimaco

For Utimaco, the provider value is 3.

If you are setting this value manually for primary-standby, set `HSM_PROVIDER="3"` in the `okv_security.conf` file. For more information about enabling HSM in a primary-standby deployment, see [Enabling HSM in a High Availability Deployment](#).

4.4.5 HSM Vendor Specific Checks for Utimaco

You should check the Utimaco vendor-specific settings.

In addition to the `p11tool2 GetSlotInfo` and `csadm ListUsers` commands, you can also check to see that a key was created after completing the HSM Initialize operation. Note that more keys may be created after subsequent HSM initialize commands.

```
root# /opt/utimaco/bin/p11tool2 LoginUser=HSM_Credential ListObjects
```

The output should look similar to the following output:

```
CKO_DATA:
+ 1.1
  CKA_LABEL = OKV 18.1 HSM Key Number
```

```
CKO_SECRET_KEY:
+ 2.1
  CKA_KEY_TYPE           = CKK_AES
  CKA_SENSITIVE          = CK_TRUE
  CKA_EXTRACTABLE        = CK_FALSE
  CKA_LABEL               = OKV 18.1 HSM Root Key
  CKA_ID                  = 0x00000001 ()
```

4.5 Vendor Specific Notes for Other HSMs

For HSMs other than Thales Luna Network HSM version 7000, Entrust nShield Connect + and XC models, or Utimaco's SecurityServer 4.31.1, Oracle Key Vault supports an integration with HSM vendors that meet the Oracle Key Vault requirements.

- [About Vendor Specific Notes for Other HSMs](#)
Oracle Key Vault provides a set of configuration files and upgrade scripts that you can use to enable Oracle Key Vault to use HSMs other than Thales Luna Network HSM version 7000, Entrust nShield Connect + and XC models, or Utimaco's SecurityServer 4.31.1.
- [Installing the HSM Client Software on the Oracle Key Vault Server for Other Vendors](#)
The vendor that you are working with should provide instructions for installing the HSM client software.
- [Configuring the okv_hsm.conf Parameters](#)
The Oracle Key Vault configuration file `okv_hsm.conf` defines information such as the vendor name and the location of the PKCS#11 library file.
- [Configuring the okv_hsm_env Environment File](#)
The Oracle Key Vault environment file `okv_hsm_env` specifies environment variables that Oracle Key Vault needs when it uses the PKCS#11 library.
- [Configuring the okv_hsm_mid_upgrade Script](#)
The Oracle Key Vault script `okv_hsm_mid_upgrade` can help to recreate information such as operating system user accounts, operating system user groups, or services.
- [Executing Pre- or Post-Upgrade Validation Scripts](#)
If the vendor has provided pre- or post-upgrade scripts, then you can run them before and after the upgrade process to ensure that the HSM configuration is correct.

4.5.1 About Vendor Specific Notes for Other HSMs

Oracle Key Vault provides a set of configuration files and upgrade scripts that you can use to enable Oracle Key Vault to use HSMs other than Thales Luna Network HSM version 7000, Entrust nShield Connect + and XC models, or Utimaco's SecurityServer 4.31.1.

If your site requires that you use a different HSM vendor, then you can perform your own integration of their HSM with your Oracle Key Vault installation. To perform this

integration, you will need to work with the vendor whose HSM you want to integrate with Oracle Key Vault. In general, you will perform the following steps:

1. Install the HSM client software onto your Oracle Key Vault server using the instructions that the HSM vendor provides.
2. Configure parameters in the `okv_hsm.conf` file to define information such as the vendor name and the location of the vendor's PKCS#11 library file.
3. If the HSM vendor requires special environment variables, then configure them in the `okv_hsm_env` environment file.
4. Configure the `okv_hsm_mid_upgrade` script, which helps to recreate information such as OS user accounts, OS user groups, or services that may be lost during the installation process.
5. Execute any pre- or post-upgrade validation scripts the vendor may have provided.

The vendor will need to do the following:

- Meet the requirements for enabling their HSM to be integrated with Oracle Key Vault.
- Provide documentation for configuring any of the parameters, environment variables, upgrade scripts, or pre- and post-upgrade scripts the Oracle Key Vault administrator will need, including updating this documentation for subsequent releases.
- Confirm the success of the integration (that is, with the standalone, multi-master cluster, and primary-standby environments) with the procedures that are provided in this guide.
- Validate the HSM as a RoT for Oracle Key Vault with the standalone, multi-master cluster, and primary-standby environments.

Related Topics

- [Vendor Instructions for Integrating an HSM as the Root of Trust for Oracle Key Vault](#)
HSM vendors are responsible for documenting and testing instructions to integrate their HSM with Oracle Key Vault.

