

Oracle® NoSQL Database

Security Guide



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

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Preface

This document describes how you can configure security for Oracle NoSQL Database using the default database features.

This book is aimed at the systems administrator responsible for the security of an Oracle NoSQL Database installation.

Conventions Used in This Book

The following typographical conventions are used within this manual:

Information that you are to type literally is presented in `monospaced` font.

Variable or non-literal text is presented in *italics*. For example: "Go to your *KVHOME* directory."

 **Note:**

Finally, notes of special interest are represented using a note block such as this.

1

Introducing Oracle NoSQL Database Security

Oracle NoSQL Database can be configured securely. In a secure configuration, network communications between NoSQL clients, utilities, and NoSQL server components are encrypted using SSL/TLS, and all processes must authenticate themselves to the components to which they connect.

There are two levels of security to be aware of. These are network security, which provides an outer layer of protection at the network level, and user authentication/authorization. Network security is configured at the file system level typically during the installation process, while user authentication/authorization is managed through NoSQL utilities.

You can use the following Oracle NoSQL Database features to configure security for your Oracle NoSQL Database installation:

- **Security Configuration Utility.** Allows you to configure and add security to a new or to an existing Oracle NoSQL Database installation.
- **Authentication methods.** Oracle NoSQL Database provides password authentication for users and systems. The EE version of Oracle NoSQL Database also supports Kerberos authentication.
- **Encryption.** Data is encrypted on the network to prevent unauthorized access to that data.
- **External Password Storage.** Oracle NoSQL Database provides two types of external password storage methods that you can manipulate (one type for CE deployments).
- **Security Policies.** Oracle NoSQL Database allows you to set up behaviors in order to ensure a secure environment.
- **Role-based authorization.** Oracle NoSQL Database provides predefined system roles, privileges, and user-defined roles to users. You can set desired privileges to users by role-granting.

In addition, [Keeping Oracle NoSQL Database Secure](#) provides guidelines that you should follow when securing your Oracle NoSQL Database installation.

Note:

Full Text Search and a secure Oracle NoSQL Database store are disjoint, that is, if Oracle NoSQL Database is configured as a secure store, Full Text Search should be disabled. On the other hand, if Full Text Search is enabled (that is, an external Elasticsearch cluster is registered) in a nonsecure store, users cannot reconfigure the nonsecure store to a secure store, unless Full Text Search is disabled before reconfiguration. See Security in Full Text Search in the *Integrations Guide*.

2

Security Configuration

This chapter describes how to use either the `makebootconfig` or `securityconfig` tool to perform the security configuration of your store. If you are installing a store with security for the first time, you can skip ahead to the next chapter [Performing a Secure Oracle NoSQL Database Installation](#).

 **Note:**

For simpler use cases (lab environments) it is possible to perform a basic installation of your store by explicitly opting out of security on the command line. If you do this, your store loses all the security features described in this book. For more information see [Configuring Security with Makebootconfig](#).

Security Configuration Overview

To set up security, you need to create an initial security configuration. To do this, run `securityconfig` before, after, or as part of the `makebootconfig` process before starting the SNA on an initial node. You should not create a security configuration at each node. Instead, you should distribute the initial security configuration across all the Storage Nodes in your store. If the stores do not share a common security configuration they will be unable to communicate with one another.

 **Note:**

The `makebootconfig` utility embeds the functionality of `securityconfig` tool.

The `securityconfig` tool creates a set of security files based on the standard configuration. It is possible to perform the same tasks manually, and advanced security configuration might require manual setup, but using this tool helps to ensure a consistent setup. For more information on the manual setup, see [SSL keystore generation](#).

 **Note:**

It is possible to modify the security configuration after it is created in order to use a non-standard configuration. It is recommended that you use a standard configuration.

Those security files are generated, by default, within a directory named "security". In a secure configuration, the bootstrap configuration file for a Storage Node includes a

reference to that directory, which must be within the KVROOT directory for the Storage Node. The security directory contains:

```
security/security.xml
security/store.keys
security/store.trust
security/store.passwd (CE or EE installations)
security/store.wallet (EE installations only)
security/store.wallet/cwallet.sso (EE installations only)
security/client.security
security/client.trust
```

where:

- `security.xml`
A configuration file that tells the Oracle NoSQL Database server how to apply security.
- `store.keys`
A Java keystore file containing one or more SSL/TLS key pairs. This keystore is protected by a keystore password, which is recorded in an accompanying password store. The password store may be either an Oracle Wallet or a FileStore. The password is stored under the alias "keystore" in the password store. This file should be accessible only by the Oracle NoSQL Database server processes, and not to Oracle NoSQL Database clients.
- `store.trust`
A Java truststore file, which is a keystore file that contains only public certificates, and no private keys.
- `store.passwd` (CE or EE installations)
A password file that acts as the password store for a Community Edition (CE) installation. It contains secret information that should be known only to the server processes. Make sure the password file is readable and writable only by the Oracle NoSQL Database server. The file should not be copied to client machines.
For Enterprise Edition (EE) installations, Oracle Wallet usage is preferred over the password file option.
- `store.wallet` (EE installations only)
An Oracle Wallet directory that acts as the password store for an Enterprise Edition (EE) installation. It contains secret information that should be known only to the server processes. Make sure the directory and its contents are readable and writable only by Oracle NoSQL Database. The file should not be copied to client machines.
- `cwallet.sso` (EE installations only)
The wallet password storage file.
- `client.security`
A security configuration file that captures the communication transport properties for connecting clients to KVStore.
The generated `client.security` file should be copied to and used by Oracle NoSQL Database clients when connecting to the KVStore.

- `client.trust`

A truststore file used by clients is generated.

The generated `client.trust` file should be copied to and used by Oracle NoSQL Database clients when connecting to the KVStore.

Note:

In a multi-host store environment, the security directory and all files contained in it should be copied to each server that will host a Storage Node.

Configuring Security with Makebootconfig

Use the `makebootconfig` command with the `-store-security` option to set up the basic store configuration with security:

```
java -Xmx64m -Xms64m
-jar KVHOME/lib/kvstore.jar makebootconfig
-root <kvroot> -port <port>
-host <hostname> -harange <harange>
-store-security configure -capacity <capacity>
[-secdir <security dir>]
[-pwdmgr {pwdfile | wallet | <class-name>}]
[-kspwd <password>]
[-external-auth {kerberos}]
[-krb-conf <kerberos configuration>]
[-kadmin-path <kadmin utility path>]
[-instance-name <database instance name>]
[-admin-principal <kerberos admin principal name>]
[-kadmin-keytab <keytab file>]
[-kadmin-ccache <credential cache file>]
[-princ-conf-param <param=value>]*
[-security-param <param=value>]*
[-noadmin]
```

where `-store-security` has the following options:

- `-store-security none`

No security will be used. If a directory named "security" exists, a warning message will be displayed. When you opt out of security, you lose all the security features in your store; you are not able to set password authentication for users and systems, encrypt your data to prevent unauthorized access, etc.

- `-store-security configure`

Security will be used and the `security` configuration utility will be invoked as part of the `makebootconfig` process. If the security directory already exists, an error message is displayed, otherwise the directory will be created.

For script-based configuration you can use the `-kspwd<password>` option to allow tools to specify the keystore password on the command line. If it is not specified, the user is prompted to enter the password.

Use the `-pwdmgr` option to select a password manager implementation. Its usage is introduced later in this section.

Use the `-external-auth` option to specify Kerberos as an external authentication service. This option is only available in the Oracle NoSQL Database EE version. If information for the Kerberos admin interface (e.g. *password*) is needed and no keytab or credential cache has been specified on the command line, an interactive version of `securityconfig config create` utility will run.

Using the `-external-auth` flag allows Oracle NoSQL Database to generate the security files needed for Kerberos authentication, based on a standard configuration. Although not recommended, it is possible to use a non-standard configuration. To do this, see [Manually Registering Oracle NoSQL Database Service Principal](#)

- `-store-security enable`

Security will be used. You will need to configure security either by utilizing the `security configuration` utility or by copying a previously created configuration from another system.

 **Note:**

The `-store-security` command is optional. Even if the user does not specify `-store-security`, it would be enabled by default.

For more information on configuring security with `makebootconfig`, see [Adding Security to a New Installation](#).

Configuring Security with Securityconfig

You can also run the `securityconfig` tool before or after the `makebootconfig` process by using the following command:

```
java -Xmx64m -Xms64m -jar <KVHOME>/lib/kvstore.jar securityconfig
```

For more information on creating, adding, removing or merging the security configuration using `securityconfig`, see the following sections.

Creating the security configuration

You can use the `config create` command to create the security configuration:

```
config create
-root <secroot> [ -secdir <security dir> ]
[-pwdmgr { pwdfile | wallet <class-name> } ]
[-kspwd <password> ]
[-external-auth {kerberos}]
  [-krb-conf <kerberos configuration>]
  [-kadmin-path <kadmin utility path>]
  [-instance-name <database instance name>]
  [-admin-principal <kerberos admin principal name>]
  [-kadmin-keytab <keytab file>]
```

```
[-kadmin-ccache <credential cache file>]
[-princ-conf-param <param=value>]*
[-param [client:|ha:|internal:|]<param>=<value>]*
```

where:

- `-root <secroot>`

Specifies the directory in which the security configuration will be created. It is not required that this directory be a full KVROOT, but the directory must exist.

- `-external-auth {kerberos}` Specifies Kerberos as an external authentication service. This option is only available in the Oracle NoSQL Database EE version. If no keytab or credential cache has been specified on the command line, an interactive version of the `securityconfig` utility will run.

Using this flag allows Oracle NoSQL Database to generate the security files needed for Kerberos authentication, based on a standard configuration. Although not recommended, it is possible to use a non-standard configuration. To do this, see [Manually Registering Oracle NoSQL Database Service Principal](#)

This flag is only permitted when the value of the `-store-security` flag is specified as `configure` or `enable`.

To remove Kerberos authentication from a running store, set the value of the `userExternalAuth` `security.xml` parameter to `NONE`.

where `-external-auth` can have the following flags:

- `-admin-principal <kerberos admin principal name>`

Specifies the principal used to login to the Kerberos admin interface. This is required while using `kadmin` keytab or password to connect to the admin interface.

- `-kadmin-ccache <credential cache file>`

Specifies the complete path name to the Kerberos credentials cache file that should contain a service ticket for the `kadmin/ADMINHOST`. `ADMINHOST` is the fully-qualified hostname of the admin server or `kadmin/admin` service.

If not specified, the user is prompted to enter the password for principal while logging to the Kerberos admin interface. This flag cannot be specified in conjunction with the `-kadmin-keytab` flag.

- `-kadmin-keytab <keytab file>`

Specifies the location of a Kerberos keytab file that stores Kerberos admin user principals and encrypted keys. The security configuration tool will use the specified keytab file to login to the Kerberos admin interface.

The default location of the keytab file is specified by the Kerberos configuration file. If the keytab is not specified there, then the system looks for the file `user.home/krb5.keytab`.

You need to specify the `-admin-principal` flag when using keytab to login to the Kerberos admin, otherwise the correct admin principal will not be recognized. This flag cannot be specified in conjunction with the `-kadmin-ccache` flag.

- `-kadmin-path <kadmin utility path>`

Indicates the absolute path of the Kerberos kadmin utility. The default value is `/usr/kerberos/sbin/kadmin`.

- `-krb-conf <kerberos configuration>`

Specifies the location of the Kerberos configuration file that contains the default realm and KDC information. If not specified, the default value is `/etc/krb5.conf`.

- `-princ-conf-param <param=value>*`

A repeatable argument that allows configuration defaults to be overridden.

Use the `krbPrincValidity` parameter to specify the expiration date of the Oracle NoSQL Database Kerberos service principal.

Use the `krbPrincPwdExpire` parameter to specify the password expiration date of the Oracle NoSQL Database Kerberos service principal.

Use the `krbKeysalt` parameter to specify the keysalt list used to generate the keytab file.

- `-secdir <security dir>`

Specifies the name of the directory within KVROOT that will hold the security configuration. This must be specified as a name relative to the specified `secdir`. If not specified, the default value is "security".

- `-pwmgr [pwdfile | wallet]`

Indicates the password manager mechanism used to hold passwords that are needed for accessing keystores, etc.

where `-pwmgr` can have the following options:

- `-pwmgr pwdfile`

Indicates that the password store is a read-protected clear-text password file. This is the only available option for Oracle NoSQL Database CE deployments. You can specify an alternate implementation. For more information on `pwdfile` manipulation, see [Password store file](#)

- `-pwmgr wallet`

Specifies Oracle Wallet as the password storage mechanism. This option is only available in the Oracle NoSQL Database EE version. For more information on Oracle wallet manipulation, see [Oracle Wallet](#)

- `-param [client:|ha:|internal:|]<param>=<value>]`

A repeatable argument that allows configuration defaults to be overridden. The value may be either a simple parameter, such as "truststore", or a qualified parameter such as "client:serverKeyAlias". If specified in qualified form, the qualifier (for example, "client") names a transport within the security configuration, and the assignment is specific to that transport. If in simple form, it applies to either the `securityParams` structure or to all transports within the file, depending on the type of parameter.

For more information on configuring security with `securityconfig`, see [Performing a Secure Oracle NoSQL Database Installation](#).

For more information on configuring Kerberos with `securityconfig`, see [Kerberos Authentication Service](#).

Adding the security configuration

You can use the `config add-security` command to add the security configuration you created earlier:

```
config add-security
-root <kvroot> [-secdir <security dir>]
[-config <config.xml>]
```

 **Note:**

When running this command, the `securityconfig` tool will verify the existence of the referenced files and will update the specified bootstrap configuration file to refer to the security configuration. This process is normally done with the KVStore instance stopped, and must be performed on each Storage Node of the store.

where:

- `-root <kvroot>`
A KVStore root directory must be provided as an argument.
- `-secdir <security dir>`
Specifies the name of the directory within the KVROOT that holds the security configuration. This must be specified as a name relative to the KVROOT. If not specified, the default value is "security".
- `-config <config.xml>`
Specifies the bootstrap configuration file that is to be updated. This must be specified as a name relative to the KVROOT. If not specified, the default value is "config.xml".

When using Kerberos as an external authentication service, you can use the `config add-kerberos` command to add the security configuration you created earlier:

```
config add-kerberos -root <secroot> [-secdir <security dir>]
[-krb-conf <Kerberos configuration>]
[-kadmin-path <kadmin utility path>]
[-instance-name <database instance name>]
[-admin-principal <kerberos admin principal name>]
[-kadmin-keytab <keytab file> ]
[-kadmin-ccache <credential cache file>]
[-princ-conf-param <param=value>]*
[-param <param=value>]*
```

Verifying the security configuration

You can use the `config verify` command to verify the consistency and correctness of a security configuration:

```
config verify -secdir <security dir>
```

where:

- `-secdir <securitydir>`
Specifies the name of the directory within the KVROOT that holds the security configuration. This must be specified as a name relative to the KVROOT. If not specified, the default value is "security".

For example:

```
security-> config verify -secdir security  
Security configuration verification passed.
```

Updating the security configuration

You can use the `config update` command to update the security parameters of a security configuration:

```
config update -secdir <security dir> [-param <param=value>]*
```

where:

- `-secdir <securitydir>`
Specifies the name of the directory within the KVROOT that holds the security configuration. This must be specified as a name relative to the KVROOT. If not specified, the default value is "security".
- `-param <param=value*>`
List of security parameters to update.

For example:

```
security-> config update -secdir security -param  
clientAuthRequired=false  
Security parameters updated.
```

Showing the security configuration

You can use the `config show` command to print out all security configuration information.

```
config show -secdir <security dir>
```

where:

For example:

```
security-> config show -secdir security
Security parameters:
certMode=shared
internalAuth=ssl
keystore=store.keys
keystorePasswordAlias=keystore
passwordClass=oracle.kv.impl.security.filestore.FileStoreManager
passwordFile=store.passwd
securityEnabled=true
truststore=store.trust
```

```
internal Transport parameters:
clientAllowProtocols=TLSv1.2,TLSv1.1,TLSv1
clientAuthRequired=true
clientIdentityAllowed=dnmatch(CN=NoSQL)
clientKeyAlias=shared
serverIdentityAllowed=dnmatch(CN=NoSQL)
serverKeyAlias=shared
transportType=ssl
```

```
client Transport parameters:
clientAllowProtocols=TLSv1.2,TLSv1.1,TLSv1
serverIdentityAllowed=dnmatch(CN=NoSQL)
serverKeyAlias=shared
transportType=ssl
```

```
ha Transport parameters:
allowProtocols=TLSv1.2,TLSv1.1,TLSv1
clientAuthRequired=true
clientIdentityAllowed=dnmatch(CN=NoSQL)
serverIdentityAllowed=dnmatch(CN=NoSQL)
serverKeyAlias=shared
transportType=ssl
```

```
Keystore:
security/store.keys
```

```
Keystore type: JKS
Keystore provider: SUN
```

Your keystore contains 1 entry

```
shared, Jun 1, 2016, PrivateKeyEntry,
Certificate fingerprint (SHA1): A6:54:9C:42:13:66:DC:E9:A8:62:DB:
A8:87:FD:DE:23:F7:AD:11:FB
```

```
Keystore:
security/store.trust
```

```
Keystore type: JKS
Keystore provider: SUN
```

Your keystore contains 1 entry

```
mykey, Jun 1, 2016, trustedCertEntry,  
Certificate fingerprint (SHA1):A6:54:9C:42:13:66:DC:E9:A8:62:DB:  
A8:87:FD:DE:23:F7:AD:11:FB
```

- `-secdir <securitydir>`
Specifies the name of the directory within the KVROOT that holds the security configuration. This must be specified as a name relative to the KVROOT. If not specified, the default value is "security".

Removing the security configuration

If you want to disable security for some reason in an existing installation, you can use the `config remove-security` command:

```
config remove-security -root <kvroot> [-config >config.xml]
```

Note:

When running this command, the `securityconfig` tool will update the specified bootstrap configuration file to refer to the security configuration. This process is normally done with the KVStore instance stopped, and must be performed on each Storage Node of the store.

where:

- `-root <kvroot>`
A KVStore root directory must be provided as an argument.
- `-config <config.xml>`
Specifies the bootstrap configuration file that is to be updated. This must be specified as a name relative to the KVROOT. If not specified, the default value is "config.xml".

For example:

```
security-> config remove-security -secdir security  
Configuration updated.
```

Merging truststore configuration

If you want to merge truststore entries from one security configuration into another security configuration use the `config merge-trust` command. This command is helpful when performing security maintenance, particularly when you need to update the SSL key/certificate. See [Guidelines for Updating SSL Keys and Certificates](#)

```
config merge-trust  
-root <secroot> [-secdir <security dir>]  
-source-root <secroot> [-source-secdir <security dir>]
```

 **Note:**

When running this command, the `securityconfig` tool will verify the existence of the referenced files and will combine trust entries from the source security configuration into the primary security configuration.

where:

- `-root <secroot>`

Specifies the directory that contains the security configuration that will be updated. It is not required that this directory be a full KVROOT, but the directory must exist and contain an existing security configuration.

- `-secdir <security dir>`

Specifies the name of the directory within the `secroot` that holds the security configuration. This must be specified as a name relative to the `secroot`. If not specified, the default value is "security".

- `-source-root <secroot>`

Specifies the directory that contains the security configuration that will provide new trust information. It is not required that this directory be a full KVROOT, but the directory must exist and must contain an existing security configuration.

- `-source-secdir <security dir>`

Specifies the name of the security directory within the source `secroot` that will provide new trust information. If not specified, the default value is "security".

3

Performing a Secure Oracle NoSQL Database Installation

It is possible to add security to a new or an existing Oracle NoSQL Database installation.

To add security to a new or an existing Oracle NoSQL Database single host deployment, see the next section. For multiple node deployments, see [Multiple Node Secure Deployment](#).

If you want to use Kerberos as an external authentication service, you should instead complete the steps under [Performing a Secure Oracle NoSQL Database Installation with Kerberos](#).

Single Node Secure Deployment

The following examples describe how to add security to a new or an existing Oracle NoSQL Database single host deployment.