4.5.2 Installing the HSM Client Software on the Oracle Key Vault Server for Other Vendors

The vendor that you are working with should provide instructions for installing the HSM client software.

Install the vendor's client software for the HSM, and follow the vendor's guidelines to ensure that the proper permissions are in place and that any new services are started in the correct order.

Related Topics

- [Requirements for the Vendor's HSM Client Installation Software](#)
The HSM client software installation process must fulfill requirements such as installing the HSM client software into its own directory

4.5.3 Configuring the `okv_hsm.conf` Parameters

The Oracle Key Vault configuration file `okv_hsm.conf` defines information such as the vendor name and the location of the PKCS#11 library file.

1. Ensure that the vendor has documented the correct way to configure the `okv_hsm.conf` file.
2. Follow the vendor's instructions for configuring the `okv_hsm.conf` file.

Related Topics

- [okv_hsm.conf Parameters](#)
Oracle Key Vault provides a configuration file to enable Oracle Key Vault administrators to define information such as the vendor name.

4.5.4 Configuring the `okv_hsm_env` Environment File

The Oracle Key Vault environment file `okv_hsm_env` specifies environment variables that Oracle Key Vault needs when it uses the PKCS#11 library.

If the HSM requires special environment variables, then you can add these to this file.

1. Ensure that the vendor has documented the correct way to configure the `okv_hsm_env` file.
2. Follow the vendor's instructions for configuring the `okv_hsm_env` file.

Related Topics

- [okv_hsm_env Environment File](#)
Oracle Key Vault provides an environment file so that Oracle Key Vault administrators can specify environment variables that are needed when Oracle Key Vault uses the PKCS#11 library.

4.5.5 Configuring the `okv_hsm_mid_upgrade` Script

The Oracle Key Vault script `okv_hsm_mid_upgrade` can help to recreate information such as operating system user accounts, operating system user groups, or services.

The installation of the vendor's HSM client software may remove this type of information during the installation process, so this script can help to restore it.

1. Ensure that the vendor has documented the correct way to configure the `okv_hsm_mid_upgrade` file.
2. Modify the `okv_hsm_mid_upgrade` script (located in the `/usr/local/okv/hsm/generic/` directory) to include information such as operating system users, operating system user groups, and services that Oracle Key Vault will need for the next time an upgrade takes place.

Related Topics

- [okv_hsm_env Environment File](#)
Oracle Key Vault provides an environment file so that Oracle Key Vault administrators can specify environment variables that are needed when Oracle Key Vault uses the PKCS#11 library.

4.5.6 Executing Pre- or Post-Upgrade Validation Scripts

If the vendor has provided pre- or post-upgrade scripts, then you can run them before and after the upgrade process to ensure that the HSM configuration is correct.

1. Ensure that the vendor has documented the correct way to configure the pre- or post-upgrade scripts.
2. Store these scripts in the `/opt` directory.
3. Execute the scripts as necessary.

Related Topics

- [Pre- or Post-Upgrade Validation Scripts](#)
You can provide pre- or post-upgrade scripts that the Oracle Key Vault administrator can run before and after the upgrade process to ensure that the HSM configuration is correct.

5

Vendor Instructions for Integrating an HSM as the Root of Trust for Oracle Key Vault

HSM vendors are responsible for documenting and testing instructions to integrate their HSM with Oracle Key Vault.

- [About Integrating an HSM as a Root of Trust for Oracle Key Vault](#)
This type of integration enables Oracle Key Vault to use HSMs other than Thales Luna Network HSM version 7000, Entrust nShield Connect + and XC models, or Utimaco's SecurityServer 4.31.1.
- [Requirements Before Starting the Integration](#)
The vendor of the HSM to be integrated with Oracle Key Vault must meet certain requirements, such as providing instructions on how to install the client software and ensuring the PKCS#11 library provides the required functionality.
- [Integrating the HSM](#)
The integration process includes setting up configuration files and scripts.
- [Confirming the Success of the HSM Configuration](#)
Testing operations such as HSM-enabling, upgrading, backing up, and restoring Oracle Key Vault while integrated with an HSM is essential to confirming a successful integration.
- [Validating the HSM as a Root of Trust for Oracle Key Vault](#)
After the vendor creates instructions on how to integrate their HSM with Oracle Key Vault, they should also validate the integration.

5.1 About Integrating an HSM as a Root of Trust for Oracle Key Vault

This type of integration enables Oracle Key Vault to use HSMs other than Thales Luna Network HSM version 7000, Entrust nShield Connect + and XC models, or Utimaco's SecurityServer 4.31.1.

You, the vendor, need to work with the Oracle Key Vault administrator to complete the integration. Oracle Key Vault provides files to enable the setting of parameters and environment variables, as well as scripts to help with the upgrade process. The Oracle Key Vault administrator will need to configure these scripts. You will need to provide documentation on how to use and configure them, and be responsible for updating this documentation for subsequent releases.

In the general, you will need to perform the following steps:

1. Ensure that your HSM meets the requirements for performing the integration, which include the ability to install the HSM client software, verifying the required functionality of the PKCS#11 library, and the ability to enroll the Oracle Key Vault as a client of the HSM.
2. Provide documentation for managing the configuration and environment variable files, and the upgrade scripts. Ensure that you update this documentation as the HSM's needs

change. Oracle Key Vault provides the following files: `okv_hsm.conf`, `okv_hsm_env`, and `okv_hsm_mid_upgrade`.

3. After you document the necessary steps to integrate Oracle Key Vault with the HSM, confirm the success of the integration. This includes enabling the HSM, and performing tasks such as upgrades, backups, and restore operations.
4. Validate the HSM as a Root of Trust (RoT) in standalone, multi-master cluster, and primary-standby environments.

5.2 Requirements Before Starting the Integration

The vendor of the HSM to be integrated with Oracle Key Vault must meet certain requirements, such as providing instructions on how to install the client software and ensuring the PKCS#11 library provides the required functionality.

- [Requirements for the Vendor's HSM Client Installation Software](#)
The HSM client software installation process must fulfill requirements such as installing the HSM client software into its own directory
- [Requirements for the PKCS#11 Library](#)
As the vendor, ensure that your library supports all of the necessary PKCS#11 functionality.
- [Configuration Requirements for Enrolling Oracle Key Vault as the HSM Client](#)
HSMs typically require additional configuration for enrolling Oracle Key Vault as a client of the HSM.

5.2.1 Requirements for the Vendor's HSM Client Installation Software

The HSM client software installation process must fulfill requirements such as installing the HSM client software into its own directory

As the vendor, you must do the following:

- Install the HSM client software into its own directory on the same server where Oracle Key Vault is installed, in a new subdirectory under the `/opt` directory.
- Set file permissions for the client software, which uses the PKCS#11 library, by running as the `oracle` user.
- Only allow the `root` user to modify any configuration files that are provided by the HSM client software.
- Ensure any new services introduced by the HSM client software are started before the Oracle Key Vault `dbfwdb.service` service. Do not edit the `dbfwdb.service` unit configuration file.

5.2.2 Requirements for the PKCS#11 Library

As the vendor, ensure that your library supports all of the necessary PKCS#11 functionality.

The PKCS#11 library must supply the following functions:

- `C_CloseSession`
- `C_Decrypt`

- `C_DecryptInit`
- `C_Encrypt`
- `C_EncryptInit`
- `C_Finalize`
- `C_FindObjects`
- `C_FindObjectsFinal`
- `C_FindObjectsInit`
- `C_GenerateKey`
- `C_GenerateRandom`
- `C_GetFunctionList`
- `C_GetSlotList`
- `C_GetTokenInfo`
- `C_Initialize`
- `C_Login`
- `C_OpenSession`

5.2.3 Configuration Requirements for Enrolling Oracle Key Vault as the HSM Client

HSMs typically require additional configuration for enrolling Oracle Key Vault as a client of the HSM.

This enrollment enables the communication between Oracle Key Vault and the HSM.

As the vendor, you must document and maintain these detailed instructions. The requirements are as follows:

- The instructions must ensure that the HSM configuration does not affect other Oracle Key Vault files or components.
- The communication between the client and the HSM server must be encrypted.

5.3 Integrating the HSM

The integration process includes setting up configuration files and scripts.

- [okv_hsm.conf Parameters](#)
Oracle Key Vault provides a configuration file to enable Oracle Key Vault administrators to define information such as the vendor name.
- [okv_hsm_env Environment File](#)
Oracle Key Vault provides an environment file so that Oracle Key Vault administrators can specify environment variables that are needed when Oracle Key Vault uses the PKCS#11 library.

- [okv_hsm_mid_upgrade Script](#)
Oracle Key Vault provides a script that can help to reapply configurations that may be lost during an upgrade.
- [Pre- or Post-Upgrade Validation Scripts](#)
You can provide pre- or post-upgrade scripts that the Oracle Key Vault administrator can run before and after the upgrade process to ensure that the HSM configuration is correct.

5.3.1 okv_hsm.conf Parameters

Oracle Key Vault provides a configuration file to enable Oracle Key Vault administrators to define information such as the vendor name.

The `okv_hsm.conf` file is located in the `/usr/local/okv/hsm/generic/` directory. As the vendor, ensure that you document the correct way to complete the `okv_hsm.conf` configuration file, including updating this documentation for subsequent releases.