Adding Security to a New Installation

To install Oracle NoSQL Database securely:

1. Run the `makebootconfig` utility with the `-store-security` option to set up the basic store configuration with security:

```
java -Xmx64m -Xms64m \  
-jar KVHOME/lib/kvstore.jar makebootconfig \  
-root KVROOT -port 5000 \  
-host node01 -harange 5010,5020 \  
-store-security configure -pwdmgr pwdfile -capacity 1
```

2. In this example, `-store-security configure` is used, so the security configuration utility is run as part of the `makebootconfig` process and you are prompted for a password to use for your keystore file:

Enter a password for the Java KeyStore:

3. Enter a password for your store and then reenter it for verification. In this case, the password file is used, and the `securityconfig` tool will automatically generate the following security related files:

```
Enter a password for the Java KeyStore: *****  
Re-enter the KeyStore password for verification: *****  
Created files:  
security/client.trust  
security/client.security  
security/store.keys
```

```
security/store.trust
security/store.passwd
security/security.xml
```

 **Note:**

In a multi-host store environment, the security directory and all files contained in it should be copied to each server that will host a Storage Node.

4. Start the Storage Node Agent (SNA): **Note:**

Before starting the SNA, set the environment variable `MALLOC_ARENA_MAX` to 1. Setting `MALLOC_ARENA_MAX` to 1 ensures that the memory usage is restricted to the specified heap size.

```
nohup java -Xmx64m -Xms64m \  
-jar KVHOME/lib/kvstore.jar start -root KVROOT&
```

When a newly created store with a secure configuration is first started, there are no user definitions available against which to authenticate access. In order to reduce risk of unauthorized access, an admin will only allow you to connect to it from the host on which it is running. This security measure is not a complete safeguard against unauthorized access. It is important that you do not provide local access to machines running KVStore. In addition, you should perform steps 5, 6 and 7 soon after this step in order to minimize the time period in which the admin might be accessible without full authentication. For more information on maintaining a secure store see [Guidelines for Securing the Configuration](#).

5. Start `runadmin` in security mode on the KVStore server host (node01). To do this, use the following command:

```
java -Xmx64m -Xms64m \  
-jar KVHOME/lib/kvstore.jar \  
runadmin -port 5000 -host node01 \  
-security KVROOT/security/client.security  
Logged in admin as anonymous
```

6. Use the `configure -name` command to specify the name of the KVStore that you want to configure:

```
kv-> configure -name mystore  
Store configured: mystore
```

7. Create an admin user. The password should comply with the security policies described in [Password Complexity Policies](#). In this case, user `root` is defined:

```
kv-> plan create-user -name root -admin -wait
Enter the new password: *****
Re-enter the new password: *****
Executed plan 6, waiting for completion...
Plan 6 ended successfully
```

For more information on user creation and administration, see [User Management](#).

8. Create a new password file to store the credentials needed to allow clients to login as the admin user (`root`):

```
java -Xmx64m -Xms64m \
-jar KVHOME/lib/kvstore.jar securityconfig \
pwdfile create -file KVROOT/security/login.passwd
java -Xmx64m -Xms64m \
-jar KVHOME/lib/kvstore.jar securityconfig pwdfile secret \
-file KVROOT/security/login.passwd -set -alias root
Enter the secret value to store: *****
Re-enter the secret value for verification: *****
Secret created
```

**Note:**

The password must match the one set for the admin in the previous step.

For more information on user creation and administration, see [User Management](#).

9. At this point, it is possible to connect to the store as the root user. To login, you can use either the `-username <user> runadmin` argument or specify the `"oracle.kv.auth.username"` property in the security file.

In this example, a security file (`mylogin.txt`) is used. To login, use the following command:

```
java -Xmx64m -Xms64m \
-jar KVHOME/lib/kvstore.jar runadmin -port 5000 \
-host localhost -security mylogin
Logged in admin as root
```

The file `mylogin.txt` should be a copy of the `client.security` file with additional properties settings for authentication. The file would then contain content like this:

```
oracle.kv.auth.username=root
oracle.kv.auth.pwdfile.file=KVROOT/security/login.passwd
oracle.kv.transport=ssl
oracle.kv.ssl.trustStore=KVROOT/security/client.trust
oracle.kv.ssl.protocols=TLSv1.2,TLSv1.1,TLSv1
oracle.kv.ssl.hostnameVerifier=dnmatch(CN\=NoSQL)
```

Note that the hostname verifier provides a way for Oracle NoSQL Database clients to specify the name that they expect the Oracle NoSQL Database server hosts to use during SSL handshake (when they attempt to connect server using SSL/TLS).

For a secure store using the standard configuration, server hosts will be required to authenticate themselves, and clients will use their SSL truststore to confirm that the server authenticates with a trusted identity. The hostname verifier provides the additional assurance that the server host authenticates using the expected identity, not just any trusted identity.

This additional check is desirable if either the truststore contains multiple certificates or if the certificate it contains is a CA certificate rather than a self-signed or leaf certificate. In both those cases, the truststore can vouch for multiple identities. The host verifier allows the user to specify the specific identity that is expected.

The only hostname verifier currently supported is the `dnmatch` verifier, which must be specified in the form of `dnmatch(distinguished-name)`, where distinguished name must be the NoSQL DB server certificate's distinguished name. If you are using the default security configuration, then the hostname verifier in the example specifies that the server should authenticate with a certificate whose distinguished name is `CN=NoSQL`. This is the name used in the server certificates that the system generates by default.

The verification is performed by checking if the distinguished name of server certificate match the specified `dnmatch` expressions, which uses regular expressions as specified by `java.util.regex.Pattern`. The distinguished name specified in `dnmatch` must be in RFC 1779 format, using the exact order, capitalization, and spaces of the attribute value. RFC 1779 defines well-known attributes for distinguished names, including CN, L, ST O, OU, C and STREET. If the distinguished name of the external certificate contains non-standard attributes, for example, EMAILADDRESS, then the expression used for `dnmatch` must replace these attribute names with an OID that is valid in RFC 1779 form, or use special constructs of regular expression to skip checking these attributes. If you are using a wild card to match a certificate with a non-standard distinguished name attribute, the `dnmatch` expression needs to match the attribute name in its OID format properly. See [User Login](#).

Adding Security to an Existing Installation

To add security to an existing Oracle NoSQL Database installation:

1. Shut down the KVStore instance:

```
java -Xmx64m -Xms64m \  
-jar KVHOME/lib/kvstore.jar stop \  
-root KVROOT
```

2. Run the `securityconfig` utility to set up the basic store configuration with security:

```
java -Xmx64m -Xms64m \  
-jar KVHOME/lib/kvstore.jar securityconfig
```

3. Use the `config create` command with the `-pwdmgr` option to specify the mechanism used to hold passwords that is needed for accessing the stores. In this

case, Oracle Wallet is used. Oracle Wallet is only available in the Oracle NoSQL Database EE version. CE deployments should use the `pwdfile` option instead.

```
config create -pwdmgr wallet -root KVRROOT
Enter a password for the Java KeyStore:
```

4. Enter a password for your store and then reenter it for verification. The configuration tool will automatically generate some security related files:

```
Enter a password for the Java KeyStore: *****
Re-enter the KeyStore password for verification: *****
Created files:
security/security.xml
security/store.keys
security/store.trust
security/store.wallet/cwallet.sso
security/client.security
security/client.trust
```

 **Note:**

In a multi-host store environment, the security directory and all files contained in it should be copied to each server that will host a Storage Node.

5. Use the `config add-security` command to add the security configuration you just created:

```
security-> config add-security -root KVRROOT
-sedir security -config config.xml
Configuration updated.
```

 **Note:**

When running this command, the `securityconfig` tool will verify the existence of the referenced files and will update the specified bootstrap configuration file to refer to the security configuration. This process is normally done with the KVStore instance stopped, and must be performed on each Storage Node of the store.

6. Start the Storage Node Agent (SNA):

 **Note:**

Before starting the SNA, set the environment variable `MALLOC_ARENA_MAX` to 1. Setting `MALLOC_ARENA_MAX` to 1 ensures that the memory usage is restricted to the specified heap size.

```
nohup java -Xmx64m -Xms64m \  
-jar KVHOME/lib/kvstore.jar start -root KVROOT &
```

7. Start `runadmin` in security mode on the KVStore server host (node01). To do this, use the following command:

```
java -Xmx64m -Xms64m \  
-jar KVHOME/lib/kvstore.jar \  
runadmin -port 5000 -host node01 \  
-security KVROOT/security/client.security  
Logged in admin as anonymous.
```

This command sets SSL as a connection method and names a copy of the generated truststore file (`client.security`). For more information on SSL properties, see [SSL communication properties](#).

8. Create an admin user. The password should comply with the security policies described in [Password Complexity Policies](#). In this case, user `root` is defined:

```
kv-> plan create-user -name root -admin -wait  
Enter the new password: *****  
Re-enter the new password: *****  
Executed plan 8, waiting for completion...  
Plan 8 ended successfully
```

For more information on user creation and administration, see [User Management](#).

9. Create a new wallet file to store the credentials needed to allow clients to login as the admin user (`root`):

```
java -Xmx64m -Xms64m \  
-jar KVHOME/lib/kvstore.jar securityconfig \  
wallet create -dir KVROOT/security/login.wallet  
java -Xmx64m -Xms64m \  
-jar KVHOME/lib/kvstore.jar securityconfig wallet secret \  
-dir KVROOT/security/login.wallet -set -alias root  
Enter the secret value to store: *****  
Re-enter the secret value for verification: *****  
Secret created
```

 **Note:**

The password must match the one set for the admin in the previous step.

For more information on user creation and administration, see [User Management](#).

10. At this point, it is possible to connect to the store as the root user. To login, you can use either the `-username <user> runadmin` argument or specify the "oracle.kv.auth.username" property in the security file.

In this example, the `oracle.kv.security` property is used. To login use the following command:

```
java -Xmx64m -Xms64m \  
-Doracle.kv.security=mylogin \  
-jar KVHOME/lib/kvstore.jar runadmin -port 5000 -host localhost  
Logged in admin as root
```

The file `mylogin.txt` should be a copy of the `client.security` file with additional properties settings for authentication. The file would then contain content like this:

```
oracle.kv.auth.username=root  
oracle.kv.auth.wallet.dir=KVROOT/security/login.wallet  
oracle.kv.transport=ssl  
oracle.kv.ssl.trustStore=KVROOT/security/client.trust  
oracle.kv.ssl.protocols=TLSv1.2,TLSv1.1,TLSv1  
oracle.kv.ssl.hostnameVerifier=dnmatch(CN\=NoSQL)
```

For more information, see [User Login](#).

Multiple Node Secure Deployment

The following examples describe how to add security to a new or to an existing Oracle NoSQL Database multiple host deployment.

Adding Security to a New Installation

To install an Oracle NoSQL Database three node, capacity=3 (3x3) secure deployment:

1. Run the `makebootconfig` utility with the `-store-security` option to set up the basic store configuration with security:

```
java -Xmx64m -Xms64m \  
-jar KVHOME/lib/kvstore.jar makebootconfig \  
-root KVROOT -port 5000 \  
-host node01 -harange 5010,5020 \  
-store-security configure -pwdmgr wallet -capacity 3
```

2. In this example, `-store-security configure` is used, so the security configuration utility is run as part of the `makebootconfig` process and you are prompted for a password to use for your keystore file:

Enter a password for the Java KeyStore:

3. Enter a password for your store and then reenter it for verification. For example, using `wallet`, the `securityconfig` tool will automatically generate the following security related files:

```
Enter a password for the Java KeyStore: *****
Re-enter the KeyStore password for verification: *****
Created files:
security/security.xml
security/store.keys
security/store.trust
security/store.wallet/cwallet.sso
security/client.security
security/client.trust
```

4. In a multi-host store environment, the security directory and all files contained in it should be copied from the first node to each server that will host a Storage Node, to setup internal cluster authentication. For example, the following commands assume that the different nodes are visible and accessible on the current node (node01):

```
cp -R node01/KVROOT/security node02/KVROOT/
cp -R node01/KVROOT/security node03/KVROOT/
```

 **Note:**

You may need to use a remote copying command, like `scp`, to do the copying if the files for the different nodes are not visible on the current node.

5. Enable security on the other two nodes using the `-store-security enable` command:

```
java -Xmx64m -Xms64m \  
-jar KVHOME/lib/kvstore.jar makebootconfig \  
-root KVROOT \  
-host node02 \  
-port 6000 \  
-harange 6010,6020 \  
-capacity 3 \  
-store-security enable \  
-pwmgr wallet
```

```
java -Xmx64m -Xms64m \  
-jar KVHOME/lib/kvstore.jar makebootconfig \  
-root KVROOT \  
-host node03 \  
-port 7000 \  
-harange 7010,7020 \  
-capacity 3 \  
-store-security enable \  
-pwmgr wallet
```

6. Start the Storage Node Agent (SNA) on each node: **Note:**

Before starting the SNA, set the environment variable `MALLOC_ARENA_MAX` to 1. Setting `MALLOC_ARENA_MAX` to 1 ensures that the memory usage is restricted to the specified heap size.

```
nohup java -Xmx64m -Xms64m \  
-jar KVHOME/lib/kvstore.jar start -root KVROOT&
```

7. Start `runadmin` in security mode on the KVStore server host (node01). To do this, use the following command:

```
java -Xmx64m -Xms64m \  
-jar KVHOME/lib/kvstore.jar \  
runadmin -port 5000 -host node01 \  
-security KVROOT/security/client.security  
Logged in admin as anonymous
```

8. Use the `configure -name` command to specify the name of the KVStore that you want to configure:

```
kv-> configure -name mystore  
Store configured: mystore
```

9. Create an admin user. The password should comply with the security policies described in [Password Complexity Policies](#). In this case, user `root` is defined:

```
kv-> plan create-user -name root -admin -wait  
Enter the new password: *****  
Re-enter the new password: *****  
Executed plan 6, waiting for completion...  
Plan 6 ended successfully
```

For more information on user creation and administration, see [User Management](#).

10. Create the wallet to enable client credentials for the admin user (root):

```
java -Xmx64m -Xms64m \  
-jar KVHOME/lib/kvstore.jar securityconfig \  
wallet create -dir KVROOT/security/login.wallet  
java -Xmx64m -Xms64m \  
-jar KVHOME/lib/kvstore.jar securityconfig wallet secret \  
-dir KVROOT/security/login.wallet -set -alias root  
Enter the secret value to store: *****  
Re-enter the secret value for verification: *****  
Secret created
```

 **Note:**

The password must match the one set for the admin in the previous step.

11. At this point, it is possible to connect to the store as the root user. To login, you can use either the `-username <user> runadmin` argument or specify the "oracle.kv.auth.username" property in the security file.

In this example, a security file (adminlogin.txt) is used. To login, use the following command:

```
java -Xmx64m -Xms64m \  
-jar KVHOME/lib/kvstore.jar runadmin -port 5000 \  
-host localhost -security adminlogin  
Logged in admin as root
```

The file adminlogin.txt should be a copy of the client.security file with additional properties settings for authentication. The file would then contain content like this:

```
oracle.kv.auth.username=root  
oracle.kv.auth.wallet.dir=KVROOT/security/login.wallet  
oracle.kv.transport=ssl  
oracle.kv.ssl.trustStore=KVROOT/security/client.trust  
oracle.kv.ssl.protocols=TLSv1.2,TLSv1.1,TLSv1  
oracle.kv.ssl.hostnameVerifier=dnmatch(CN\=NoSQL)
```

For more information, see [User Login](#).

12. Once logged in as admin, you can create some users:

```
kv-> plan create-user -name user1 -wait  
Enter the new password: *****  
Re-enter the new password: *****  
Executed plan 7, waiting for completion...  
Plan 7 ended successfully
```

```
kv-> plan create-user -name user2 -wait  
Enter the new password: *****  
Re-enter the new password: *****  
Executed plan 8, waiting for completion...  
Plan 8 ended successfully
```

13. Create the wallet to enable client credentials for each user. Typically you will reuse this wallet for all your regular users:

```
java -Xmx64m -Xms64m \  
-jar KVHOME/lib/kvstore.jar securityconfig \  
wallet create -dir KVROOT/security/users.wallet  
java -Xmx64m -Xms64m \  
-jar KVHOME/lib/kvstore.jar securityconfig wallet secret \  
-dir KVROOT/security/users.wallet -set -alias user1
```

```

Enter the secret value to store: *****
Re-enter the secret value for verification: *****
Secret created
java -Xmx64m -Xms64m \
-jar KVHOME/lib/kvstore.jar securityconfig wallet secret \
-dir KVROOT/security/users.wallet -set -alias user2
Enter the secret value to store: *****
Re-enter the secret value for verification: *****
Secret created

```

 **Note:**

Each password must match the one set for each user in the previous step. This wallet is independent from the admin one. It is possible to store admin/user passwords using the same wallet.

14. At this point, it is possible to connect to the store as a user. To login, you can use either the `-username <user> runadmin` argument or specify the "oracle.kv.auth.username" property in the security file.

In this example, a security file (userlogin.txt) is used. To login, use the following command:

```

java -Xmx64m -Xms64m \
-jar KVHOME/lib/kvstore.jar runadmin -port 5000 \
-host localhost -security userlogin
Logged in admin as user1

```

The file `userlogin.txt` should be a copy of the `client.security` file with additional properties settings for authentication. The file would then contain content like this:

```

oracle.kv.auth.username=user1
oracle.kv.auth.wallet.dir=KVROOT/security/users.wallet
oracle.kv.transport=ssl
oracle.kv.ssl.trustStore=KVROOT/security/client.trust
oracle.kv.ssl.protocols=TLSv1.2,TLSv1.1,TLSv1
oracle.kv.ssl.hostnameVerifier=dnmatch(CN\=NoSQL)

```

For more information, see [User Login](#).

Adding Security to an Existing Installation

To add security to an existing three node, capacity=3 (3x3) Oracle NoSQL Database installation:

1. Shut down the KVStore instance on each node:

```

java -Xmx64m -Xms64m \
-jar KVHOME/lib/kvstore.jar stop \
-root KVROOT

```

2. Run the `securityconfig` utility to set up the basic store configuration with security:

```
java -Xmx64m -Xms64m \  
-jar KVHOME/lib/kvstore.jar securityconfig
```

3. Use the `config create` command with the `-pwdmgr` option to specify the mechanism used to hold passwords that is needed for accessing the stores. In this case, Oracle Wallet is used:

```
config create -pwdmgr wallet -root KVRROOT  
Enter a password for the Java KeyStore:
```

4. Enter a password for your store and then reenter it for verification. The configuration tool will automatically generate some security related files:

```
Enter a password for the Java KeyStore: *****  
Re-enter the KeyStore password for verification: *****  
Created files:  
security/security.xml  
security/store.keys  
security/store.trust  
security/store.wallet/cwallet.sso  
security/client.security  
security/client.trust
```

5. In a multi-host store environment, the security directory and all files contained in it should be copied from the first node to each server that will host a Storage Node, to setup internal cluster authentication. For example, the following commands assume that the different nodes are visible and accessible on the current node (node01):

```
cp -R node01/KVRROOT/security node02/KVRROOT/  
cp -R node01/KVRROOT/security node03/KVRROOT/
```

 **Note:**

You may need to use a remote copying command, like `scp`, to do the copying if the files for the different nodes are not visible on the current node.

6. Use the `config add-security` command on each node to add the security configuration you just created:

```
security-> config add-security -root KVRROOT -secdir security
```

 **Note:**

When running this command, the `securityconfig` tool will verify the existence of the referenced files and will update the specified bootstrap configuration file to refer to the security configuration. This process is normally done with the KVStore instance stopped, and must be performed on each Storage Node of the store.