The `okv_hsm.conf` file contains the following settings:

- `VENDOR_NAME="name_of_vendor"`
 - This parameter is required.
 - This setting enables the Oracle Key Vault management console to display the `name_of_vendor` value in the vendor drop-down lists when users perform the HSM initialize and set credential operations.
- `PKCS11_LIB_LOC="pkcs11_library_path"`
 - This parameter is required.
 - The Oracle Key Vault administrator must specify the full path to the location of the installed HSM PKCS#11 library, and include this file in the list of files that are defined in the `PRESERVED_FILES` parameter.
- `PRESERVED_FILES="path_to_directory:path_to_file:pkcs11_library_path"`
 - The parameter is required, but it will not be used until the next major version upgrade.
 - Oracle Key Vault upgrades are to the next major Oracle Key Vault version, or to a newer upgrade of the same major Oracle Key Vault version. Upgrading to a newer major Oracle Key Vault version is called a release upgrade or major version upgrade. Upgrading to a newer minor version is termed as release update upgrade or minor version upgrade. Upgrading to Oracle Key Vault release 21.x from Oracle Key Vault release 18.x is an example of a major version upgrade. Similarly, upgrading from Oracle Key Vault release 21.1 to Oracle Key Vault release 21.2 is an example a minor version upgrade. Major version upgrades can also refresh the major version of OL of the Oracle Key Vault appliance. For example, an upgrade from Oracle Key Vault release 18 to Oracle Key Vault release 21 refreshes the OS version from OL 6 to OL 7.
 - Oracle Key Vault uses this parameter for major version upgrades only, when the OS version is refreshed to a newer major version. This parameter enables vendor-specific files and directories to survive these upgrades. Files and directories that are not specified using this parameter will likely be deleted. Therefore, all files and directories that were created while you set up the HSM client software or are required for Oracle Key Vault to be able to communicate

with HSM using the PKCS#11 library should be included. Do not specify files and directories that existed on Oracle Key Vault by default.

- The Oracle Key Vault administrator will need to specify files and directories using the following format, including separating each of the paths by colons (:), as shown here:

```
PRESERVED_FILES="path_to_directory:path_to_file:pkcs11_library_path"
```

5.3.2 okv_hsm_env Environment File

Oracle Key Vault provides an environment file so that Oracle Key Vault administrators can specify environment variables that are needed when Oracle Key Vault uses the PKCS#11 library.

If the HSM's PKCS#11 library requires special environment variables, then the Oracle Key Vault administrator can include these variables in the `okv_hsm_env` file. Ensure that you document the correct way to complete the `okv_hsm_env` file, including updating this documentation for subsequent releases.

5.3.3 okv_hsm_mid_upgrade Script

Oracle Key Vault provides a script that can help to reapply configurations that may be lost during an upgrade.

As the vendor, ensure that you document the correct way to complete the `okv_hsm_mid_upgrade` script, including updating this documentation for subsequent releases.

This script is necessary during upgrades, particularly a major version that upgrades the operating system version, to ensure that information such as user accounts are recreated in the newer Oracle Key Vault version. Because Oracle Key Vault will need access to the Root of Trust (RoT) key in the HSM after the appliance restarts with the newer operating system version, these changes must be executed mid-upgrade.

As the vendor, you must address any configurations that need to be modified during the upgrade. The script must perform the following actions:

- Check the installed HSM software, users, groups, services, or any other configuration that is needed for Oracle Key Vault to successfully connect to the HSM.
- Correct any configuration (users, groups, configuration, services) that was changed during upgrade or missing after upgrade.

For example, if your HSM installation includes a service as a part of the HSM client software setup, and the service is needed for Oracle Key Vault to connect to the HSM, then in the mid-upgrade script, you should check and enforce that both the service exists and is running. If you created a user, in the mid-upgrade script, then you should check both that the user exists and that it continues to own any HSM-related files that it owned before the upgrade was started (or recreate the user and `chown` any files as appropriate). Anything that is not a preserved file or directory as specified in the parameter file is liable to be removed, so ideally this script would check and fix all vendor-owned files and directories (and their permissions) on the Oracle Key Vault server itself in detail.

You can rely on host name resolution to work during this step, provided that DNS servers were saved in Oracle Key Vault's settings before upgrading.

5.3.4 Pre- or Post-Upgrade Validation Scripts

You can provide pre- or post-upgrade scripts that the Oracle Key Vault administrator can run before and after the upgrade process to ensure that the HSM configuration is correct.

These scripts are useful for Oracle Key Vault administrators to ensure that all HSM-related configurations are as expected either before the upgrade begins or after the upgrade completes.

As the vendor, ensure that you document the correct way to configure these scripts, including updating this documentation for subsequent releases.