7. Start the Storage Node Agent (SNA) on each node:

 **Note:**

Before starting the SNA, set the environment variable `MALLOC_ARENA_MAX` to 1. Setting `MALLOC_ARENA_MAX` to 1 ensures that the memory usage is restricted to the specified heap size.

```
java -Xmx64m -Xms64m \  
-jar KVHOME/lib/kvstore.jar start -root KVROOT&
```

8. Start `runadmin` in security mode on the KVStore server host (node01). To do this, use the following command:

```
java -Xmx64m -Xms64m \  
-jar KVHOME/lib/kvstore.jar \  
runadmin -port 5000 -host node01 \  
-security KVROOT/security/client.security
```

This command sets SSL as a connection method and names a copy of the generated truststore file (`client.security`). For more information on SSL properties, see [SSL communication properties](#).

9. Create an admin user. The password should comply with the security policies described in [Password Complexity Policies](#). In this case, user `root` is defined:

```
kv-> plan create-user -name root -admin -wait  
Enter the new password: *****  
Re-enter the new password: *****  
Executed plan 8, waiting for completion...  
Plan 8 ended successfully
```

For more information on user creation and administration, see [User Management](#).

10. Create the wallet to enable client credentials for the admin user (root):

```
java -Xmx64m -Xms64m \  
-jar KVHOME/lib/kvstore.jar securityconfig \  
wallet create -dir KVROOT/security/login.wallet  
java -Xmx64m -Xms64m \  
-jar KVHOME/lib/kvstore.jar securityconfig wallet secret \  
-dir KVROOT/security/login.wallet -set -alias root
```



```
Enter the secret value to store: *****  
Re-enter the secret value for verification: *****  
Secret created
```

 **Note:**

The password must match the one set for the admin in the previous step.

11. At this point, it is possible to connect to the store as the root user. To login, you can use either the `-username <user> runadmin` argument or specify the "oracle.kv.auth.username" property in the security file.

In this example, the `oracle.kv.security` property is used. To login use the following command:

```
java -Xmx64m -Xms64m \  
-Doracle.kv.security=adminlogin \  
-jar KVHOME/lib/kvstore.jar runadmin -port 5000 -host localhost  
Logged in admin as root >
```

The file `adminlogin.txt` should be a copy of the `client.security` file with additional properties settings for authentication. The file would then contain content like this:

```
oracle.kv.auth.username=root  
oracle.kv.auth.wallet.dir=KVROOT/security/login.wallet  
oracle.kv.transport=ssl  
oracle.kv.ssl.trustStore=KVROOT/security/client.trust  
oracle.kv.ssl.protocols=TLSv1.2,TLSv1.1,TLSv1  
oracle.kv.ssl.hostnameVerifier=dnmatch(CN\=NoSQL)
```

For more information, see [User Login](#).

4

Kerberos Authentication Service

Existing or new installations of Oracle NoSQL Database can be configured to use Kerberos as an external authentication service. Kerberos is an industry standard authentication protocol for large client/server systems.

Setting up and configuring a Kerberos deployment is beyond the scope of this chapter. This chapter assumes that you have a running Key Distribution Center (KDC) and realm setup.

This chapter first describes some Kerberos concepts and then shows you how to configure existing or new installations of Oracle NoSQL Database to use Kerberos as an external authentication service.

Installation Prerequisites

Make sure that you have Kerberos V5 installed. Oracle NoSQL Database is compatible and tested with MIT Kerberos V5.

If your Kerberos installation/keytab is configured to use a strong encryption type - for example, AES with 256-bit keys - the JCE Unlimited Strength Jurisdiction Policy Files must be obtained and installed in the JDK/JRE. Be aware that these files might already exist in your installation. If so, they must be updated.

Kerberos Principal

A Kerberos Principal represents a unique identity in a Kerberos system to which Kerberos can assign tickets to access Kerberos-aware services. A service principal should be created for each Storage Node. Oracle NoSQL Database service principals follow this naming format: <service_name>/instance@REALM.

where:

- `service_name`

Is a case-sensitive string that represents the Oracle NoSQL Database service. The default value is `oraclenosql`.

All Oracle NoSQL Database service principals should use the same service name across different Storage Nodes.

- `instance`

Represents the service principal instance name. It is recommended to use the fully qualified domain name (FQDN) of the Storage Node where Oracle NoSQL Database is running.

If `instance` is not specified, the default principal will be created as `oraclenosql@REALM`.

- `REALM`

Represents the Kerberos realm name where the database service is registered. It must be specified in UPPERCASE and is typically the DNS domain name.

If no realm is given, the service principal is assumed to belong to the default realm, as configured in the Kerberos configuration file.

Keytabs

A keytab is a file containing pairs of Kerberos principals and an encrypted copy of that principal's key.

Keytabs are used to authenticate a principal on a host to Kerberos.



Note:

Because having access to the keytab file for a principal allows one to act as that principal, access to the keytab files should be tightly secured.

Kadmin and kadmin.local

`kadmin` and `kadmin.local` are command-line interfaces to the Kerberos administration system.

In general, both interfaces provide the same functionality. When creating Kerberos principals and keytabs, you can use `kadmin.local` or `kadmin` depending on your access and account.

For more information, see the MIT Kerberos documentation.

Kerberos Security Properties

To set up the Kerberos security properties, you can set them in a login file or through the `KVStoreConfig` class.

The minimal configuration needed to set up Kerberos includes the following properties:

- `oracle.kv.auth.username`

Specifies the Kerberos user name in Oracle NoSQL Database. It must match the principal name in KDC and match the Kerberos user account name created in the database. The client will use the value of this option to create the credential which is used in the client-server authentication. If the short name of principal is specified in this field, you must also specify `oracle.kv.auth.kerberos.realm`.

If `KerberosCredentials` is not used, this field has to be specified in the login file or security properties field of `KVStoreConfig`.
- `oracle.kv.auth.kerberos.services`

Specifies the Kerberos principals for services associated with each helper host. Setting this property is required if, as recommended, each host uses a different principal that includes its own principal name. All principals should specify the same service and realm. If this property is not set, the client will use `oraclenosql` as the principal name for services on all helper hosts.

Each entry should specify the helper host name followed by the Kerberos service name, and optionally an instance name and realm name. The entries are separated by commas, ignoring spaces. If any entry does not specify a realm, each entry will use the default realm specified in Kerberos configuration file. If any entry specifies a realm name, then all entries must specify the same one. The syntax is:

```
host:service[:instance[@realm]][, host:service[:instance[@realm]]]*
```

For example:

```
host37:nosql/host37@EXAMPLE.COM,  
host53:nosql/host53@EXAMPLE.COM
```

- `oracle.kv.auth.kerberos.keytab`

The default location of the keytab file is specified by the Kerberos configuration file. If the keytab is not specified there, then the system looks for the file `user.home/krb5.keytab`.

- `oracle.kv.auth.kerberos.realm`

Specifies the Kerberos realm for the user principal if using a short name to specify the client login principal.

- `oracle.kv.auth.kerberos.ccache`

Specifies the path of the Kerberos ticket cache. This field is optional. The default ticket cache is `/tmp/krbcc_<uid>`. If the credential cache is not found, the system will look for the file `user.home/krb5cc_<user.name>`. If you want to use your own ticket cache, set this field to the path of the ticket cache.

- `oracle.kv.auth.kerberos.mutualAuth`

Specifies whether the client should use mutual authentication. If this value is set to `true`, the client will authenticate the server's identity in the login results.

The default value is `false`, so mutual authentication is disabled.

Setting Security Properties in a security login file

To set the properties in a security file, specify the location of the login file by setting the `oracle.kv.security` Java system property. For example:

```
java -Doracle.kv.security=kerberoslogin.txt HelloWorld
```

where the file `kerberoslogin.txt` should be a copy of the `client.security` file with additional properties settings for Kerberos authentication. The file would then contain content like this:

```
oracle.kv.auth.username=krbuser@EXAMPLE.COM  
oracle.kv.auth.external.mechanism=kerberos  
oracle.kv.auth.kerberos.keytab=/kerberos/krb5.keytab  
oracle.kv.auth.kerberos.services=  
    node01:oraclenosql/node01.example.com@EXAMPLE.COM  
oracle.kv.auth.kerberos.mutualAuth=false
```

You can specify the location of the Kerberos configuration file by specifying the `java.security.krb5.conf` Java system property. For example:

```
java -Djava.security.krb5.conf=/kerberos/krb5.conf \  
-Doracle.kv.security=kerberoslogin.txt HelloWorld
```

You can also set the default realm using `java.security.krb5.realm`. To set the default KDC, use `java.security.krb5.kdc`.

 **Note:**

Set the Java system properties for both the realm and the KDC or neither of them. These properties override the default realm and KDC values specified in the `krb5.conf` file.

Setting Security Properties through KVStoreConfig

You can also set security properties using `KVStoreConfig`. For example:

```
Properties securityProps = new Properties();  
securityProps.setProperty("oracle.kv.auth.username",  
                           "krbuser@EXAMPLE.COM");  
securityProps.setProperty("oracle.kv.auth.external.mechanism",  
                           "kerberos");  
securityProps.setProperty("oracle.kv.auth.kerberos.keytab",  
                           "/kerberos/krb5.keytab");  
securityProps.setProperty("oracle.kv.auth.kerberos.services",  
                           "node01:oraclenosql/node01.example.com@EXAMPLE.COM");  
securityProps.setProperty("oracle.kv.auth.kerberos.ccache",  
                           "/kerberos/krbcc_501");  
securityProps.setProperty("oracle.kv.auth.kerberos.mutualAuth",  
                           "false");  
  
KVStoreConfig kvConfig = new KVStoreConfig("mystore", "node01:5000");  
kvConfig.setSecurityProperties(securityProps);
```

Using Security Properties to Log In

To log in to Oracle NoSQL Database using security properties, you can use credential cache, a keytab file or the principal password.

 **Note:**

When connecting through the Admin CLI, if credential cache or keytabs login attempts fail, Oracle NoSQL Database prompts for the principal's password.

Using Credential Cache

To login to Oracle NoSQL Database using credential cache:

1. Run the `kinit` Kerberos tool to save the credential in the credential cache.

For example, to authenticate the client principal `krbuser@EXAMPLE.COM` to KDC:

```
kinit krbuser@EXAMPLE.COM
Password for krbuser@EXAMPLE.COM: *****
```

The granted ticket-granting ticket (TGT) will be saved in the default credential cache for later authentication.

2. You can also generate a separate cache. To do this run the following command:

```
kinit krbuser@EXAMPLE.COM -c krbcc_krbuser
```

3. Perform the login by specifying `oracle.kv.auth.kerberos.ccache` in a security login file or through `KVStoreConfig`. In this case, a security login file is used:

```
java -Xmx64m -Xms64m \
-Doracle.kv.security=mylogin.txt \
-jar KVHOME/lib/kvstore.jar runadmin -port 5000 -host localhost
Logged in admin as krbuser
```

The file `mylogin.txt` should be a copy of the `client.security` file with additional properties settings for Kerberos authentication. The file would then contain content like this:

```
oracle.kv.auth.kerberos.ccache=/kerberos/krbcc_krbuser
oracle.kv.auth.username = krbuser@EXAMPLE.COM
oracle.kv.auth.external.mechanism=kerberos
oracle.kv.auth.kerberos.services=
                                node01:oraclenosql/node01.example.com@EXAMPLE.COM
oracle.kv.auth.kerberos.mutualAuth=false
```

In this case, Oracle NoSQL Database reads the credential cache and logs in to Kerberos without needing a password.

Using credential cache

To login to Oracle NoSQL Database using credential cache:

1. Run the `kinit` Kerberos tool to save the credential in the credential cache.

For example, to authenticate the client principal `krbuser@EXAMPLE.COM` to KDC:

```
kinit krbuser@EXAMPLE.COM
Password for krbuser@EXAMPLE.COM: *****
```

The granted ticket-granting ticket (TGT) will be saved in the default credential cache for later authentication.

2. You can also generate a separate cache. To do this run the following command:

```
kinit krbuser@EXAMPLE.COM -c krbcc_krbuser
```

3. Perform the login by specifying `oracle.kv.auth.kerberos.ccache` in a security login file or through `KVStoreConfig`. In this case, a security login file is used:

```
java -Xmx64m -Xms64m \  
-Doracle.kv.security=mylogin.txt \  
-jar KVHOME/lib/kvstore.jar runadmin -port 5000 -host localhost  
Logged in admin as krbuser
```

The file `mylogin.txt` should be a copy of the `client.security` file with additional properties settings for Kerberos authentication. The file would then contain content like this:

```
oracle.kv.auth.kerberos.ccache=/kerberos/krbcc_krbuser  
oracle.kv.auth.username = krbuser@EXAMPLE.COM  
oracle.kv.auth.external.mechanism=kerberos  
oracle.kv.auth.kerberos.services=  
    node01:oraclenysql/node01.example.com@EXAMPLE.COM  
oracle.kv.auth.kerberos.mutualAuth=false
```

In this case, Oracle NoSQL Database reads the credential cache and logs in to Kerberos without needing a password.

Using a keytab

To login to Oracle NoSQL Database using a keytab:

1. Run the `kinit` Kerberos tool to extract the keytab:

```
kadmin.local: ktadd -k /tmp/mykeytab krbuser@EXAMPLE.COM  
Entry for principal krbuser@EXAMPLE.COM added to  
keytab WRFILE:/tmp/mykeytab.
```

2. Copy the keytab file to any client machine that will use the `krbuser@EXAMPLE.COM` principal to login automatically to Oracle NoSQL Database.
3. Set the Kerberos security properties, including the keytab file location, on each client by specifying them in a security file or through the `KVStoreConfig` class.

In this example, a security file (login) is used. To login, specify the keytab location by using `oracle.kv.auth.kerberos.keytab`. You must also specify the username using `oracle.kv.auth.username`. For example, the login file would then contain content like this:

```
oracle.kv.auth.kerberos.keytab = /kerberos/mykeytab  
oracle.kv.auth.username = krbuser@EXAMPLE.COM  
oracle.kv.auth.external.mechanism=kerberos  
oracle.kv.auth.kerberos.services=
```

```
node01:oraclenosql/node01.example.com@EXAMPLE.COM
oracle.kv.auth.kerberos.mutualAuth=false
```

In this case, Oracle NoSQL Database reads the keytab and logs in to Kerberos without needing a password.

For more information on Kerberos security properties, see [Kerberos Security Properties](#).

JAAS programming framework integration

Oracle NoSQL Database allows client applications to integrate with programs using the Java Authentication and Authorization Service (JAAS) programming framework.

Use the `oracle.kv.jaas.login.conf.entryName` security property to specify the JAAS login configuration.

Note:

If a JAAS login configuration file is set, you cannot specify keytab or credential cache in security properties.

A login configuration file would then contain content like this:

```
oraclenosql {
    com.sun.security.auth.module.Krb5LoginModule required
    useKeyTab=true
    keyTab=test.keytab
    storeKey=true
    principal=krbuser
    doNotPrompt=false;
};
```

where `oraclenosql` is the value for `oracle.kv.jaas.login.conf.entryName`. This configuration file can be used for Kerberos login.

In the following example, assume the client application has already obtained the Kerberos credentials for user `krbuser` before it tries to connect to Oracle NoSQL Database. You do not have to specify security properties in the login file. You can specify the credentials using the `Subject.doAs` method:

```
final LoginContext lc =
    new LoginContext("oraclenosql", new TextCallbackHandler());

// Attempt authentication
lc.login();

// Get the authenticated Subject
final Subject subj = lc.getSubject();

// Specify configuration
```



```
final KVStoreConfig kvConfig =
    new KVStoreConfig("mystore", "nosql1:5000");

// Set security properties SSL needed
final Properties securityProps = new Properties();
securityProps.setProperty(KVSecurityConstants.TRANSPORT_PROPERTY,
    KVSecurityConstants.SSL_TRANSPORT_NAME);
securityProps.setProperty(
    KVSecurityConstants.SSL_TRUSTSTORE_FILE_PROPERTY,
    trustStore);
kvConfig.setSecurityProperties(securityProps);

// Set Kerberos properties
final Properties krbProperties = new Properties();

// Set service principal associated with helper host
krbProperties.setProperty(KVSecurityConstants.AUTH_KRB_SERVICES_PROPERTY
    ,
        hostName + ":" + servicePrincipal);

// Set default realm name, because the short name
// for user principal is used.
krbProperties.setProperty(KVSecurityConstants.AUTH_KRB_REALM_PROPERTY,
    "EXAMPLE.COM");

// Specify Kerberos principal
final KerberosCredentials krbCreds =
    new KerberosCredentials("krbuser", krbProperties);

// Get store using credentials in subject
KVStore kvstore = Subject.doAs(
    subj, new PrivilegedExceptionAction<KVStore>() {
        @Override
        public KVStore run() throws Exception {
            return KVStoreFactory.getStore(kvConfig, krbCreds, null);
        }
    });
```

In this case, a `KerberosCredentials` instance is used to set the security properties needed to retrieve the credentials of the specified user principal from KDC.

Performing a Secure Oracle NoSQL Database Installation with Kerberos

It is possible to add Kerberos to a new or an existing Oracle NoSQL Database secure installation.

At a high-level, to configure a Oracle NoSQL Database installation to use Kerberos, you first need to register Oracle NoSQL Database as a service principal in KDC and extract corresponding keytab files on each database server node. Then, to allow client login, a user principal must be added in KDC and a mapped user account with the same name of principal needs to be created in the database. Finally, login can be performed through the CLI or the `kvclient` driver.

Adding Kerberos to a New Installation

To install Oracle NoSQL Database with Kerberos authentication:

Note:

The following example assumes you have configured an admin/admin principal on the KDC and that you distributed its keytab (kadm5.keytab) to the Oracle NoSQL Database Storage Nodes. For more information, see [Configuring the Kerberos Administrative Utility](#).

1. Run the `makebootconfig` utility with the `-store-security configure` and `-external-auth kerberos` flags to set up the basic store configuration with Kerberos security:

```
java -Xmx64m -Xms64m \  
-jar KVHOME/lib/kvstore.jar makebootconfig \  
-root KVROOT -port 5000 \  
-host node01 -harange 5010,5020 \  
-capacity 3 \  
-store-security configure \  
-external-auth kerberos \  
-instance-name node01.example.com \  
-kadmin-keytab /kerberos/kadm5.keytab \  
-admin-principal admin/admin
```

2. In this example, `-store-security configure` is used, so the security configuration utility is run as part of the `makebootconfig` process and you are prompted for a password to use for your keystore file:

```
Enter a password for the Java KeyStore:
```

3. Enter a password for your store and then reenter it for verification. In this case, Oracle Wallet is used. Oracle Wallet and Kerberos support are only available in the Oracle NoSQL Database EE version.

```
Enter a password for the Java KeyStore: *****  
Re-enter the KeyStore password for verification: *****
```

4. In this case, `-kadmin-keytab` points to the admin/admin keytab file you distributed earlier. Once authenticated, the configuration tool will automatically generate some security related files:

```
Login Kerberos admin via  
keytab /kerberos/kadm5.keytab  
Adding principal oraclenosql/node01.example.com@EXAMPLE.COM  
Authenticating as principal admin/admin with  
keytab /kerberos/kadm5.keytab  
Extracting keytab KVROOT/security/store.keytab  
Created files:
```

```

security/security.xml
security/store.keys
security/store.trust
security/store.wallet/cwallet.sso
security/store.keytab
security/client.security
security/client.trust

```

5. In a multi-host store environment, the security directory and all files contained in it should be copied from the first node to each server that will host a Storage Node, to setup internal cluster authentication. For example, the following commands assume that the different nodes are visible and accessible on the current node (node01):

```

cp -R node01/KVROOT/security node02/KVROOT/
cp -R node01/KVROOT/security node03/KVROOT/

```

 **Note:**

You may need to use a remote copying command, like Secure Copy Protocol (SCP), to do the copying if the files for the different nodes are not visible on the current node.

6. Run `makebootconfig` on the other two nodes:

- Add Kerberos and create their individual service principal and keytab:

```

java -Xmx64m -Xms64m \
-jar KVHOME/lib/kvstore.jar makebootconfig \
-root KVROOT -port 6000 \
-host node02 -harange 6010,6020 \
-capacity 3 \
-store-security configure \
-external-auth kerberos \
-instance-name node02.example.com \
-kadmin-keytab /kerberos/kadm5.keytab \
-admin-principal admin/admin

```

```

java -Xmx64m -Xms64m \
-jar KVHOME/lib/kvstore.jar makebootconfig \
-root KVROOT -port 7000 \
-host node03 -harange 7010,7020 \
-capacity 3 \
-store-security configure \
-external-auth kerberos \
-instance-name node03.example.com \
-kadmin-keytab /kerberos/kadm5.keytab \
-admin-principal admin/admin

```

 **Note:**

The service principal name of node2 and node3 are using the same service name "oraclenosql", but different instance names. Their keytab files are different, which contains the key for principal "oraclenosql/node2.example.com" and "oraclenosql/node3.example.com" respectively.

- To enable Kerberos authentication if the store is using the same service principal on every node:

```
java -Xmx64m -Xms64m \  
-jar KVHOME/lib/kvstore.jar makebootconfig \  
-root KVROOT -port 6000 \  
-host node02 -harange 6010,6020 \  
-capacity 3 \  
-store-security enable
```

```
java -Xmx64m -Xms64m \  
-jar KVHOME/lib/kvstore.jar makebootconfig \  
-root KVROOT -port 6000 \  
-host node03 -harange 6010,6020 \  
-capacity 3 \  
-store-security enable
```

 **Note:**

The service principal created in step one is "oraclenosql/node01.example.com". The instance name can be replaced with any more general one like "nosql". In above example, node02 and node03 are all using the same service principal and keytab file without creating new one individually.

7. Start the Storage Node Agent (SNA) on each node:

 **Note:**

Before starting the SNA, set the environment variable `MALLOC_ARENA_MAX` to 1. Setting `MALLOC_ARENA_MAX` to 1 ensures that the memory usage is restricted to the specified heap size.

```
nohup java -Xmx64m -Xms64m \  
-jar KVHOME/lib/kvstore.jar start -root KVROOT&
```

When a newly created store with a secure configuration is first started, there are no user definitions available against which to authenticate access. In order to

reduce risk of unauthorized access, an admin will only allow you to connect to it from the host on which it is running. This security measure is not a complete safeguard against unauthorized access. It is important that you do not provide local access to machines running KVStore. In addition, you should perform the following steps soon after this step in order to minimize the time period in which the admin might be accessible without full authentication. For more information on maintaining a secure store see [Guidelines for Securing the Configuration](#).

8. Start `runadmin` in security mode on the KVStore server host (node01). To do this, use the following command:

```
java -Xmx64m -Xms64m \  
-jar KVHOME/lib/kvstore.jar \  
runadmin -port 5000 -host node01 \  
-security KVR00T/security/client.security  
Logged in admin as anonymous
```

9. Use the `configure -name` command to specify the name of the KVStore that you want to configure:

```
kv-> configure -name mystore  
Store configured: mystore
```

10. Register the user principal on the KDC. To do this, use `kadmin` or `kadmin.local`:

```
kadmin.local: addprinc krbuser@EXAMPLE.COM  
Enter password for principal: "krbuser@EXAMPLE.COM": *****  
Re-enter password for principal: "krbuser@EXAMPLE.COM": *****
```

11. After user principal is registered on KDC, create the user in Oracle NoSQL Database. The username needs to match the full principal name in the KDC (includes realm name). In this case, user `krbuser` is defined:

```
kv-> execute 'CREATE USER "krbuser@EXAMPLE.COM" IDENTIFIED  
EXTERNALLY'
```

For more information on user creation and administration, see [User Management](#).

12. At this point, it is possible to connect to the store as the `krbuser`. To login, you can use credential cache, a keytab file or enter the principal password.

In this example, a keytab file is used. To do this, first extract the keytab of principal `krbuser@EXAMPLE.COM` on the KDC host by using `kadmin.local`.

```
kadmin.local: ktadd -k /tmp/mykeytab krbuser@EXAMPLE.COM  
Entry for principal krbuser@EXAMPLE.COM added to  
keytab WRFILE:/tmp/mykeytab.
```

13. Copy the keytab file to client machines that will use the `krbuser@EXAMPLE.COM` principal to login automatically to Oracle NoSQL Database.
14. Set the Kerberos security properties, including the keytab file location, on each client by specifying them in a security file or through the `KVStoreConfig` class.

In this example, a security file (mylogin.txt) is used. To login, specify the file location by using the `oracle.kv.security` property. For example:

```
java -Xmx64m -Xms64m \  
-Doracle.kv.security=mylogin.txt \  
-jar KVHOME/lib/kvstore.jar runadmin -port 5000 -host localhost  
Logged in admin as krbuser
```

The file `mylogin.txt` should be a copy of the `client.security` file with additional properties settings for Kerberos authentication. The file would then contain content like this:

```
oracle.kv.auth.kerberos.keytab = kerberos/mykeytab  
oracle.kv.auth.username = krbuser@EXAMPLE.COM  
oracle.kv.auth.external.mechanism=kerberos  
oracle.kv.auth.kerberos.services=  
    node01:oraclenosql/node01.example.com@EXAMPLE.COM  
oracle.kv.auth.kerberos.mutualAuth=false
```

In this case, Oracle NoSQL Database reads the keytab and logs in to Kerberos without needing a password.

For more information on Kerberos security properties, see [Kerberos Security Properties](#).

Adding Kerberos to an Existing Secure Installation

To add Kerberos to an existing Oracle NoSQL Database secure installation:

Note:

The following example assumes you have configured an `admin/admin` principal on the KDC and that you distributed its keytab (`kadm5.keytab`) to the Oracle NoSQL Database Storage Nodes. For more information, see [Configuring the Kerberos Administrative Utility](#).

Note:

If your Kerberos installation/keytab will be configured to use a strong encryption type — for example, AES with 256-bit keys — the JCE Unlimited Strength Jurisdiction Policy Files must be obtained and installed in the JDK/JRE. Be aware that these files might already exist in your installation. If so, they must be updated.

1. Shut down the KVStore instance:

```
java -Xmx64m -Xms64m \  
-jar KVHOME/lib/kvstore.jar stop \  
-root KVROOT
```

2. Use the `config add-kerberos` command to add Kerberos authentication:

```
java -Xmx64m -Xms64m \  
-jar KVHOME/lib/kvstore.jar securityconfig \  
config add-kerberos -root KVROOT \  
-secdir security \  
-admin-principal admin/admin
```

```
Adding principal oraclenosql@EXAMPLE.COM  
Password for admin/admin: *****  
Created files:  
    security/store.keytab  
Updated Kerberos configuration
```

 **Note:**

When running this command, the `securityconfig` tool will verify the existence of the referenced files and will update the specified bootstrap configuration file to refer to the security configuration. This process is normally done with the KVStore instance stopped, and must be performed on each Storage Node of the store.

3. Start the Storage Node Agent (SNA) on each node:

 **Note:**

Before starting the SNA, set the environment variable `MALLOC_ARENA_MAX` to 1. Setting `MALLOC_ARENA_MAX` to 1 ensures that the memory usage is restricted to the specified heap size.

```
nohup java -Xmx64m -Xms64m \  
-jar KVHOME/lib/kvstore.jar start -root KVROOT&
```

4. Start `runadmin` in security mode on the KVStore server host (node01). To do this, use the following command:

```
java -Xmx64m -Xms64m \  
-jar KVHOME/lib/kvstore.jar \  
runadmin -port 5000 -host node01 \  
-security KVROOT/security/client.security  
Logged in admin as anonymous.
```

This command sets SSL as a connection method and names a copy of the generated truststore file (client.security). For more information on SSL properties, see [SSL communication properties](#).

5. Register the user principal on the KDC. To do this, use `kadmin` or `kadmin.local`:

```
kadmin.local: addprinc krbuser@EXAMPLE.COM
Enter password for principal: "krbuser@EXAMPLE.COM": *****
Re-enter password for principal: "krbuser@EXAMPLE.COM": *****
```

6. After user principal is registered on KDC, create the user in Oracle NoSQL Database. The username needs to match the full principal name in the KDC (includes realm name). In this case, user `krbuser` is defined:

```
kv-> execute 'CREATE USER "krbuser@EXAMPLE.COM" IDENTIFIED
EXTERNALLY'
```

For more information on user creation and administration, see [User Management](#).

7. At this point, it is possible to connect to the store as the `krbuser`. To login, you can use credential cache, a keytab file or enter the principal password.

In this example, a keytab file is used. To do this, first extract the keytab of principal `krbuser@EXAMPLE.COM` on the KDC host by using `kadmin.local`.

```
kadmin.local: ktadd -k /tmp/mykeytab krbuser@EXAMPLE.COM
Entry for principal krbuser@EXAMPLE.COM added to
keytab WRFILE:/tmp/mykeytab.
```

8. Copy the keytab file to any client machine that will use the `krbuser@EXAMPLE.COM` principal to login automatically to Oracle NoSQL Database.
9. Set the Kerberos security properties, including the keytab file location, on each client by specifying them in a security file or through the `KVStoreConfig` class.

In this example, a security file (`mylogin.txt`) is used. To login, specify the file location by using the `oracle.kv.security` property. For example:

```
java -Xmx64m -Xms64m \
-Doracle.kv.security=mylogin.txt \
-jar KVHOME/lib/kvstore.jar runadmin -port 5000 -host localhost
Logged in admin as krbuser
```

The file `mylogin.txt` should be a copy of the `client.security` file with additional properties settings for Kerberos authentication. The file would then contain content like this:

```
oracle.kv.auth.kerberos.keytab = kerberos/mykeytab
oracle.kv.auth.username = krbuser@EXAMPLE.COM
oracle.kv.auth.external.mechanism=kerberos
oracle.kv.auth.kerberos.services=
    node01:oraclenysql/node01.example.com@EXAMPLE.COM
oracle.kv.auth.kerberos.mutualAuth=false
```


In this case, Oracle NoSQL Database reads the keytab and logins to Kerberos without needing a password.

For more information on Kerberos security properties, see [Kerberos Security Properties](#).

Using Oracle NoSQL Database with Kerberos and Microsoft Active Directory (AD)

To use Oracle NoSQL Database with Kerberos and Microsoft Active Directory:

1. Update Kerberos Configuration `krb5.conf` with AD.

The *Microsoft Guide* (see [here](#)) details how to update the Kerberos configuration file on a Unix host in step 3: *Edit the file (/etc/krb5.conf) to refer to the Windows 2000 domain controller as the Kerberos KDC*. After changing the Kerberos configuration file, run `kinit` using a user account in AD to verify that the configuration is correct.

For example, suppose you have user account `krbuser08` on domain `TEST08` of AD, and the KDC realm name is `TEST08.LOCAL`:

```
$ kinit krbuser08@TEST08.LOCAL
Password for krbuser08@TEST08.LOCAL
```

After you provide the password, the command should return without error. An error indicates there are probably configuration issues. If the `kinit` command ran successfully, then run `klist` to check that the ticket cache contains the TGT of `krbuser08`.

```
$ klist
Ticket cache: FILE:/tmp/krb5cc_500
Default principal: krbuser08@TEST08.LOCAL
```

```
Valid starting    Expires          Service principal
08/12/16 11:45:03 08/12/16 21:45:11 krbtgt/
TEST08.LOCAL@TEST08.LOCAL
renew until 08/19/16 11:45:03
```

The `klist` shows the tickets in your ticket cache. Perform this step to check if the ticket-granting ticket has been properly obtained using the principal `krbuser08` described by "Default Principal." The "Service Principal" describes each ticket, the ticket-granting ticket has the primary `krbtgt`, and the instance name is the KDC realm name. Also check if the lifetime indicated by "Valid Starting" and "Expires" is correct.

2. Create service instance account and generate keytab on AD.

The *Microsoft Guide* (see <https://technet.microsoft.com/en-us/library/bb742433.aspx#EEAA>) details how to support a service running on a Unix system when using Active Directory. Follow the steps in this document to generate the service principal and keytab file for Oracle NoSQL Database. Note that you do not need to perform step 3 in the Microsoft Guide to merge keytab files if you plan to use same keytab file on every host.

For example, you can set the instance name to `nosql` and use this keytab on every node.

- Use the Active Directory Management tool to create a user account named `oraclenosql`.

In the user creation interface, you can choose which Kerberos encryption type this account can support. The user account may use Data Encryption Standard (DES) encryption as default. To enable other encryption types for this account, you need to manually configure in the "Properties" interface, or by using `ktpass` utility. Note that you need to disable the "User must change password at next logon" setting.

- Use `ktpass` tool on Windows Server to set up an identity mapping.

```
c:\ktpass -princ oraclenosql/nosql@TEST08.LOCAL
-mapuser oraclenosql -pass "*" -crypto DES-CBC-MD5 -ptype
KRB5_NT_PRINCIPAL -out c:\store.keytab
```

You may need to add `allow_weak_crypto = true` to the `krb5.conf` file on the Unix host, as well as `default_tkt_enctypes` and `default_tgs_enctypes`, if you use the DES decryption type. The default name of the keytab for Oracle NoSQL Database is `store.keytab` and the default service name of the service principal is `oraclenosql`.

- Copy the keytab file to your Unix hosts used by Oracle NoSQL Database.

Typically, you can use Secure Copy Protocol (`scp`) or PuTTY Secure Copy (PSCP) to transfer this file securely, or upload this file to an FTP server shared by Windows Server and Unix hosts. After creating the service principal and keytab, run `kinit` tests on your Unix hosts (described next) to confirm that they are configured properly.

3. Test if the user account can acquire service tickets for the service principal, and if the service keytab is generated correctly by running `kinit`:

- Test if the user account can acquire service tickets for service principal `oraclenosql`.

```
$ kinit -S oraclenosql/nosql@TEST08.LOCAL krbuser08@TEST08.LOCAL
Password for krbuser08@TEST08.LOCAL:
$ klist
Ticket cache: FILE:/tmp/krb5cc_500
Default principal: krbuser08@TEST08.LOCAL

Valid starting    Expires          Service principal
08/12/16 11:50:55 08/12/16 21:51:00 oraclenosql/
nosql@TEST08.LOCAL
                renew until 08/19/16 11:50:55
```

If the ticket cache does not contains a service ticket for `oraclenosql/nosql`, or if any errors are reported in the first command, then check if the account was created properly.

- Test if the service keytab was generated correctly by running `kinit oraclenosql`.

```
$ kinit -k -t store.keytab oraclenosql/nosql@TEST08.LOCAL
$ klist
Ticket cache: FILE:/tmp/krb5cc_500
Default principal: oraclenosql/nosql@TEST08.LOCAL

Valid starting    Expires          Service principal
08/12/16 11:51:44 08/12/16 21:51:45 krbtgt/
TEST08.LOCAL@TEST08.LOCAL
                renew until 08/19/16 11:51:44
```

As with the previous tests, any errors need to be fixed before attempting to configure Oracle NoSQL Database. Some versions of the `kinit` utility may need to explicitly specify `default_tkt_enctypes` and `default_tgs_enctypes` with the encryption type you configured for the service account `oraclenosql` in Active Directory, otherwise `kinit` cannot successfully obtain tickets from AD.

4. Begin to configure Oracle NoSQL Database.

Oracle NoSQL Database utilizes the Unix `kadmin` tool to help users create service principal and generate keytab file. However, AD does not have remote admin utility support, so it is necessary to skip this step in AD Kerberos environment.

For Oracle NoSQL Database releases prior to 4.2, you must specify `none` as the value for both the `-kadmin-path` and `-admin-principal` `makebootconfig` command line options.

```
java -Xmx64m -Xms64m \
-jar $KVHOME/lib/kvstore.jar makebootconfig -root kvroot \
-port 5000 \
-host node01.example.com -harange 5010,5020 \
-store-security configure -kspwd password \
-external-auth kerberos \
-kadmin-path none \
-admin-principal none \
-instance-name nosql
Adding principal oraclenosql/nosql
IO error encountered: Cannot run program "none": error=13,
Permission denied
Created files
  KVROOT/security/client.security
  KVROOT/security/client.trust
  KVROOT/security/security.xml
  KVROOT/security/store.wallet/cwallet.sso
  KVROOT/security/store.keys
  KVROOT/security/store.trust
```

The IO error can be ignored in this example, because we did not specify a correct `kadmin` path.

For Oracle NoSQL Database 4.2 and later releases, you only need to specify `none` as the value for the `-kadmin-path` flag:

```
java -Xmx64m -Xms64m \
-jar $KVHOME/lib/kvstore.jar makebootconfig -root kvroot \
-port 5000 \
-host node01.example.com -harange 5010,5020 \
-store-security configure -kspwd password \
-external-auth kerberos \
-kadmin-path none \
-instance-name nosql
```

The `kadmin` path was specified as `NONE`, so this example is not creating a keytab for the database server. The keytab must be generated and copied to the security configuration directory manually.

```
Created files
  KVROOT/security/client.security
  KVROOT/security/client.trust
  KVROOT/security/security.xml
  KVROOT/security/store.wallet/cwallet.sso
  KVROOT/security/store.keys
  KVROOT/security/store.trust
```

After the security directory is created, it is worth checking that the Kerberos parameters are configured as expected.

Check `security.xml` in `kvroot/security` and look for the following parameters:

- `krbInstanceName`
- `krbRealmName`

For Oracle NoSQL Database 4.2 and later releases, you can use the `securityconfig` tool to view the parameters:

```
java -Xmx64m -Xms64m \
-jar KVHOME/lib/kvstore.jar securityconfig \
config show -secdir kvroot/security
...
krbInstanceName=nosql
krbRealmName=TEST08.LOCAL
```

5. Manage service principals in a multi-node environment.

- In a multi-node environment, if you want to use a single service principal `oraclenosql/nosql` for all nodes, you can simply copy the contents of the first security directory to the other nodes. For example, the following commands assume that the different nodes are visible and accessible on the current node (`node01`):

```
cp -R node01/KVROOT/security node02/KVROOT/
cp -R node01/KVROOT/security node03/KVROOT/
```

You may need to use a remote copying command, like `scp`, to do the copying if the files for the different nodes are not visible on the current node.

Run `makebootconfig` on the other two nodes to enable Kerberos authentication.

```
java -Xmx64m -Xms64m \  
-jar KVHOME/lib/kvstore.jar makebootconfig \  
-root KVROOT -port 5000 \  
-host node02 -harange 5010,5020 \  
-store-security enable
```

```
java -Xmx64m -Xms64m \  
-jar KVHOME/lib/kvstore.jar makebootconfig \  
-root KVROOT -port 5000 \  
-host node03 -harange 5010,5020 \  
-store-security enable
```

 **Note:**

The service principal for `node02` and `node03` will be configured as `oracelnosql/nosql@TEST08.LOCAL`. Also they will use the same keytab file generated in step two.

- To set up individual service principals for each node, run step two to create a service account on AD and generate a new keytab for each node. For example, each node uses host name as instance name of service principal and their corresponding keytab files.

```
oracelnosql/node01@TEST08.LOCAL  
oracelnosql/node02@TEST08.LOCAL  
oracelnosql/node03@TEST08.LOCAL
```

Copy the security directory created on `node01` to other nodes. For example, the following commands assume that the different nodes are accessible using `ssh` from the current node (`host01`):

```
cp -R node01/KVROOT/security node02/KVROOT/  
cp -R node01/KVROOT/security node03/KVROOT/
```

 **Note:**

You may need to use a remote copying command, like `scp`, to copy the files for the different nodes if they are not visible on the current node.

Replace keytab files of node2 and node3 generated in step two with the one in their security configuration directory. For example:

```
cp store.keytab node02/KVROOT/security
cp store.keytab node03/KVROOT/security
```

 **Note:**

The name of all of the keytab files generated in step two is `store.keytab` by default. Make sure that you have given each node the proper keytab file. Use the `klist` tool to check keytab file on each node to make sure they contain the correct key of service principal for the node.