5.4 Confirming the Success of the HSM Configuration

Testing operations such as HSM-enabling, upgrading, backing up, and restoring Oracle Key Vault while integrated with an HSM is essential to confirming a successful integration.

- [Enabling the HSM in a Standalone Environment](#)
The HSM should be enabled as a Root of Trust (RoT) for a standalone Oracle Key Vault environment in much the same way that any of the standard HSMs, such as Thales Luna Network HSM version 7000, Entrust nShield Connect + and XC models, or Utimaco's SecurityServer 4.31.1, can be enabled.
- [Performing an Upgrade of an HSM-Enabled Oracle Key Vault Server](#)
The vendor should be able to upgrade an Oracle Key Vault server that is integrated with other HSMs in much the same way that Oracle Key Vault is normally upgraded.
- [Performing a Backup of an HSM-Enabled Oracle Key Vault Server](#)
The vendor should be able to perform a backup of an HSM-enabled Oracle Key Vault server in the Oracle Key Vault management console.
- [Performing a Restore of an HSM-Enabled Oracle Key Vault Server](#)
The vendor should be able to perform a restore of an HSM-enabled Oracle Key Vault server from the Oracle Key Vault management console.
- [Confirming the Success of the HSM Configuration in a Multi-Master Cluster](#)
To confirm the HSM configuration in a multi-master cluster environment, the vendor must be able to HSM-enable a multi-master cluster starting with a single node or an entire cluster.
- [Confirming the Success of the HSM Configuration in a Primary-Standby Environment](#)
To confirm the HSM configuration in a primary-standby environment, the vendor should perform switchover and reverse migration operations.
- [Performing a Reverse Migration Operation](#)
In this operation, the vendor removes the HSM as a Root of Trust (RoT) configuration by reverse migrating an Oracle Key Vault server.

5.4.1 Enabling the HSM in a Standalone Environment

The HSM should be enabled as a Root of Trust (RoT) for a standalone Oracle Key Vault environment in much the same way that any of the standard HSMs, such as

Thales Luna Network HSM version 7000, Entrust nShield Connect + and XC models, or Utimaco's SecurityServer 4.31.1, can be enabled.

The HSM vendor must provide instructions on how to specify the token label. Oracle recommends that a token label is specified.

The following behavior indicates that the HSM-enable operation is successful:

- There should be a success message appear on the Hardware Security Module page of the Oracle Key Vault management console after the operation completes.
- There should be a green, upward status arrow on the Hardware Security Module page on the Oracle Key Vault management console, with the correct HSM information beneath it.
- After restarting Oracle Key Vault, the Oracle Key Vault management console should appear and a user should be able to log in. This ensures that the server can use the new HSM in unattended mode when the server is restarted. You can restart Oracle Key Vault from the Oracle Key Vault management console, as described in *Oracle Key Vault Administrator's Guide*.

Check the log files in the `/var/okv/log/hsm` directory.

This operation creates a RoT key and creates or updates a key number object in the HSM. The key number object is used to associate a unique key number with each RoT key that is created in the HSM. The key number starts at 1 and is incremented by 1 with each successive HSM-enable operation. To increment the number, the current value is fetched and updated. It is possible the key number object's value could change before the update operation completes. The HSM vendor must take special care to document any additional steps that may be necessary to prevent conflicts (for example, two RoT keys created with the same key number). Failure to do so may render an Oracle Key Vault unable to create the auto-login wallet when the Oracle Key Vault server is restarted, and will require manual intervention. You can find the key number in the generated log files in the `/var/okv/log/hsm` directory.

Related Topics

- [HSM-Enabling in a Standalone Oracle Key Vault Deployment](#)
You can use the Oracle Key Vault management console to HSM-enable Oracle Key Vault, which configures additional protection for the TDE master encryption key.
- *Oracle Key Vault Administrator's Guide*

5.4.2 Performing an Upgrade of an HSM-Enabled Oracle Key Vault Server

The vendor should be able to upgrade an Oracle Key Vault server that is integrated with other HSMs in much the same way that Oracle Key Vault is normally upgraded.

Perform the Oracle Key Vault upgrade, and include any additional steps that the HSM vendor's documentation requires.

When an Oracle Key Vault server is configured with an HSM, the following activities indicate that the upgrade was successful:

- For all servers, there should be a message saying `Oracle Key Vault Server version_number upgrade has completed` on the console (with a blue background).
- For a standalone, multi-master cluster, or primary-standalone configuration, log in to the Oracle Key Vault management console as a user who has the System Administrator role. Select the **System** tab. Verify that the version displayed is the latest release number. The

release number is also at the bottom of each page, to the right of the copyright information.