Run the `securityconfig` tool on node02 and node03 to modify instance name of security configuration:

```
security -> config update -secdir KVROOT/security \
-param krbInstanceName=node02
```

```
security -> config update -secdir KVROOT/security \
-param krbInstanceName=node03
```

Run `makebootconfig` on the other two nodes to enable Kerberos authentication.

```
java -Xmx64m -Xms64m \
-jar KVHOME/lib/kvstore.jar makebootconfig \
-root KVROOT -port 5000 \
-host node02 -harange 5010,5020 \
-store-security enable
```

```
java -Xmx64m -Xms64m \
-jar KVHOME/lib/kvstore.jar makebootconfig \
-root KVROOT -port 5000 \
-host node03 -harange 5010,5020 \
-store-security enable
```

6. Start the Storage Node Agent (SNA) on each node:

 **Note:**

Before starting the SNA, set the environment variable `MALLOC_ARENA_MAX` to 1. Setting `MALLOC_ARENA_MAX` to 1 ensures that the memory usage is restricted to the specified heap size.

```
nohup java -Xmx64m -Xms64m \  
-jar KVHOME/lib/kvstore.jar start -root KVROOT&
```

When a newly created store with a secure configuration is first started, there are no user definitions available against which to authenticate access. To reduce risk of unauthorized access, an admin will only allow you to connect to it from the host on which it is running. This security measure is not a complete safeguard against unauthorized access. It is important that you do not provide local access to machines running KVStore. In addition, perform the following steps to minimize the time period in which the admin might be accessible without full authentication. For more information on maintaining a secure store see [Guidelines for Securing the Configuration](#).

7. Start `runadmin` in security mode on the KVStore server host (node01). To do this:

```
java -Xmx64m -Xms64m \  
-jar KVHOME/lib/kvstore.jar \  
runadmin -port 5000 -host node01 \  
-security KVROOT/security/client.security  
Logged in admin as anonymous
```

8. Use the `configure -name` command to specify the name of the KVStore that you want to configure, and then complete store deployment. For more information, see the *Oracle NoSQL Database Administrator's Guide*:

```
kv-> configure -name mystore  
Store configured: mystore  
...
```

9. Create a user account on Microsoft Active Directory. In this example, `krbuser` is created on Active Directory.
10. Create mapping user in Oracle NoSQL Database. The username needs to match the full principal name in the KDC (includes realm name). In this case, user `krbuser` is defined:

```
kv-> execute 'CREATE USER "krbuser@TEST08.LOCAL"  
IDENTIFIED EXTERNALLY'
```

For more information on user creation and administration, see [User Management](#).

11. At this point, it is possible to connect to the store as the `krbuser`. To login, you can use credential cache, a keytab file or enter the principal password.
12. Set the Kerberos security properties, including the keytab file location, on each client by specifying them in a security file or through the `KVStoreConfig` class.

In this example, a security file (mylogin.txt) is used. To login, specify the file location by using the `oracle.kv.security` property. For example:

```
java -Xmx64m -Xms64m \  
-Doracle.kv.security=mylogin.txt \  
-jar KVHOME/lib/kvstore.jar runadmin -port 5000 -host localhost  
krbuser@TEST08.LOCAL's kerberos password:  
Logged in admin as krbuser@TEST08.LOCAL  
kv->
```

The file `mylogin.txt` should be a copy of the `client.security` file with additional properties settings for Kerberos authentication. The file would then contain content like this:

```
oracle.kv.auth.username = krbuser@TEST08.LOCAL  
oracle.kv.auth.external.mechanism=kerberos  
oracle.kv.auth.kerberos.services=node01:oraclenosql/  
nosql@TEST08.LOCAL  
oracle.kv.transport=ssl  
oracle.kv.ssl.trustStore=KVROOT/security/client.trust  
oracle.kv.ssl.protocols=TLSv1.2,TLSv1.1,TLSv1  
oracle.kv.ssl.hostnameVerifier=dnmatch(CN\=NoSQL)
```

In this example, the store nodes are using the single service principal `oraclenosql/nosql`. Without specifying keytab or credential cache, Admin CLI prompts for principal password.

For more information on Kerberos security properties, see [Kerberos Security Properties](#).

5

External Password Storage

Depending on the type of store deployment, there are two ways passwords can be externally stored. For Enterprise Edition (EE) deployments, Oracle Wallet is used. For Community Edition (CE) deployments, a simple read protected clear-text password file is used.

In the most basic mode of operation, external passwords are used only by the server to track the keystore password. User passwords, which are stored securely within the database, can also be supplied during client authentication.

When a password store is used as a component of a login file, the alias that is used for the password store type should be the username to which the password applies. For example, for a user named `root`, the password should be stored under the alias `root`.

When a password store is used as part of the server, the alias `keystore` is used. The user password store should be a completely different file than the one in the `security` directory located under `KVROOT`.

Oracle Wallet

The following commands provide functionality to manipulate Oracle wallet stores within the `securityconfig` tool. These commands are available in EE only. For more information on the `securityconfig` tool, see [Configuring Security with Securityconfig](#).

To create a new auto-login wallet, run the `wallet create` command:

```
wallet create
-dir <wallet directory>
```

Auto-login wallets store passwords in an obfuscated state. Access to the wallet is secured against reading by unauthorized users using the OS-level login.

To manipulate secrets (passwords), which are associated with a name (alias), run the `wallet secret` command:

```
wallet secret
-dir <wallet directory>
{-set | -delete} -alias <alias>
```

If the `-set` option is specified, the user is prompted for a new password for the specified alias and required to verify the new secret.

If the `-delete` option is specified, the secret is deleted from the store.

Special considerations should be taken if Oracle wallet is used and you are deploying your Oracle NoSQL Database. For more information, see [Guidelines for Deploying Secure Applications](#).

Password store file

The following commands are used to create and manipulate CE password store files within the `securityconfig` tool. CE password store files managed through this interface are never password protected. For more information on the `securityconfig` tool, see [Configuring Security with Securityconfig](#).

To create a new password store file, run the `pwdfile create` command:

```
pwdfile create  
-file <password store file>
```

To manipulate secrets (passwords), which are associated with a name (alias), run the `pwdfile secret` command:

```
pwdfile secret  
-file <password store file>  
{-set | -delete} -alias <alias>
```

If the user specifies the `-set` option, the user is prompted for a new password for the specified alias and required to verify the new password.

If the `-delete` option is specified, the alias is deleted from the store.

6

Security.xml Parameters

This chapter describes the parameters that can be set in the `security.xml` configuration file. This file is generated by `makebootconfig` or `securityconfig` and tells the Oracle NoSQL Database server how to apply security.

The `security.xml` file specifies parameters that primarily control network communications. It contains top-level parameters, plus nested transport parameters. A transport is a grouping of parameter settings that are specific to a particular type of network connection.

Note:

A subset of all the configuration options listed below related to SSL can be specified through Java system properties, security file properties, or through the `KVStoreConfig` API. For more information, see [SSL communication properties](#).

Top-level parameters

The following top-level parameters can be set to the `security.xml` file:

- `internalAuth`
Specifies how internal systems authenticate. This parameter must be set to `SSL`.
- `keystore`
Identifies the keystore file within the security directory. This parameter is normally set to `store.keys`.
- `keystoreType`
Identifies the type of keystore that the keystore property references. If not set, the `JKS` keystore type is used by default.
- `securityEnabled`
To enable security this parameter must be set to `true`.
- `certMode`
Specifies the key/certificate management model in use. This must be set to `"shared"`.
- `truststore`
Identifies the truststore file within the security directory. This is normally set to `store.trust`.
- `truststoreType`

Identifies the type of keystore that the truststore property references. If not set, the JKS keystore type is used by default.

- walletDir

Identifies a directory within the security directory that contains a wallet password store, which in turn holds the password for the keystore.

- passwordFile

Identifies a file within the security directory that contains a file password store, which in turn holds the password for the keystore.

- krbServiceName

Specifies the service name of the Oracle NoSQL Database Kerberos service principal.

- krbInstanceName

Specifies the service principal instance name.

- krbServiceKeytab

Specifies the keytab file name in the security directory that contains the KVStore server service principal and encrypted copy of principal's key.

- krbConf

Specifies the location of the Kerberos configuration file that contains the default realm and KDC information. If not specified, the default value is `/etc/krb5.conf`.

- krbRealmName

Specifies the realm name of service principal. If not specified, this value is acquired from the Kerberos configuration file.

- userExternalAuth

Specifies and enables the external mechanism used for authentication. Kerberos is supported. Set the value to `KERBEROS` to enable Kerberos authentication. To remove Kerberos authentication from a running store, set the value to `NONE`.

Transport parameters

There are three standard transport types:

- ha

Controls the communications between the data replication layer.

- client

Controls most RMI communication.

- internal

Controls the SSL internal authentication mechanism.

The following parameters can be set and associated to a transport type:

- transportType

This parameter should be set to `SSL`.

- serverKeyAlias

The keystore alias that identifies the keypair used by the server end of a connection.

- `clientKeyAlias`

The keystore alias that identifies the keypair used by the client end of a connection.

- `clientAuthRequired`

Should always be true for ha and internal transports and should be false for client transports.

- `clientIdentityAllowed`

When `clientAuthRequired` is true, this specifies what client identification check should be applied. This should be set to `dnmatch(XXX)` where XXX is the Distinguished name from the client certificate.

- `serverIdentityAllowed`

This specifies what server verification should be performed. This should normally be set to `dnmatch(XXX)` where XXX is the Distinguished name from the server certificate.

- `allowCipherSuites`

This is a comma-delimited list of SSL/TLS cipher suites that should be considered for use. For valid options, see the Java JSSE documentation corresponding to your JDK version. If not specified, the JDK default set of cipher suites is allowed.

- `allowProtocols`

This is a comma-delimited list of SSL/TLS protocols that should be considered for use. For valid options, see the Java JSSE documentation corresponding to your JDK version. If not specified, the JDK default set of protocols is used.

- `clientAllowCipherSuites`

See `allowCipherSuites` for a description of the format. This parameter sets the cipher suite requirements only for the initiating side of a connection. If set, it overrides any setting of `allowCipherSuites` for the connection initiator.

- `clientAllowProtocols`

See `allowProtocols` for a description of the format. This parameter sets the protocol requirements only for the initiating side of a connection. If set, it overrides any setting of `allowProtocols` for the connection initiator.

7

Encryption

Network data encryption provides data privacy so that unauthorized parties are unable to view plain text data during transmission across the network.

Oracle NoSQL Database uses SSL-based encryption to encrypt network traffic between applications and the server, command line-utilities and the server, as well as between server components.

Note:

JMX access requires the use of SSL.

SSL model

Oracle NoSQL Database uses a simple SSL key management strategy. A single, shared, RSA key is used to protect communication. In this shared key model, you must be sure that there is a master copy of the security directory and that it gets copied to each server. You should not run `makebootconfig` with the `-store-security configure` option on all servers. Most servers should have the `-store-security enable` option specified in their `makebootconfig` command.

The shared key has an associated self-signed certificate with a Subject Distinguished Name that is not server-specific. The automatically-created certificates are generated with the Distinguished Name: `CN=NoSQL`.

Each server component listens on SSL interfaces and presents the shared certificate to clients and other servers that connect to it, as proof of its authenticity. Each client and server component uses a Java truststore containing a copy of the shared certificate to validate the certificate presented by servers.

When accessing a NoSQL instance that is secured using SSL/TLS, you must specify at least the following information:

1. You must specify that the client will connect using SSL. This is done by setting the security property `oracle.kv.transport` to "ssl".
2. You must specify the Java truststore file that is used to validate the server certificate. This is done by setting the security property `oracle.kv.ssl.trustStore`.

For example, to start `runadmin` in security mode use the following command:

```
java -Xmx64m -Xms64m \  
-Doracle.kv.security=mylogin.txt \  
-jar KVHOME/lib/kvstore.jar runadmin
```

where the file `mylogin.txt` should be a copy of the `client.security` file with additional properties settings for authentication. The file would then contain content like this:

```
oracle.kv.auth.username=root
oracle.kv.auth.wallet.dir=login.wallet
oracle.kv.transport=ssl
oracle.kv.ssl.trustStore=client.trust
oracle.kv.ssl.protocols=TLSv1.2,TLSv1.1,TLSv1
oracle.kv.ssl.hostnameVerifier=dnmatch(CN\=NoSQL)
```

 **Note:**

If you fail to correctly specify the `oracle.kv.transport` property or the `truststore`, the client will fail to connect to the server.

SSL communication properties

Assuming that the NoSQL server is secured by SSL, client connections from Oracle NoSQL Database administrative clients will need to connect over SSL as well. This can be achieved by providing security properties for the connection.

For Oracle-provided command line tools, a security file must be specified. The security configuration process automatically generates a basic security file (`client.security`) that can be used to connect to the store. You may wish to make a copy of this and modify it to include additional configuration properties.

The minimal configuration needed to connect to a secure store includes setting the following properties:

- `oracle.kv.transport=ssl`
Directs KVStore clients and utilities to connect to the KVStore RMI registry via SSL.
- `oracle.kv.ssl.trustStore=<path-to-ssl-truststore>`
Names a copy of the truststore file generated by `makebootconfig` or `securityconfig` to enable validation of the KVStore server SSL certificate.

 **Note:**

You can use SSL to communicate an application with other SSL servers without using truststore-based certification validation.

In addition to the two properties listed above, the following properties are also supported for control of SSL communications:

- `oracle.kv.ssl.ciphersuites`
Specifies a comma-separated list of SSL cipher suites that should be allowed in communication with the server.
- `oracle.kv.ssl.protocols`

Specifies a comma-separated list of SSL protocols that should be allowed in communication with the server.

- `oracle.kv.ssl.trustStoreType`

Specifies the type of truststore being used. If not specified, the default type for the Java runtime is used.

 **Note:**

Applications may also set these security properties through API methods on `KVStoreConfig`.

Disk Encryption in a Linux Environment

If you are using the Linux operating system, you can secure your data by configuring disk encryption to encrypt whole disks (including removable media), partitions, software RAID volumes, logical volumes, as well as your NoSQL files.

`dm-crypt` is the Linux kernel's device mapper crypto target which provides transparent disk encryption subsystem in the Linux kernel using the kernel crypto API.

`Cryptsetup` is the command line tool to interface with `dm-crypt` for creating, accessing and managing encrypted devices. The most commonly used encryption is `Cryptsetup` for the Linux Unified Key Setup (LUKS) extension, which stores all of the needed setup information for `dm-crypt` on the disk itself and abstracts partition and key management in an attempt to improve ease of use.

This topic demonstrates how to convert a normal disk to a `dm-crypt` enabled disk and vice versa using the command-line interface.

Assume that you have the following disks in your Linux system. The `df -h` command displays the amount of available disk space for each disk.

```
$df -h
/dev/nvme0n1 2.9T 76G 2.7T 3% /ons/nvme0n1
/dev/nvme1n1 2.9T 76G 2.7T 3% /ons/nvme1n1
...
```

If you nominate disk `/dev/nvme0n1` to store databases, then you should encrypt this disk to secure the data within it.

Normal disk to a `dm-crypt` enabled disk:

Execute the following commands to convert a normal disk to a `dm-crypt` enabled disk:

1. Unmount the file system on the disk.

```
sudo umount -l /dev/nvme0n1
```

2. Generate the key to be used by `luksFormat`.

```
sudo dd if=/dev/urandom of=/home/opc/key0.key bs=1 count=4096
```


3. Initialize a LUKS partition and set the initial key.

```
sudo /usr/sbin/cryptsetup -q -s 512 \  
luksFormat /dev/nvme0n1 /home/opc/key0.key
```

4. Open the LUKS partition on disk/device and set up a mapping name.

```
sudo /usr/sbin/cryptsetup --allow-discards \  
luksOpen -d /home/opc/key0.key /dev/nvme0n1 dm-nvme0n1
```

5. Create an ext4 file system on the disk.

```
sudo /sbin/mkfs.ext4 /dev/mapper/dm-nvme0n1
```

6. Set parameters for the ext4 file system.

```
sudo /usr/sbin/tune2fs -e remount-ro /dev/mapper/dm-nvme0n1
```

7. Mount the file system to a specified directory.

```
sudo mount /dev/mapper/dm-nvme0n1 /ons/nvme0n1
```

dm-crypt enabled disk to normal disk:

If you want to convert the encrypted disk back to its normal state, execute the following steps:

1. Unmount the file system on the disk.

```
sudo umount -l /ons/nvme0n1
```

2. Remove luks mapping.

```
sudo /usr/sbin/cryptsetup luksClose /dev/mapper/dm-nvme0n1
```

3. Create an ext4 file system on the disk.

```
sudo /sbin/mkfs.ext4 /dev/nvme0n1
```

4. Mount the file system on a specified directory.

```
sudo mount /dev/nvme0n1 /ons/nvme0n1
```

Note:

If you convert a normal disk to a dm-crypt enabled disk or convert a dm-crypt enabled disk to a normal disk, you cannot bring the disk back to its previous state without losing its data. This is because the `mkfs.ext4` command will format the disk. Therefore, all the data stored in the disk will be lost.

8

Configuring Authentication

Authentication means verifying the identity of someone (a user, server, or other entity) who wants to use data, resources, or applications. Validating that identity establishes a trust relationship for further interactions. Authentication also enables accountability by making it possible to link access and actions to specific identities.

Within a secure Oracle NoSQL Database, access to the database and internal APIs is generally limited to authenticated users. When a secure Oracle NoSQL Database is first started, there are no users defined, and login to the administrative interface is allowed without authentication. However, no data access operations can be performed without user authentication.

User Management

You can create, modify, or remove users in the Oracle NoSQL Database through the Admin CLI, where the commands for manipulating users are exposed in SQL format through DDL API. You can also display information about a specific user account, as well as get a summary list of registered users. For more information, see the next sections describing each user management operation.

All user passwords should follow the password security policies. For more information see [Password Complexity Policies](#).

User Creation

To create a user, use the following command:

```
CREATE USER user_name
  (IDENTIFIED EXTERNALLY | IDENTIFIED BY password
  [PASSWORD EXPIRE | PASSWORD LIFETIME duration_time_unit])
  [ACCOUNT LOCK|UNLOCK]
  [ADMIN]
```

where:

- *user_name*

Assigns a name to identify a user. If you are creating a Kerberos user, the *user_name* must match the fully qualified principal name created in the Key Distribution Center (KDC) at your site. A username is an ID, just as a table name. The formal definition for each ID is as follows:

```
ALPHA (ALPHA | DIGIT | UNDER)* ;
```

Each ID must start with a letter (a-z, A-Z), followed by other letters, numerical values (0 - 9), and underscore (_) characters. There is no ID size limit for the number of characters it contains. An ID can consist of as many characters

as the memory required to accommodate its length. In practice, most sites have name length recommendations, but they are not checked or enforced by Oracle NoSQL Database.

Kerberos users must have different names from existing users, since you cannot change the authentication type of an existing user.

- IDENTIFIED EXTERNALLY

Indicates that Oracle NoSQL Database will use an external mechanism to authenticate the user. Currently, Oracle NoSQL Database supports only Kerberos as an external authentication service.

- IDENTIFIED BY "password"

Indicates that Oracle NoSQL Database authenticates the new user by the password you assign. The new user must log on using that password.

 **Note:**

You must specify a user password with quotation marks, for example, "password".

- PASSWORD EXPIRE

Specifies that the assigned password has already expired. With this setting the user is forced to change the given password as soon as they initially login. They must enter a password of their choice (which meets any site requirements) before accessing Oracle NoSQL Database.

- PASSWORD LIFETIME {INT duration_time_unit}

Indicates the password duration unit, which is required for using the assigned password. Enter the integer *time_unit* as follows:

```
time_unit : (SECONDS | MINUTES | HOURS | DAYS)
```

Using zero (0) with any time unit specifies that the password never expires. Entering a negative value causes an error. If you do not specify a PASSWORD LIFETIME *time_unit*, the lifetime from the global configuration is used. The default for this parameter is 180 days.

Following is a basic example of creating new user Kate, IDENTIFIED BY a password you assign to her, represented here as "password", with a PASSWORD LIFETIME duration specifying the integer unit of time as 30 DAYS. We do not recommend using this practice.

```
kv-> execute 'CREATE USER Kate IDENTIFIED BY \"password\"
  PASSWORD LIFETIME: 30 DAYS'
```

- ACCOUNT {LOCK | UNLOCK}

Specify ACCOUNT LOCK to lock a user's account to disable access. An Admin can use this option to remove access from a user, but retain the account. Then, as required, reinstate the user account specifying ACCOUNT UNLOCK.