Related Topics

- [Upgrade Considerations When Using HSMs in Oracle Key Vault](#)
When you upgrade an Oracle Key Vault deployment that is integrated with an HSM, consider factors such as the version of Oracle Key Vault.
- *Oracle Key Vault Installation and Upgrade Guide*

5.4.3 Performing a Backup of an HSM-Enabled Oracle Key Vault Server

The vendor should be able to perform a backup of an HSM-enabled Oracle Key Vault server in the Oracle Key Vault management console.

Perform the Oracle Key Vault backup operation.

The following behavior indicates that the backup operation is successful:

- In the Completed Backups table on the System Backup page in the Oracle Key Vault management console, the most recent backup should show `DONE` in the Status column and there should be nothing in the Run Error column.
- The backup should be able to be successfully restored.

Check the log files in the `/var/okv/log/hsm` directory.

Related Topics

- [Backup and Restore Operations in an HSM-Enabled Oracle Key Vault Instance](#)
You can back up and restore an HSM-enabled Oracle Key Vault instance.
- *Oracle Key Vault Administrator's Guide*

5.4.4 Performing a Restore of an HSM-Enabled Oracle Key Vault Server

The vendor should be able to perform a restore of an HSM-enabled Oracle Key Vault server from the Oracle Key Vault management console.

Perform the Oracle Key Vault restore operation.

The following behavior indicates that the restore operation is successful:

- On the Restore page, under Last Restore Details in the Oracle Key Vault management console, the most recent backup should show `DONE` in the Status column and there should be nothing in the Run Error column.
- Oracle Key Vault should automatically restart during the restore operation. If it did not restart, then it is likely that the restore operation did not complete successfully. Check `/var/log/messages` on the server for details. Also check the log files in the `/var/okv/log/hsm` directory.

Related Topics

- [Restore Operations in an HSM-Enabled Oracle Key Vault Instance](#)
Backups taken from an HSM-enabled Oracle Key Vault instance can only be restored onto a standalone Oracle Key Vault server with access to the same Root of Trust key that was in use when the backup was taken.
- *Oracle Key Vault Administrator's Guide*

5.4.5 Confirming the Success of the HSM Configuration in a Multi-Master Cluster

To confirm the HSM configuration in a multi-master cluster environment, the vendor must be able to HSM-enable a multi-master cluster starting with a single node or an entire cluster.

- [Starting with an HSM-Enabled Single Node](#)
The vendor should be able to build a multi-master cluster, starting with a single HSM-enabled node, and then add other HSM-enabled nodes to the cluster.
- [HSM-Enabling a Cluster with Multiple Nodes](#)
The vendor must first build the multi-master cluster with no HSM-enabled nodes. From there, the vendor HSM-enables each node one at a time.

5.4.5.1 Starting with an HSM-Enabled Single Node

The vendor should be able to build a multi-master cluster, starting with a single HSM-enabled node, and then add other HSM-enabled nodes to the cluster.

1. HSM-enable one node, and then add a second HSM-enabled node as a read-write peer of the first node.

After the pairing completes, the Oracle Key Vault management console Cluster Management page on both nodes must show both nodes in the `ACTIVE` state.
2. Restart both nodes, as described in *Oracle Key Vault Administrator's Guide*.
3. After Oracle Key Vault restarts, ensure that the Oracle Key Vault management console is accessible to both of the nodes.
4. Add a third HSM-enabled node to the cluster, using either the first or the second node as the controller node.

After the pairing completes, the Oracle Key Vault management console Cluster Management page on all three nodes must show that these nodes are in the `ACTIVE` state.
5. Restart the third node, and then ensure that the Oracle Key Vault management console is accessible to this node.
6. Create a wallet on both of the read-write nodes.
7. Ensure that the status for both of the wallets goes from `PENDING` to `ACTIVE`.

To do so, check the wallets' name status on all three nodes.

Related Topics

- [Configuring an HSM for a Multi-Master Cluster Starting with Single Node \(Recommended\)](#)
Oracle recommends that to use an HSM with a multi-master cluster, you start with a single HSM-enabled node and add additional HSM-enabled nodes using the node induction process.
- *Oracle Key Vault Administrator's Guide*

5.4.5.2 HSM-Enabling a Cluster with Multiple Nodes

The vendor must first build the multi-master cluster with no HSM-enabled nodes. From there, the vendor HSM-enables each node one at a time.

1. Create or use an existing multi-master cluster that has at least three nodes, in which two are read-write peer nodes and one is a read-only node.
2. HSM-enable one node in this cluster.
3. Create the HSM bundle on the HSM-enabled node and apply the HSM bundle to the other two nodes in the cluster.
4. Restart all nodes, as described in *Oracle Key Vault Administrator's Guide*.
5. After Oracle Key Vault restarts, confirm that the Oracle Key Vault management console is accessible to these nodes and that replication works between all three nodes.
6. HSM-enable the other two nodes.
7. Restart the three nodes.
8. After Oracle Key Vault restarts, ensure that the Oracle Key Vault management console is accessible to all three nodes.
9. Create a wallet on both of the read-write nodes.
10. Ensure that the status for both of the wallets goes from `PENDING` to `ACTIVE`.