- ADMIN Clause
Specify ADMIN to grant the user `sysadmin` role automatically.

 **Note:**

To create the first user in an Oracle NoSQL Database instance, you must start the Admin CLI as an anonymous user and use the `plan create-user` command. However, creating an initial user is only one of several steps for setting up a secure site, and is not described here. For further explanation, see, [Performing a Secure Oracle NoSQL Database Installation](#).

User Modification

To alter a user, use the following command:

```
ALTER USER user_name [IDENTIFIED BY password  
[RETAIN CURRENT PASSWORD]] [CLEAR RETAINED PASSWORD] [PASSWORD EXPIRE]  
[PASSWORD LIFETIME duration] [ACCOUNT UNLOCK|LOCK]
```

where:

- `user_name`
Name of user to alter. If specifying a Kerberos user, you can only alter the ACCOUNT clause options.
- IDENTIFIED Clause
Specify BY `password` to specify a new password for the user.
- RETAIN CURRENT PASSWORD
Used with BY `password` clause. If specified, causes the current password defined for the user to be remembered as a valid alternate password for a limited duration (24 hours by default), or until the password is explicitly cleared. Only one alternate password may be retained at a time. This option allows a password to be changed while an application is still running without affecting its operation.
- CLEAR RETAINED PASSWORD Clause
Erases the current alternate retained password.
- PASSWORD EXPIRE
Causes the user's password to expire immediately, then the user or the user having `sysadmin` role must change the password before attempting to log in to the database following the expiration.
- PASSWORD LIFETIME `duration`
Specify the duration that current password can be used for authentication.

`duration: [0-9]+ unit`

`unit: S | M | H | SECONDS | MINUTES | HOURS | DAYS`

Note that specifying 0 time unit for PASSWORD LIFETIME will make the password as "never expired".

- ACCOUNT Clause

Specify ACCOUNT LOCK to lock the user's account and disable access. Specify ACCOUNT UNLOCK to enable the user.

If you are updating the password of an existing user, the new password should comply with the password security policies. For more information see [Password Complexity Policies](#).

User Removal

```
DROP USER user_name [CASCADE]
```

Use the `DROP USER user_name` command to remove the specified user account (users cannot remove themselves), where *user_name* is the name of the user to drop.

If the user has existing tables, drop each of the tables first, and then drop the user. Alternatively, use the optional `CASCADE` option, which drops the user tables along with the user.

For example:

```
kv-> execute 'DROP USER Kate CASCADE'
```

Dropping a user occurs immediately. If another user was accessing tables that the user owned, the tables are no longer available for DML or DDL operations.

User Status

```
SHOW USER[S] [-name user_name] [-json | -json-v1]
```

Notice that the `S` on the `SHOW USERS` command is optional for the Admin CLI, except for DDL statements you call with `execute`. For DDL `"SHOW USER -name user_name"` shows information about a single user, and `SHOW USERS` displays information about all users.



Note:

The `SHOW USERS` command differs between the Admin CLI and the SQL CLI. This section describes the differences wherever possible. For example, the JSON options are not available for all the Admin CLI commands.

From the SQL CLI, add one of the `-json` flags to output the information in JSON.

From the Admin CLI, use the `SHOW USERS` without further qualification to list all existing users in the system. For example, here are three users in the system:

```
kv-> execute 'SHOW USERS'
user: id=u1 name=Ken
user: id=u2 name=Kate
user: id=u3 name=Alice
```

 **Note:**

The User ID values are incremented sequentially as you add each user. They are an internal mechanism for ensuring each user is unique.

From the Admin CLI, specify `SHOW USERS -name user_name` to view detailed information about a specific user:

```
kv-> execute 'SHOW USERS -name Kate'
id=u2 name=kate enabled=true auth-type=LOCAL retain-passwd=inactive
granted-role=[public]
```

From the SQL CLI, you can omit the `-name` flag:

```
sql-> show user Kate
```

From this CLI, entering `SHOW USER name` automatically interprets *name* as a *user_name*.

To specify a Kerberos user from the Admin CLI, the returned `auth-type` value is `EXTERNAL`:

```
kv-> execute 'SHOW USERS krbuser@EXAMPLE.COM'
user: id=u4 name=krbuser@EXAMPLE.COM enabled=true auth-type=EXTERNAL
retain-passwd=inactive granted-roles=[readwrite, public, sysadmin]
```

User Login

You can use either the `-username <user>` or the `-security <path to security file>` `runadmin` argument to login to the admin CLI:

- `-username <user>`
Specifies the username to log in as. This option is used in conjunction with security properties like `oracle.kv.transport`.
- `-security <path-to-security-file>`
Specifies the security file that contains property settings for the login. Relative filename references within the security file are interpreted relative to the location of the security properties file. For example, if a security properties file contains the setting `oracle.kv.ssl.truststore=client.trust` then, the `client.trust` file should

be in the same directory as the security properties file. If the file is named with an absolute path then it can be anywhere in the file system.

The following properties can be set in the file in addition to any of the SSL communication properties documented in the previous chapter:

```
oracle.kv.auth.username  
oracle.kv.auth.wallet.dir  
oracle.kv.auth.pwdfile.file
```

where the `oracle.kv.auth.wallet.dir` and `oracle.kv.auth.pwdfile.file` properties in this file indicate the location of an EE wallet directory or CE password store file, respectively.

 **Note:**

The `oracle.kv.security` Java system property can be used as an alternative mechanism for providing a security file path. Setting this system property is equivalent to adding the `-security` option to the command line for the Admin CLI. This property is supported by all tools as well as by the KVStore client library.

Password Management

The Admin can configure the lifetime of users' passwords for various units of time, or make them expire immediately. When a password expires, the user needs to renew it to log in Oracle NoSQL Database successfully. All user passwords should follow the password security policies. For more information see [Password Complexity Policies](#).

The two ways to manage passwords from expiring are as follows:

- Explicit Expiration

It makes the current password expire immediately as well as the retained password, if it exists. For this user, the user must change the password before attempting to log in the database.

For example:

```
kv-> execute 'CREATE USER John IDENTIFIED BY \"password\" PASSWORD  
EXPIRE'
```

- Password Lifetime Configuration

If a user logs into the database with John's account, the user must input the new password for John.

```
Logged in admin as John
```

```
The password of John has expired, it is required to change the  
password.
```

```
Enter the new password:
```

```
Re-enter the new password:
```

Password lifetime limits the duration that current password can be used for authentication.

 **Note:**

This configuration only works for the current password but not the retained one.

For example:

```
kv-> execute 'ALTER USER John PASSWORD LIFETIME 15 days'
```

In the example above, the current password for user John will expire after 15 days. After expiration, if the user John attempts to log into the database, the system displays a notification to change the password.

A retained password is used to allow a password to be changed while an application is still running without affecting its operation. It is only saved by the system for a limited duration (24 hours) and there is no way to specify individual duration for each user. For retained password, only explicit expiration is supported using the following command:

```
kv->execute 'ALTER USER John CLEAR RETAINED PASSWORD'
```

Sessions

When a user successfully logs in, it receives an identifier for a login session that allows a single login operation to be shared across Storage Nodes. That session has an initial lifetime associated with it, after which the session is no longer valid.

The server notifies the user with an error once the session is no longer valid. The application then needs to re-authenticate.

 **Note:**

The KVStoreFactory API provides a reauthentication handler, which allows the reauthentication to be completed transparently, except for the delay in reauthentication processing.

If allowed, the Oracle NoSQL Database client will transparently attempt to extend session lifetime. For best results, your application should include logic to deal with reauthentication, as operational issues could prevent it from succeeding initially. In this way, you can avoid the use of extended logic in your application to reacquire a valid session state.

You can configure the behavior regarding session management to meet the needs of the application and environment. To do this, you can modify the following parameters using the `plan change-parameters` command: `sessionTimeout`,

sessionExtendAllowed and loginCacheTimeout. For more information, see [Security Policy Modifications](#)

9

Configuring Authorization

Oracle NoSQL Database provides role-based authorization which enables the user to assign kvstore roles to user accounts to define accessible data and allow database administrative operations for each user account.

Users can acquire desired privileges by role-granting. The user-defined role feature allows the user to create new roles using kvstore built-in privileges, and add new privilege groups to users by assigning newly-defined roles to users. You can grant users multiple roles.

For more information, see:

- [Privileges](#)
- [Roles](#)
- [Managing Roles, Privileges and Users](#)

Privileges

A privilege is an approval to perform an operation on one or more Oracle NoSQL Database objects. In Oracle NoSQL Database, all privileges fall into the two general categories:

- System privileges
This gives a user the ability to perform a particular action, or to perform an action on any data objects of a particular type.
- Object privileges
This gives a user the ability to perform a particular action on a specific object, such as a table.

System Privileges

Oracle NoSQL Database provides the following system privileges, covering both data access and administrative operations:

- SYSDBA
Can perform Oracle NoSQL Database management, including table create/drop/evolve and index create/drop.
- SYSVIEW
Can view/show system information, configuration and metadata.
- DBVIEW
Can query data object information. The object is defined as a resource in Oracle NoSQL Database, subject to access control. At present, you can have this privilege to query the table and index information.

- `USRVIEW`
Can query users' own information, like their own user information, the status of commands they issued.
- `SYSOPER`
Can perform Oracle NoSQL Database system configuration, topology management, user privilege/role management, diagnostic and maintenance operations. Allows a role to perform cancel, execute, interrupt, and wait on any plan.
- `WRITE_SYSTEM_TABLE`
Can make modifications to system tables if the necessary read and write privileges are granted for the table. The multi-region agent is the intended user of this privilege. Typically, normal users should not modify system tables.
- `READ_ANY`
Can get/iterate keys and values in the entire store, including any tables.
- `WRITE_ANY`
Can put/delete values in the entire store, including any tables.
- `CREATE_ANY_TABLE`
Can create any table in the store.
- `DROP_ANY_TABLE`
Can drop any table from the store.
- `EVOLVE_ANY_TABLE`
Can evolve any table in the store.
- `CREATE_ANY_INDEX`
Can create any index on any table in the store.
- `DROP_ANY_INDEX`
Can drop any index from any table in the store.
- `READ_ANY_TABLE`
Can read from any table in the store.
- `DELETE_ANY_TABLE`
Can delete data from any table in the store.
- `INSERT_ANY_TABLE`
Can insert and update data in any table in the store.

Object Privileges

The object privileges defined in Oracle NoSQL Database are:

- `READ_TABLE`
Can read from a specific table.
- `DELETE_TABLE`

Can delete data from a specific table.

- `INSERT_TABLE`

Can insert and update data to a specific table.

- `EVOLVE_TABLE`

Can evolve a specific table.

- `CREATE_INDEX`

Can create indexes on a specific table.

- `DROP_INDEX`

Can drop indexes from a specific table.

For more information on the privileges required by the user to access specific KVStore APIs as well as CLI commands, see [KVStore Required Privileges](#).

Table Ownership

When you are using a secure store, tables are owned by the user that created them. A table's owner has by default full privileges to the table. That is, the owner has all the table object privileges.

Note:

For tables created in a non-secured store, or tables created prior to the 3.3 release, the table's owner is null.

Once a table is created, its owner cannot be changed. If a table is dropped and then recreated, all previously granted table privileges must be granted again.

Parent and child tables are required to have the same owner. However, table privileges are not automatically granted to the table's children. For example, if `READ_TABLE` is granted to table `myTable`, then that privilege is not automatically granted to any of that table's children. To grant `READ_TABLE` to the child tables, you must individually grant the privilege to each child table in turn.

A table's owner can grant or revoke all table privileges to or from other roles. To do this, use the `GRANT` DDL statement. (See [Grant Roles or Privileges](#) for details.) To make a user other than the owner be able to read/insert/delete a specific table, two conditions must be met:

1. The user has the read/insert/delete privilege for the table in question; and
2. The user has the same privilege, or read privilege, for all parent tables of that table.

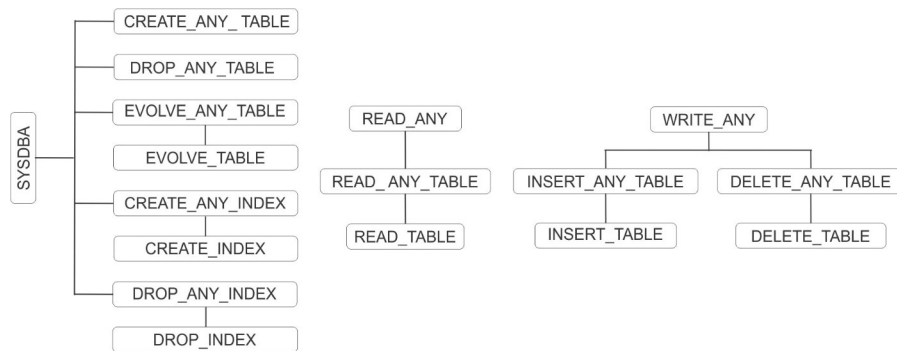
For example, for table `myTable` and its child `myTable.child1`, a non-owner user can only insert data to `myTable.child1` when she has insert privilege (or better) on `myTable.child1`, and read and/or insert privilege on `myTable`.

Privilege Hierarchy

In Oracle NoSQL Database, there is a relationship between parts of existing privileges, called 'implications'. Implication means that a privilege may be a superset of some other privileges.

For example, Privilege A implies (\Rightarrow) B means that privilege A has all the permissions defined in privilege B.

The following illustration depicts all implication relationship among Oracle NoSQL Database privileges:



Note:

All implications are transitive, that is, if $A \Rightarrow B$ and $B \Rightarrow C$, then $A \Rightarrow C$.

Roles

In Oracle NoSQL Database a role is a set of privileges that defines the authority and responsibility of users assigned to the role. Oracle NoSQL Database provides a set of system built-in roles. Users can create new roles to group together privileges or other roles.

System Built-in Roles

The following system roles are predefined:

- `readonly`
Contains the `READ_ANY` privilege. Users with this role can read all data in the KVStore.
- `writeonly`
Contains the `WRITE_ANY` privilege. Users with this role can write to the entire KVStore.
- `readwrite`

Contains both the `READ_ANY` and `WRITE_ANY` privileges. Users with this role can both read and write the entire KVStore.

- `dbadmin`

Contains the `SYSDBA` privilege. Users with this role can execute data definition operations, including table and index administration.

- `sysadmin`

Contains the `SYSDBA`, `SYSVIEW` and `SYSOPER` privileges. Users with this role can execute the same operations as `dbadmin`, and have the ability of executing all Oracle NoSQL Database management tasks. A user created with the `-admin` option is granted with the `sysadmin` role besides the default `public` role.

- `writesystable`

Contains the `WRITE_SYSTEM_TABLE` privilege. Users with this role can modify system tables if they have the necessary read and write privileges. The multi-region table agent is the intended user of this role. Typically, normal users should not modify system tables.

- `public`

Contains the `USRVIEW` and `DBVIEW` privileges. A default role for all Oracle NoSQL Database users, which cannot be revoked. Users with this role can login to database, view and change their own user information, as well as check and operate the plans owned by them. Users with this role can also obtain a read-only view of the data object information, for example, table names, indices, and others.

User-Defined Roles

Oracle NoSQL Database allows the user to create new roles using `kvstore` built-in privileges, and add new privilege groups to users by assigning defined roles to the users. To perform role and privilege granting and revocation operations, the user must have a role having `SYSOPER` privilege, for example, the `sysadmin` role.

To manage user-defined roles, use the following commands from the Admin CLI:

```
kv-> execute 'CREATE ROLE role_name'
```

```
kv-> execute 'DROP ROLE role_name'
```

Note:

The names of user-defined roles are case-insensitive, and are not the same as any existing privilege names or names of system built-in roles. Also, a reserved keyword cannot be used as a role name. For a list of reserved keywords, see *Reserved Words* in the *SQL Reference Guide*.

The following example shows how to create user-defined roles and grant them to, or revoke them from users:

Create two users with the following commands:

```
kv-> execute 'CREATE USER Ken IDENTIFIED BY \"password\" '
```

```
kv-> execute 'CREATE USER Kate IDENTIFIED BY \"password\" '
```

Now, create two roles – manager with the `write_any` privilege and `employee` with the `read_any` privilege:

```
kv-> execute 'CREATE ROLE manager'  
kv-> execute 'GRANT WRITE_ANY TO manager'  
kv-> execute 'CREATE ROLE employee'  
kv-> execute 'GRANT READ_ANY TO employee'
```

The next example shows granting role `employee` to role `manager` (sub-role of `manager`), and then grants role `manager` to user `Kate`. User `Kate` then has both `manager` and `employee` role, with both of their privileges, to `write_any` data to the store, and `read_any` data.

```
kv-> execute 'GRANT employee TO ROLE manager'  
kv-> execute 'GRANT manager TO USER Kate'
```

Use the following command to see the user's role status:

```
kv-> execute 'SHOW USER Kate'  
id=u2 name=Kate enabled=true type=LOCAL retain-passwd=inactive  
granted-role=[public, manager]
```

Once the user drops a role, this role and its sub-roles will be revoked automatically from any users and user-defined roles having this role. However, all of its sub-roles will not be removed from the Oracle NoSQL Database.

For example:

```
kv-> execute 'DROP ROLE manager'  
kv->execute 'SHOW USERS Kate'  
id=u2 name=Kate enabled=true type=LOCAL retain-passwd=inactive  
granted-role=[public]
```

Now, the `show roles` command will list the roles in the system without the `'manager'` role.

If the administrator decides to drop the `manager` role, the system revokes the `manager` role from user `Kate` automatically, as well as the `employee` role. In the above example, `Kate` cannot perform any read or write operations.

 **Note:**

Granting circular roles is not allowed. For example, role `manager` cannot be granted to role `employee` if role `employee` has previously been granted to role `manager`.

Managing Roles, Privileges and Users

Oracle NoSQL Database provides a set of security operations, including commands to create, drop, show, grant or revoke roles to or from users, and to grant or revoke privileges to or from roles. All these statements can be executed through the SQL CLI or the Admin CLI `execute` command, or the API of `KVStore.execute()` or `KVStore.executeSync()`.

Role Creation

```
CREATE ROLE role_name
```

Where, `role_name` is the case insensitive name of the role.

For example,

```
kv-> execute 'CREATE ROLE administrator'  
Statement completed successfully
```

Role Removal

```
DROP ROLE role_name
```

Where, `role_name` is the name of the role, which is case insensitive.

For example,

```
kv-> execute 'DROP ROLE administrator'  
Statement completed successfully
```

Role Status

```
SHOW [AS JSON] ROLES | ROLE role_name
```

Where, `role_name` is the name of the role.

List all available role names by running 'SHOW ROLES', or view the detailed information of a role if the role name is specified.

For example,

```
kv->execute 'SHOW ROLES'
role:name=dbadmin
role:name=public
role:name=readonly
role:name=readwrite
role:name=sysadmin
role:name=writeonly
```

The detailed information of a role can be viewed by specifying the role name:

```
kv->execute 'SHOW ROLE dbadmin'
name=dbadmin assignable=true readonly=true
granted-privileges=[SYSDBA, DBVIEW]
```



Note:

Assignable indicates whether this role can be explicitly granted to or revoked from a user.

Object privileges will appear in the form of PRIVILEGE(obj). For example, privilege of READ_TABLE on table 'emp' will appear as:

```
kv->execute 'CREATE ROLE emptablereader'
kv->execute 'GRANT READ_TABLE ON emp TO emptablereader'
kv->execute 'SHOW ROLE emptablereader'
name=emptablereader assignable=true readonly=false
granted-privileges=[READ_TABLE(emp)]
```

Grant Roles or Privileges

```
GRANT { grant_roles | grant_system_privileges
| grant_object_privileges }
grant_roles ::= role [, role]... TO { USER user | ROLE role }
grant_system_privileges ::=
{system_privilege | ALL PRIVILEGES}
[, {system_privilege | ALL PRIVILEGES}]...
TO role
grant_object_privileges ::=
{object_privileges | ALL [PRIVILEGES]}
[, {object_privileges | ALL [PRIVILEGES]}]...
ON object TO role
```

where:

- role
The role that is granted.