To do so, check the wallets' name status on all three nodes.

Related Topics

- [Configuring an HSM for a Multi-Master Cluster with Multiple Nodes](#)
You can configure HSM for multiple nodes by copying a bundle from the first HSM-enabled node to the other nodes in the cluster before configuring HSM for the other nodes.
- *Oracle Key Vault Administrator's Guide*

5.4.6 Confirming the Success of the HSM Configuration in a Primary-Standby Environment

To confirm the HSM configuration in a primary-standby environment, the vendor should perform switchover and reverse migration operations.

- [Creating an HSM-Enabled Primary Standby Configuration](#)
The vendor should be able to configure both the primary and standby Oracle Key Vault servers to use an HSM as a Root of Trust (RoT).

- [Performing an HSM-Enabled Primary-Standby Switchover Operation](#)
The vendor should be able to execute a switchover operation between a pair of HSM-enabled primary and standby Oracle Key Vault servers, as described in *Oracle Key Vault Administrator's Guide*.
- [Performing a Reverse Migration of an HSM-Enabled Primary-Standby Configuration](#)
The vendor should be able to perform a reverse migration of both the primary and standby HSM-enabled Oracle Key Vault servers.

5.4.6.1 Creating an HSM-Enabled Primary Standby Configuration

The vendor should be able to configure both the primary and standby Oracle Key Vault servers to use an HSM as a Root of Trust (RoT).

After you complete the configuration, in the Oracle Key Vault management console of the primary server Primary-Standby Status page, you should see `Primary-Standby mode is enabled`, and the `Switchover Status` should be `TO STANDBY`.

Check the log files in the `/var/okv/log/hsm` directories of both the primary and standby servers.

Related Topics

- [HSM-Enabling in a Primary-Standby Oracle Key Vault Deployment](#)
In an Oracle Key Vault primary-standby deployment, you must perform the HSM-enabling tasks separately on the Oracle Key Vault servers that will become primary and standby servers.
- *Oracle Key Vault Administrator's Guide*

5.4.6.2 Performing an HSM-Enabled Primary-Standby Switchover Operation

The vendor should be able to execute a switchover operation between a pair of HSM-enabled primary and standby Oracle Key Vault servers, as described in *Oracle Key Vault Administrator's Guide*.

After you complete the switchover operation, the Oracle Key Vault management console Primary-Standby Status page for the new primary should show `Primary-Standby mode is enabled`, and the `Switchover Status` should be `TO STANDBY`.

Check the log files in the `/var/okv/log/hsm` directories of both the primary and standby servers.

Related Topics

- *Oracle Key Vault Administrator's Guide*

5.4.6.3 Performing a Reverse Migration of an HSM-Enabled Primary-Standby Configuration

The vendor should be able to perform a reverse migration of both the primary and standby HSM-enabled Oracle Key Vault servers.

After you complete the reverse migration operation on the primary Oracle Key Vault server, there should be a green success message, and there should be a red downward status arrow.

Next, do the following:

1. Reverse migrate the standby Oracle Key Vault server.
2. Perform a switchover operation as described in *Oracle Key Vault Administrator's Guide*, and then verify the operation's success.
3. Restart both the primary and standby Oracle Key Vault servers, as described in as described in *Oracle Key Vault Administrator's Guide*.
4. Verify that the primary server can access the Oracle Key Vault management console.

Related Topics

- [Reverse Migrating a Primary-Standby Deployment](#)
To reverse migrate a primary-standby deployment, use both the Oracle Key Vault management console and the command line.
- *Oracle Key Vault Administrator's Guide*
- *Oracle Key Vault Administrator's Guide*

5.4.7 Performing a Reverse Migration Operation

In this operation, the vendor removes the HSM as a Root of Trust (RoT) configuration by reverse migrating an Oracle Key Vault server.

Perform the reverse migration operation as is normally done in Oracle Key Vault.

The following behavior indicates that the reverse migration operation is successful:

- There should be a success message appear on the Oracle Key Vault management console after the operation completes.
- There should be a red, downward status arrow on the Hardware Security Module page on the Oracle Key Vault management console.
- Restart the Oracle Key Vault server, as described in *Oracle Key Vault Administrator's Guide*. After doing so, the Oracle Key Vault management console should appear and a user should be able to log in. This ensures that the server no longer has to use the HSM to recreate the auto-login wallet when the server is restarted.

Check the log files in the `/var/okv/log/hsm` directory.