- `user`
The user to which the privileges are granted.
- `system_privileges`
The system privileges that are granted.
- `object_privileges`
The object privileges that are granted.
- `object`
The object on which the privilege is granted. Currently only table privileges are supported.
- `ALL PRIVILEGES`
Grants all of the system privileges. This is a shortcut for specifying all system privileges.
- `ALL [PRIVILEGES]`
Grants all object privileges defined for the object. The keyword `PRIVILEGES` is provided for semantic clarity and is optional.

For example, you can grant a role with fewer privileges to one with more privileges, such as `employee` to role `manager`:

```
kv-> execute 'GRANT EMPLOYEE TO ROLE manager'  
kv-> execute 'GRANT MANAGER TO USER Kate'  
Statement completed successfully
```

If you try to grant the same role in the other direction, an error occurs:

```
kv-> execute 'GRANT employee to ROLE manager'
```

You will receive an error of "Could not recursively grant role `employee` to role `manager`" because this would lead to a cyclic definition of role `manager`.

The user can now add new privileges to their defined role. For example:

```
kv-> execute 'GRANT READ_ANY TO Kate'
```

For example, to grant read permission on table `T1` to `Kate`:

```
kv-> execute 'GRANT READ_TABLE on T1 TO Kate'
```

See also notes on granting table privileges in [Table Ownership](#).

Revoke Roles or Privileges

```
REVOKE { revoke_roles | revoke_system_privileges  
| revoke_object_privileges}  
revoke_roles ::= role [, role]... FROM { USER user | ROLE role }
```

```
revoke_system_privileges ::=
{ system_privilege | ALL PRIVILEGES }
[, {system_privilege | ALL PRIVILEGES}]...
FROM role
revoke_object_privileges ::=
{ object_privileges| ALL [PRIVILEGES] }
[, { object_privileges | ALL [PRIVILEGES] }]...
ON object FROM role
```

where:

- role
The role to revoke.
- user
The user from which the privileges are revoked.
- system_privileges
The system privileges to revoke.
- object_privileges
The object privileges to revoke.
- object
The table from which the privileges are revoked. Currently, the only objects supported are tables.
- ALL PRIVILEGES
Revokes all of the system privileges that have been granted to the revokee.
- ALL [PRIVILEGES]
Revokes all object privileges defined on the object from the revokee. The keyword PRIVILEGES is provided for semantic clarity and is optional.

For example, to revoke role 'employee' from role 'manager':

```
kv-> execute 'REVOKE employee FROM ROLE manager'
Statement completed successfully
```

To revoke the role 'manager' from user 'Kate':

```
kv-> execute 'REVOKE manager FROM USER Kate'
Statement completed successfully
```

10

Security Policies

The following default policies in Oracle NoSQL Database may be used to tailor system behavior to meet your security requirements:

- Login sessions have a limited duration of validity. After that duration has passed, the session needs re-authentication.
- Session login errors are tracked at the component level. Access to an account for a single client host is temporarily disabled if too many failed logins occur at that component within a configurable time duration.

Note:

Both of these behaviors can be customized by modifying the values of their respective security parameters. For more information, see the following section.

Security Policy Modifications

You can use the `plan change-parameters` command in order to change a security policy in the system:

```
plan change-parameters -security <id>...
```

Security parameters are applied implicitly and uniformly across all SNs, RNs and Admins.

The following security parameters can be set:

- `sessionTimeout=<Long TimeUnit>`
Specifies the length of time for which a login session is valid, unless extended. The default value is 24 hours.
- `sessionExtendAllowed=<Boolean>`
Indicates whether session extensions should be granted. Default value is true.
- `accountErrorLockoutThresholdInterval=<Long TimeUnit>`
Specifies the time period over which login error counts are tracked for account lockout monitoring. The default value is 10 minutes.
- `accountErrorLockoutThresholdCount=<Integer>`
Number of invalid login attempts for a user account from a particular host address over the tracking period needed to trigger an automatic account lockout for a host. The default value is 10 attempts.
- `accountErrorLockoutTimeout=<Long TimeUnit>`

Time duration for which an account will be locked out once a lockout has been triggered. The default value is 30 minutes.

- loginCacheTimeout=<Long TimeUnit>

Time duration for which KVStore components cache login information locally to avoid the need to query other servers for login validation on every request. The default value is 5 minutes.

11

Audit Logging

Oracle NoSQL Database monitors and records security sensitive activities. These log messages are available through the SN-local log files and the store-wide logging view. High risky security activities are also visible by using the `show events` command.

Security Log Messages

For ease of grepping and analysis, the auditing log message uses `KVAuditInfo` as a prefix. For example:

```
# General audit logging:
<Timestamp>: KVAuditInfo[user: <user_name>,
clienthost: <client_host>, operation:
<operation_description>, status: <SUCCESS/FORBIDDEN>,
reason: <failure_reason>]
```

```
# General audit logging:
# Particular logging for successful execution of plan:
<Timestamp>: KVAuditInfo[<plan_name>, owned by <plan_owner>,
executed by <plan_executor> from <client_host>,
state=<end state of plan execution>]
```

To distinguish security related messages from standard log messages, the following two security related logging levels are introduced:

- `SEC_WARNING`
Logs unauthenticated login, unauthorized read/write data access and unauthorized execution of CLI commands. Unauthenticated login does not log the reasons of failure.
- `SEC_INFO`
Logs the success of a user login and the successful execution of plans that require `dbadmin` or `sysadmin` role related privileges.

12

Keeping Oracle NoSQL Database Secure

This chapter provides a set of guidelines to keep your Oracle NoSQL Database secure. To maximize the security features offered by Oracle NoSQL Database, it is imperative that the database itself be well protected.

Security guidelines provide advice about how to securely configure Oracle NoSQL Database by recommending security practices for operational database deployments.

Guidelines for Securing the Configuration

Follow these guidelines to keep the security configuration secure:

- The initial security configuration should be generated on a host that is not intended for KVStore operational use, using the `securityconfig create config` command.
- Storage Nodes should be deployed by running `makebootconfig` with the `-store-security enable` argument. The configured security directory from the reference host should be copied to the new Storage Node KVROOT using a secure copy mechanism prior to starting the store.
- The security configuration should be kept in a protected location for future use.
- Updates to the security configuration should be performed on the configuration host and copied to the operational Storage Node hosts using a secure copy mechanism.
- After the first user is configured but before allowing applications to use the store, you may wish to restart all SNA processes on hosts running Admin processes and then use the Admin CLI `show users` command to ensure that there is only the single user definition that is expected. This step validates that no other user creation occurred during the period when administrative login was not required.

Guidelines for Deploying Secure Applications

Follow these guidelines when deploying your Oracle NoSQL Database and if the properties include `oracle.kv.auth.wallet.dir` in order to use Oracle wallet to hold a user password:

- Include the `kvstore-ee.jar` file in the application classpath.
- The `kvstore-ee.jar`, `oraclepki.jar`, `osdt_cert.jar`, `osdt_core.jar` files should all be made available on the application machine.

Note:

`kvstore-ee` references the other files, so they do not need to be included in the classpath explicitly.

Guidelines for Securing the SSL protocol

Follow these guidelines to keep the SSL protocol secure:

- When configuring SSL communication for your store, you should consider both performance and security.
- For a more secure store you should opt for higher security where possible.
- The Oracle JDK 7 supports TLSv1.2 as an SSL protocol level.

Guidelines for using JMX securely

Follow these guidelines to securely use your Java Management Extensions (JMX) agent:

- If you enable JMX for a secure store, your JMX monitoring application must access the store using SSL.
- You should consult the configuration details for the JMX product you wish to use. In this case, you can use `jconsole` with a secure store by running the following command:

```
jconsole -J-Djavax.net.ssl.trustStore=/home/nosql/client.trust \  
node01:5000
```

where `node01` is the registry host to be monitored and `5000` is the registry port configured for the Storage Node.

Guidelines for Updating Keystore Passwords

Follow these steps to update the keystore passwords:

1. In the security directory on the configuration host run the `keytool` command. You can provide the new passwords through the `keytool` interactive prompt or using arguments. For example, to set the new key and store passwords for `store.keys` as well as the new store password for `store.trust` using the `keytool` prompt:

 **Note:**

The 3 new passwords must be equal, otherwise the store cannot be successfully restarted.

```
keytool -keypasswd -keystore store.keys -alias shared  
Enter keystore password:  
New key password for <shared>:  
Re-enter new key password for <shared>:
```

```
keytool -storepasswd -keystore store.keys  
Enter keystore password:
```



```
New keystore password:  
Re-enter new keystore password:
```

```
keytool -storepasswd -keystore store.trust  
Enter keystore password:  
New keystore password:  
Re-enter new keystore password:
```

You could also run the `keytool` command and set the new passwords using arguments instead. For example:

```
keytool -keypasswd -keystore store.keys \  
-alias shared -keypass <old_pwd> -new <new_pwd> -storepass  
<old_pwd>
```

```
keytool -storepasswd -keystore store.keys \  
-storepass <old_pwd> -new <new_pwd>
```

```
keytool -storepasswd -keystore store.trust \  
-storepass <old_pwd> -new <new_pwd>
```

2. If using a Password File store, skip ahead to the next step. To update the keystore password for wallets, use the following command:

```
java -Xmx64m -Xms64m \  
-jar <KVHOME>/lib/kvstore.jar securityconfig \  
wallet secret -directory store.wallet -set -alias keystore
```

Securityconfig will prompt for the new password. The new password should match the new one provided earlier to the `keytool` command.

3. If using Password File stores instead of wallets, use the following command to update the keystore password:

```
java -Xmx64m -Xms64m \  
-jar <KVHOME>/lib/kvstore.jar securityconfig \  
pwdfile secret -file store.pwd -set -alias keystore
```

Securityconfig will prompt for the new password. The new password should match the new one provided earlier to the `keytool` command.

4. Copy the updated `store.keys`, `store.trust` file, and either `store.pwd` or the contents of `store.wallet` to the security directory on each host and restart the Storage Node using the following commands:

```
java -Xmx64m -Xms64m \  
-jar <KVHOME>/lib/kvstore.jar stop -root KVROOT
```

 **Note:**

Before starting the SNA, set the environment variable `MALLOC_ARENA_MAX` to 1. Setting `MALLOC_ARENA_MAX` to 1 ensures that the memory usage is restricted to the specified heap size.

```
java -Xmx64m -Xms64m \  
-jar <KVHOME>/lib/kvstore.jar start -root KVROOT&
```

Guidelines for Updating Kerberos Passwords

The password of Kerberos principal should be periodically changed. To do this, you can either manually specify it by using `kadmin.local` or automatically randomize principal keys by using the `config renew-keytab` command of the `securityconfig` tool.

The syntax for this command is:

```
config renew-keytab -root <secroot> [-secdir <security dir>]  
[-keysalt <enc:salt[,enc:salt,..]>]  
[-kadmin-path <kadmin utility path>]  
[-instance-name <database instance name>]  
[-admin-principal <kerberos admin principal name>]  
[-kadmin-keytab <keytab file> ]  
[-kadmin-ccache <credential cache file>]
```

where:

- `-keysalt`
Sets the list of encryption types and salt types to be used for any new keys created. The default value is `des3-cbc-shal:normal,aes128-cts-hmac-shal-96:normal,arcfour-hmac:normal`.
- `-kadmin-path`
Indicates the absolute path of Kerberos `kadmin` utility. The default value is `/usr/kerberos/sbin/kadmin`.
- `-instance-name`
Specifies the service principal name. The default value is the fully qualified domain name (FQDN) of the Storage Node where Oracle NoSQL Database is running.
- `-admin-principal`
Specifies the principal used to login to the Kerberos admin interface. This is required while using `kadmin` keytab or password to connect to the admin interface.
- `-kadmin-keytab`
Specifies the location of a Kerberos keytab file that stores Kerberos admin user principals and encrypted keys. The security configuration tool will use the specified keytab file to login to the Kerberos admin interface.

You need to specify the `-admin-principal` flag when using `keytab` to login to the Kerberos admin, otherwise the correct admin principal will not be recognized. This flag cannot be specified in conjunction with the `-kadmin-ccache` flag.

- `-kadmin-ccache`

Specifies the complete path name to the Kerberos credentials cache file that should contain a service ticket for the `kadmin/ADMINHOST`. `ADMINHOST` is the fully-qualified hostname of the admin server or `kadmin/admin` service.

If not specified, the user is prompted to enter the password for principal while logging to the Kerberos admin interface. This flag cannot be specified in conjunction with the `-kadmin-keytab` flag.

To manually update the Kerberos principal password instead, you should follow these steps:

1. Use `kadmin.local` utility to change the service principal password:

```
kadmin.local: cpw nosql/myhost
Enter password for principal nosql/myhost@EXAMPLE.COM
Re-enter password for principal nosql/myhost@EXAMPLE.COM
```

2. Regenerate the keytab file for Oracle NoSQL Database service principal.

```
kadmin.local: ktadd -norandkey -k new.keytab
```

3. Copy the new keytab file for Oracle NoSQL Database service principal to each Storage Node. For example:

```
scp new.keytab kvuser@mystore:KVROOT/security/store.keytab
...
```

4. Validate the keytab file by comparing the key version number (kvno):

```
kadmin.local:getprinc nosql/myhost@EXAMPLE.COM
Principal: nosql/myhost@EXAMPLE.COM
Expiration date: [never]
Last password change: Thu Jun 04 03:16:38 UTC 2015
Password expiration date: [none]
Maximum ticket life: 1 day 00:00:00
Maximum renewable life: 0 days 00:00:00
Last modified: Thu Jun 04 03:16:38 UTC 2015
(root/admin@ORACLE.EXAMPLE.COM)
Last successful authentication: [never]
Last failed authentication: [never]
Failed password attempts: 0
Number of keys: 4
Key: vno 12, aes256-cts-hmac-sha1-96
Key: vno 12, aes128-cts-hmac-sha1-96
Key: vno 12, des3-cbc-sha1
Key: vno 12, arcfour-hmac
MKey: vno 1
Attributes:
Policy: [none]
Kadmin.local: quit
# klist -k new.keytab
```

```
KVNO Principal
-----
12 nosql/myhost@EXAMPLE.COM
12 nosql/myhost@EXAMPLE.COM
12 nosql/myhost@EXAMPLE.COM
12 nosql/myhost@EXAMPLE.COM
```

Client side user principals require similar password rotation. Keytab or credential cache used to login to the database should be renewed. If `kinit` tool is used to create a credential cache, you should run `kdestroy` to clear cached tickets and re-run `kinit` to generate a new credential cache.

For example:

```
# kdestroy -c /tmp/krb5ccache
# kinit -c /tmp/krb5ccache
```

Guidelines for Updating SSL Keys and Certificates

If the certificate that the server uses is going to expire, or is no longer valid, you may need to replace the SSL key and certificate. This section describes the procedure to complete this task.

These directions describe creating a self-signed certificate, and an associated key, which is the default for Oracle NoSQL Database. Alternatively, you can use an external certificate, as described in [Guidelines for Configuring External Certificates for an Existing Default Secure Installation](#).

Updating the SSL key/certificate involves several steps:

1. Create a new key/certificate pair on a storage node.
2. Copy the new key/certificate pair to every storage node and merge the new certificate into the existing trust store files: `client.trust` and `store.trust`.
3. Restart each storage node sequentially.
4. Copy the `client.trust` with the merged entries to each of the clients.
5. Copy the `store.keys` that has the merged entries to each of the storage nodes, and restart each storage node sequentially, a second time.
6. Remove the old certificate in `store.trust` in all the storage nodes.
7. Verify that only the new certificate is in use.

Complete these steps to update the SSL keys and certificates on a running store. Oracle NoSQL Database can remain operational throughout the entire process.

Note:

The Oracle NoSQL Database development environment used for this set of tasks has one (1) shard, with a replication factor of three (RF=3).

Before starting this procedure, create a temporary directory in which to store the key. In the sample output for Step 1, you'll see the temporary directory created as `newKey`, created under `/Users/my_name/tmp/kvroot/`:

```
cd /Users/my_name/tmp/kvroot/  
mkdir newKey
```

For more information on security configuration files, see [Security Configuration](#).

Create a New SSL Key Certificate

1. From your NoSQL development environment on one of the SN nodes, SN1, run the `securityconfig` utility to create a new key in the new directory, `newKey`. The new configuration needs to specify the same keystore password as your current configuration. If you do not specify a password with the `-kspwd` option, the utility prompts you to set a password.

```
cd /Users/my_name/tmp/kvroot/  
mkdir newKey  
java -jar $KVHOME/lib/kvstore.jar securityconfig config create -  
root /Users/my_name/tmp/kvroot/newKey  
-kspwd 123456  
cd newKey  
~/tmp/kvroot/newKey=> ls -R  
security  
./security:  
client.security security.xml store.trust temp.cert client.trust  
store.keys store.wallet  
./security/store.wallet:  
cwallet.sso  
(~/tmp/kvroot/newKey)=>
```

2. On the SN node on which you created the new key, merge the truststore entries using the `config merge-trust` command, as follows. Then, continue from your NoSQL development environment:

```
java -jar <KVHOME>/lib/kvstore.jar securityconfig \  
config merge-trust -root <standard config dir> \  
-source-root <new config dir>  
  
java -jar $KVHOME/lib/kvstore.jar securityconfig config merge-trust  
-root $KVROOT1 -source-root /Users/my_name/tmp/kvroot/newKey  
cd $KVROOT1/security (~/tmp/kvroot/kvroot1/security)=> keytool -  
list -keystore store.trust  
Enter keystore password: <No password was needed for this Test, so  
we just pressed Enter>  
***** WARNING WARNING WARNING *****  
* The integrity of the information stored in your keystore *  
* has NOT been verified! In order to verify its integrity, *  
* you must provide your keystore password. *  
***** WARNING WARNING WARNING *****  
Keystore type: JKS
```

```
Keystore provider: SUN
Your keystore contains 2 entries
mykey_2, Feb 6, 2018, trustedCertEntry,
Certificate fingerprint (SHA1):
A3:75:F2:97:25:20:F9:AD:52:61:71:8F:6B:7E:B1:BB:E8:54:D1:7A
mykey, Feb 6, 2018, trustedCertEntry,
Certificate fingerprint (SHA1):
89:71:8C:F1:6D:7E:25:D7:AD:C4:7E:23:8C:09:0D:AC:CE:AE:3F:67
```

 **Note:**

In a multiple Storage Node deployment, you must copy the new configuration (the security directory and its contents) to each Storage Node host's new configuration directory and run `merge-trust` as described on each host.

3. To update the SSL key, merge the new key (on SN1) into all SNs as follows:

```
(~/tmp/kvroot/kvroot1/security)=> java -jar $KVHOME/lib/kvstore.jar
securityconfig
config merge-trust -root $KVROOT2 -source-root /Users/my_name/tmp/
kvroot/newKey
Configuration updated.
```

```
(~/tmp/kvroot/kvroot1/security)=> java -jar $KVHOME/lib/kvstore.jar
securityconfig config
merge-trust -root $KVROOT3 -source-root /Users/my_name/tmp/kvroot/
newKey
Configuration updated.
```

```
(~/tmp/kvroot/kvroot2/security)=> keytool -list -keystore
store.trust
Enter keystore password:
```

```
***** WARNING WARNING WARNING *****
* The integrity of the information stored in your keystore *
* has NOT been verified! In order to verify its integrity, *
* you must provide your keystore password. *
***** WARNING WARNING WARNING *****
Keystore type: JKS
Keystore provider: SUN
Your keystore contains 2 entries
mykey_2, Feb 6, 2018, trustedCertEntry,
Certificate fingerprint (SHA1):
A3:75:F2:97:25:20:F9:AD:52:61:71:8F:6B:7E:B1:BB:E8:54:D1:7A
mykey, Feb 6, 2018, trustedCertEntry,
Certificate fingerprint (SHA1):
89:71:8C:F1:6D:7E:25:D7:AD:C4:7E:23:8C:09:0D:AC:CE:AE:3F:67
```

```
(~/tmp/kvroot)=> cd kvroot3/security
(~/tmp/kvroot/kvroot3/security)=> keytool -list -keystore
store.trust
```

```
Enter keystore password:
***** WARNING WARNING WARNING *****
* The integrity of the information stored in your keystore *
* has NOT been verified! In order to verify its integrity, *
* you must provide your keystore password. *
***** WARNING WARNING WARNING *****
```

```
Keystore type: JKS
Keystore provider: SUN
```

Your keystore contains 2 entries

```
mykey_2, Feb 6, 2018, trustedCertEntry,
Certificate fingerprint (SHA1):
A3:75:F2:97:25:20:F9:AD:52:61:71:8F:6B:7E:B1:BB:E8:54:D1:7A
mykey, Feb 6, 2018, trustedCertEntry,
Certificate fingerprint (SHA1):
89:71:8C:F1:6D:7E:25:D7:AD:C4:7E:23:8C:09:0D:AC:CE:AE:3F:67
```

4. Copy the updated `client.trust` file (the one with the merged keys) to the security directory on each host so that clients can use it to access the store.