Related Topics

- [Reverse Migration Operations](#)
Reverse migrating an HSM-enabled Oracle Key Vault server reverts the Key Vault server to using the recovery passphrase to protect the TDE wallet.
- *Oracle Key Vault Administrator's Guide*

5.5 Validating the HSM as a Root of Trust for Oracle Key Vault

After the vendor creates instructions on how to integrate their HSM with Oracle Key Vault, they should also validate the integration.

- [Test Cases for Standalone Configurations](#)
For a standalone Oracle Key Vault server, the vendor should be able to HSM-enable a server (initialize) and perform backup and restore operations.
- [Test Cases for Multi-Master Cluster Configurations](#)
For Oracle Key Vault servers in a multi-master cluster environment, the vendor should be able to HSM-enable nodes, perform backup and restore operations, reverse migrate a cluster, and upgrade a cluster.
- [Test Cases for Primary-Standby Configurations](#)
For Oracle Key Vault servers in a primary-standby configuration, the vendor should be able to create the HSM-enabled primary-standby, and perform standard primary-standby operations.

5.5.1 Test Cases for Standalone Configurations

For a standalone Oracle Key Vault server, the vendor should be able to HSM-enable a server (initialize) and perform backup and restore operations.

- **Test 1: Perform three successive HSM-enable operations.** Perform the following operations on the Oracle Key Vault standalone server in this order:
 1. HSM-enable the server.
 2. Perform a reverse migration operation on the server.
 3. HSM-enable the server a second time.
 4. Perform a reverse migration operation on the server.
 5. HSM-enable the server a third time.

Independently verify each operation to ensure that the operation is successful. This is important because the first three HSM-enable operations on the HSM do different things: the first HSM-enable operation creates the key number object that is used to track the current Root of Trust (RoT) key. This first HSM-enable operation also creates the RoT key. The second HSM-enable operation updates the key number object and creates a new RoT key. The third HSM-enable operation is the same as the second, but is used for verifying that the second HSM-enable operation successfully updated the key number object.

- **Test 2: Perform at least three successive HSM-enable operations on different Oracle Key Vault servers.** Perform at least three initialize operations on different Oracle Key Vault servers, sequentially. Independently verify each operation to ensure that it is successful.
- **Test 3: Perform a backup and restore operation on the standalone Oracle Key Vault server.** Create a remote and a local backup on an Oracle Key Vault server that is HSM-enabled. Verify each for success. Afterward, restore the local backup to the Oracle Key Vault server on which it was taken. Restore the remote backup to a different Oracle Key Vault server. Verify each for success.

5.5.2 Test Cases for Multi-Master Cluster Configurations

For Oracle Key Vault servers in a multi-master cluster environment, the vendor should be able to HSM-enable nodes, perform backup and restore operations, reverse migrate a cluster, and upgrade a cluster.

As the vendor, perform the following tests:

- **Test 1: Create an HSM-enabled cluster configuration, starting with a single HSM-enabled node.** Afterward, verify that this operation was successful.
- **Test 2: Create an HSM-enabled cluster configuration, HSM-enabling a cluster with multiple nodes.** Afterward, verify that this operation was successful.
- **Test 3: Perform a backup and restore operation on the HSM-enabled nodes.** Create a remote backup on more than one node and restore these nodes to freshly installed, separate Oracle Key Vault servers. Verify that the operations were successful.
- **Test 4: Reverse migrate the cluster that has HSM-enabled nodes.** Reverse migrate each HSM-enabled node in the cluster. Verify that each operation was successful.
- **Test 5: Perform an upgrade on the cluster that has HSM-enabled nodes.** Perform cluster upgrades from all previous versions of Oracle Key Vault on which your vendor is certified. Verify that each upgrade is successful on all nodes of the cluster.

5.5.3 Test Cases for Primary-Standby Configurations

For Oracle Key Vault servers in a primary-standby configuration, the vendor should be able to create the HSM-enabled primary-standby, and perform standard primary-standby operations.

These operations include switchovers, reverse migrations, backups and restores, and upgrades.

- **Test 1: Create an HSM-enabled primary-standby configuration.** Verify that the operation was successful.
- **Test 2: Perform a primary-standby switchover operation.** Verify that the operation was successful.
- **Test 3: Reverse migrate an HSM-enabled primary-standby configuration.** Verify that the operation was successful.
- **Test 4: Perform a backup and restore operation on the HSM-enabled configuration.** Create a remote backup on the primary server and then restore it to a freshly installed, separate Oracle Key Vault server. Verify that the operations were successful.
- **Test 5: Upgrade the HSM-enabled configuration.** Perform primary-standby upgrades from all previous versions of Oracle Key Vault on which your vendor is certified. Verify that each upgrade is successful on both the primary and standby servers.