 **Note:**

The `store.trust` and the `client.trust` files have the same content, but different uses. The `client.trust` is used to authenticate client-server communication, and `store.trust` to authenticate server-server communication.

5. From your NoSQL development environment, get the `client.trust` file from SN 3, as follows:

```
(~/tmp/kvroot/kvroot3/security)=> cat client.security
#Security property settings for communication with KVStore servers
#Tue Feb 06 15:03:40 CST 2018
oracle.kv.ssl.trustStore=client.trust
oracle.kv.transport=ssl
oracle.kv.ssl.protocols=TLSv1.2,TLSv1.1,TLSv1
oracle.kv.ssl.hostnameVerifier=dnmatch(CN\=NoSQL)
```

6. Check that all Replication Nodes are online (using either the Admin CLI `ping` or `verify configuration` command).
7. Restart each Storage Node sequentially, making sure that each SN is completely up before restarting the next SN. Use the following commands:

```
java -jar <KVHOME>/lib/kvstore.jar stop -root KVROOT
java -jar <KVHOME>/lib/kvstore.jar start -root KVROOT&
```

- Continuing from your NoSQL development environment, start the Admin CLI, and check that all RNs are up using the ping command:

```
(~/tmp/kvroot/newKey)=> java -jar $KVHOME/lib/kvstore.jar
runadmin -host localhost -port 5000 -security
$KVROOT1/security/client.security
Logged in admin as anonymous
kv-> ping
Pinging components of store HSRStore based upon topology sequence
#18
10 partitions and 3 storage nodes
Time: 2018-02-07 00:34:37 UTC Version: 12.2.4.5.12
Shard Status: healthy:1 writable-degraded:0 read-only:0 offline:0
Admin Status: healthy
Zone [name=Austin id=zn1 type=PRIMARY allowArbiters=false]
RN Status: online:3 offline:0 max
DelayMillis:1 max CatchupTimeSecs:0
Storage Node [sn1] on localhost:5000 Zone: [name=Austin
id=zn1 type=PRIMARY allowArbiters=false] Status: RUNNING
Ver: 12cR2.4.5.12 2018-02-06 08:51:55 UTC Build id: 0d00330822fc
Admin [admin1] Status: RUNNING,MASTER
Rep Node [rg1-rn1] Status: RUNNING,MASTER
sequenceNumber:63 haPort:5011
Storage Node [sn2] on localhost:6000 Zone: [name=Austin
id=zn1 type=PRIMARY allowArbiters=false] Status: RUNNING
Ver: 12cR2.4.5.12 2018-02-06 08:51:55 UTC Build id: 0d00330822fc
Rep Node [rg1-rn2] Status: RUNNING,REPLICA
sequenceNumber:63 haPort:6010 delayMillis:1 catchupTimeSecs:0
Storage Node [sn3] on localhost:7000 Zone: [name=Austin
id=zn1 type=PRIMARY allowArbiters=false] Status: RUNNING
Ver: 12cR2.4.5.12 2018-02-06 08:51:55 UTC Build id: 0d00330822fc
Rep Node [rg1-rn3] Status: RUNNING,REPLICA
sequenceNumber:63 haPort:7010 delayMillis:? catchupTimeSecs:?
```

- Restart each SN sequentially. Make sure that the last one you restarted is completely up before continuing to the next SN:

```
java -jar $KVHOME/lib/kvstore.jar stop -root
/Users/my_name/tmp/kvroot/kvroot1
(~/hg/kv/kvstore)=> java -jar $KVHOME/lib/kvstore.jar start -root
$KVROOT1 &
kv-> ping
Pinging components of store HSRStore based upon topology sequence
#18
10 partitions and 3 storage nodes
Time: 2018-02-06 21:23:56 UTC Version: 12.2.4.5.12
Shard Status: healthy:1 writable-degraded:0 read-only:0 offline:0
Admin Status: healthy
Zone [name=Austin id=zn1 type=PRIMARY allowArbiters=false]
RN Status: online:3 offline:0 maxDelayMillis:0 maxCatchupTimeSecs:0
Storage Node [sn1] on localhost:5000 Zone: [name=Austin
id=zn1 type=PRIMARY allowArbiters=false]
Status: RUNNING Ver: 12cR2.4.5.12 2018-02-06 08:51:55 UTC Build
id: 0d00330822fc
```



```

Admin [admin1] Status: RUNNING,MASTER
Rep Node [rg1-rn1] Status: RUNNING,REPLICA
sequenceNumber:62 haPort:5011 delayMillis:0 catchupTimeSecs:0
Storage Node [sn2] on localhost:6000 Zone: [name=Austin
id=zn1 type=PRIMARY allowArbiters=false]
Status: RUNNING Ver: 12cR2.4.5.12 2018-02-06 08:51:55 UTC Build id:
0d00330822fc
Rep Node [rg1-rn2] Status: RUNNING,MASTER
sequenceNumber:62 haPort:6010
Storage Node [sn3] on localhost:7000 Zone: [name=Austin
id=zn1 type=PRIMARY allowArbiters=false]
Status: RUNNING Ver: 12cR2.4.5.12 2018-02-06 08:51:55 UTC Build id:
0d00330822fc
Rep Node [rg1-rn3] Status: RUNNING,REPLICA
sequenceNumber:62 haPort:7010 delayMillis:0 catchupTimeSecs:0
Rep Node [rg1-rn1] Status: RUNNING,REPLICA is up, now restart the
next SN

```

```

(~/hg/kv/kvstore)=> java -jar $KVHOME/lib/kvstore.jar stop -root /
Users/my_name/tmp/kvroot/kvroot2
kv->ping
Pinging components of store HSRStore based upon topology sequence
#18
10 partitions and 3 storage nodes
Time: 2018-02-06 21:25:39 UTC Version: 12.2.4.5.12
Shard Status: healthy:0 writable-degraded:1 read-only:0 offline:0
Admin Status: healthy
Zone [name=Austin id=zn1 type=PRIMARY allowArbiters=false]
RN Status: online:2 offline:1 maxDelayMillis:? maxCatchupTimeSecs:?
Storage Node [sn1] on localhost:5000 Zone: [name=Austin id=zn1
type=PRIMARY allowArbiters=false]
Status: RUNNING Ver: 12cR2.4.5.12 2018-02-06 08:51:55 UTC Build id:
0d00330822fc
Admin [admin1] Status: RUNNING,MASTER
Rep Node [rg1-rn1] Status: RUNNING,REPLICA
sequenceNumber:62 haPort:5011
Storage Node [sn2] on localhost:6000
Zone: [name=Austin id=zn1 type=PRIMARY allowArbiters=false]
UNREACHABLE
Rep Node [rg1-rn2] Status: UNREACHABLE
Storage Node [sn3] on localhost:7000
Zone: [name=Austin id=zn1 type=PRIMARY allowArbiters=false]
Status: RUNNING Ver: 12cR2.4.5.12 2018-02-06 08:51:55 UTC Build id:
0d00330822fc
Rep Node [rg1-rn3] Status: RUNNING,REPLICA
sequenceNumber:62 haPort:7010 delayMillis:? catchupTimeSecs:?

(~/hg/kv/kvstore)=> java -jar $KVHOME/lib/kvstore.jar start -root
$KVROOT2 & kv->ping
Pinging components of store HSRStore based upon topology sequence
#18
10 partitions and 3 storage nodes
Time: 2018-02-06 21:26:09 UTC Version: 12.2.4.5.12
Shard Status: healthy:1 writable-degraded:0 read-only:0 offline:0
Admin Status: healthy

```

```

Zone [name=Austin id=zn1 type=PRIMARY allowArbiters=false]
RN Status: online:3 offline:0 maxDelayMillis:1 maxCatchupTimeSecs:0
Storage Node [sn1] on localhost:5000 Zone: [name=Austin id=zn1
type=PRIMARY allowArbiters=false]
Status: RUNNING Ver: 12cR2.4.5.12 2018-02-06 08:51:55 UTC Build id:
0d00330822fc
  Admin [admin1] Status: RUNNING,MASTER
  Rep Node [rg1-rn1] Status: RUNNING,REPLICA
sequenceNumber:63 haPort:5011

Storage Node [sn2] on localhost:6000
Zone: [name=Austin id=zn1 type=PRIMARY allowArbiters=false]
Status: RUNNING Ver: 12cR2.4.5.12 2018-02-06 08:51:55 UTC Build id:
0d00330822fc
  Rep Node [rg1-rn2] Status: RUNNING,REPLICA
sequenceNumber:63 haPort:6010 delayMillis:1 catchupTimeSecs:0
Storage Node [sn3] on localhost:7000
Zone: [name=Austin id=zn1 type=PRIMARY allowArbiters=false]
Status: RUNNING Ver: 12cR2.4.5.12 2018-02-06 08:51:55 UTC Build id:
0d00330822fc
  Rep Node [rg1-rn3] Status: RUNNING,REPLICA
sequenceNumber:63 haPort:7010 delayMillis:1 catchupTimeSecs:0
  
```

10. Now that SN2 is up and running, restart SN3 as follows:

```

(~/hg/kv/kvstore)=> java -jar $KVHOME/lib/kvstore.jar stop -root
/Users/my_name/tmp/kvroot/kvroot3
kv-> ping
Pinging components of store HSRStore based upon topology sequence
#18
10 partitions and 3 storage nodes
Time: 2018-02-06 21:26:43 UTC Version: 12.2.4.5.12
Shard Status: healthy:0 writable-degraded:1 read-only:0 offline:0
Admin Status: healthy
Zone [name=Austin id=zn1 type=PRIMARY allowArbiters=false]
RN Status: online:2 offline:1 maxDelayMillis:1 maxCatchupTimeSecs:0
Storage Node [sn1] on localhost:5000 Zone: [name=Austin id=zn1
type=PRIMARY allowArbiters=false]
Status: RUNNING Ver: 12cR2.4.5.12 2018-02-06 08:51:55 UTC Build id:
0d00330822fc
  Admin [admin1] Status: RUNNING,MASTER
  Rep Node [rg1-rn1] Status: RUNNING,MASTER
sequenceNumber:63 haPort:5011
Storage Node [sn2] on localhost:7000
Zone: [name=Austin id=zn1 type=PRIMARY allowArbiters=false]
Status: RUNNING Ver: 12cR2.4.5.12 2018-02-06 08:51:55 UTC Build id:
0d00330822fc
Rep Node [rg1-rn2] Status: RUNNING,REPLICA
sequenceNumber:63 haPort:6010 delayMillis:1 catchupTimeSecs:0
Storage Node [sn3] on localhost:7000
Zone: [name=Austin id=zn1 type=PRIMARY allowArbiters=false]
UNREACHABLE
  Rep Node [rg1-rn3] Status: UNREACHABLE
  
```

```
(~/hg/kv/kvstore)=> java -jar $KVHOME/lib/kvstore.jar start -root
$KVROOT3 &
kv-> ping
Pinging components of store HSRStore based upon topology sequence
#18
10 partitions and 3 storage nodes
Time: 2018-02-06 21:27:15 UTC Version: 12.2.4.5.12
Shard Status: healthy:1 writable-degraded:0 read-only:0 offline:0
Admin Status: healthy
Zone [name=Austin id=zn1 type=PRIMARY allowArbiters=false]
RN Status: online:3 offline:0 maxDelayMillis:1 maxCatchupTimeSecs:0
Storage Node [sn1] on localhost:5000
Zone: [name=Austin id=zn1 type=PRIMARY allowArbiters=false]
Status: RUNNING Ver: 12cR2.4.5.12 2018-02-06 08:51:55 UTC Build id:
0d00330822fc
    Admin [admin1]      Status: RUNNING,MASTER
    Rep Node [rg1-rn1]  Status: RUNNING,MASTER
sequenceNumber:63 haPort:5011
Storage Node [sn2] on localhost:6000
Zone: [name=Austin id=zn1 type=PRIMARY allowArbiters=false]
Status: RUNNING Ver: 12cR2.4.5.12 2018-02-06 08:51:55 UTC Build id:
0d00330822fc
    Rep Node [rg1-rn2] Status: RUNNING,REPLICA
sequenceNumber:63 haPort:6010 delayMillis:1 catchupTimeSecs:0
Storage Node [sn3] on localhost:7000
Zone: [name=Austin id=zn1 type=PRIMARY allowArbiters=false]
Status: RUNNING Ver: 12cR2.4.5.12 2018-02-06 08:51:55 UTC Build id:
0d00330822fc
    Rep Node [rg1-rn3] Status: RUNNING,REPLICA
sequenceNumber:63 haPort:7010 delayMillis:? catchupTimeSecs:?
```

11. Copy the `store.keys` file from the security directory of the newly generated key to the security directory on each storage node. This copies the new generated key to replace the old ones on the server node (SNs). Then, check that all Replication Nodes are online and restart each Storage Node, one by one, using the following commands:

```
java -jar <KVHOME>/lib/kvstore.jar stop -root KVROOT
java -jar <KVHOME>/lib/kvstore.jar start -root KVROOT&
```

These commands copy the new generated key to replace the old keys on the server node (SNs). Then restart each of the SNs:

```
(~/tmp/kvroot/kvroot3/security)=> cp /Users/my_name/tmp/kvroot/
newKey/security/store.keys
/Users/my_name/tmp/kvroot/kvroot1/security/.
(~/tmp/kvroot/kvroot3/security)=> cp /Users/my_name/tmp/kvroot/
newKey/security/store.keys
/Users/my_name/tmp/kvroot/kvroot2/security/.
(~/tmp/kvroot/kvroot3/security)=> cp /Users/my_name/tmp/kvroot/
newKey/security/store.keys
/Users/my_name/tmp/kvroot/kvroot3/security/.
```

```
java -jar <KVHOME>/lib/kvstore.jar stop -root KVROOT
java -jar <KVHOME>/lib/kvstore.jar start -root KVROOT&
```

12. On each Storage Node, remove the obsolete certificate `mykey` in `store.trust`. Then, rename the new certificate `mykey_2` to `mykey` using the following command:

```
keytool -delete -keystore KVROOT/security/store.trust \
  -alias mykey keytool -changealias -keystore \
  KVROOT/security/store.trust -alias mykey_2 -destalias mykey
```

This step removes the old certificate (`mykey`) and renames the newly created certificate, `myKey_2`, to the previous key's name, `mykey`. One key then exists, the newly generated one, called `myKey`.

```
(~/tmp/kvroot/kvroot3/security)=> keytool -delete -keystore
$KVROOT1/security/store.trust -alias mykey
Enter keystore password:
```

```
(~/tmp/kvroot/kvroot3/security)=> keytool -delete -keystore
$KVROOT2/security/store.trust -alias mykey
Enter keystore password:
```

```
(~/tmp/kvroot/kvroot3/security)=> keytool -delete -keystore
$KVROOT3/security/store.trust -alias mykey
Enter keystore password:
```

```
(~/tmp/kvroot/kvroot3/security)=> keytool -changealias -keystore
$KVROOT3/security/store.trust -alias mykey_2 -destalias mykey
```

```
(~/tmp/kvroot/kvroot3/security)=> keytool -changealias -keystore
$KVROOT2/security/store.trust -alias mykey_2 -destalias mykey
```

```
(~/tmp/kvroot/kvroot3/security)=> keytool -changealias -keystore
$KVROOT1/security/store.trust -alias mykey_2 -destalias mykey
```

Verify that the new certificate is the only one used using the following command:

```
keytool -list -keystore KVROOT/security/store.trust
(~/tmp/kvroot/newKey/security)=> keytool -list -keystore store.keys
Enter keystore password:
```

```
Keystore type: JKS
Keystore provider: SUN
```

Your keystore contains one entry, which is correct:

```
shared, Feb 6, 2018, PrivateKeyEntry,
Certificate fingerprint (SHA1):
A3:75:F2:97:25:20:F9:AD:52:61:71:8F:6B:7E:B1:BB:E8:54:D1:7A
```

Guidelines for Configuring External Certificates for a new Installation

Follow these steps to configure a new store to use external certificates:

 **Note:**

This procedure assumes you already have a Java keystore and truststore setup. For more information see [Java KeyStore Preparation](#).

1. Collect the distinguished name from the verbose information of the external certificate. In this example, it is the value of the owner field.

```
keytool -list -v -keystore store.keys alias shared
Certificate chain length: 3
Certificate[1]:
Owner: CN=myhost, OU=TeamA, O=MyCompany, L=Unknown, ST=California,
C=US
Issuer: CN=intermediate CA, OU=CA, O=MyCompany, ST=California,
C=US
```

2. Prepare `dnmatch` expression using a distinguished name. Oracle NoSQL Database verifies identities of server and client while establishing SSL connection between the server components. The verification is performed by checking if principal names on each side match the specified `dnmatch` expressions, which uses regular expressions as specified by `java.util.regex.Pattern`. The principal names represent the identities, which are specified by the subject name attribute of the certificate, represented as a distinguished name in RFC 1779 format, using the exact order, capitalization, and spaces of the attribute value. RFC 1779 defines well-known attributes for distinguished names, including CN, L, ST O, OU, C and STREET. If the distinguished name of the external certificate contains non-standard attributes, for example, EMAILADDRESS, then the expression used for `dnmatch` must replace these attribute names with an OID that is valid in RFC 1779 form, or use special constructs of regular expression to skip checking these attributes. The format for a `dnmatch` expression is:

`dnmatch(regular expression)`

In above example, the `dnmatch` expression is:

```
dnmatch(CN=myhost, OU=TeamA, O=MyCompany, L=Unknown,
ST=California, C=US)
```

If you are using a wild card to match a certificate with a non-standard distinguished name attribute, the `dnmatch` expression needs to match the attribute name in its OID format properly. For example, if the distinguished name is:

```
EMAILADDRESS=person@example.com, CN=myhost, OU=TeamA, O=MyCompany,
L=Unknown, ST=California, C=US
```

Then wild card should represent the entire EMAILADDRESS attribute name:

```
dnmatch(*=person@example.com, CN=myhost, OU=TeamA, O=MyCompany,
L=Unknown, ST=California, C=US)
```

3. Run `makebootconfig` to setup the secure store. Also specify the keystore password and `dnmatch` expressions in the security parameters. The keystore password "`password`" must use the same password as the Java Keystore of the external certificates. See:

```
java -Xmx64m -Xms64m -jar <KVHOME>/lib/kvstore.jar makebootconfig \
-root KVROOT -host node01 -port 5000 -harange 5010,5020 -admin 5001 \
-store-security configure \
-pwdmgr wallet -kspwd password \
-security-param client:serverIdentityAllowed="dnmatch
(CN=myhost, OU=TeamA, O=MyCompany, L=Unknown, ST=California, C=US)" \
-security-param internal:serverIdentityAllowed="dnmatch
(CN=myhost, OU=TeamA, O=MyCompany, L=Unknown, ST=California, C=US)" \
-security-param internal:clientIdentityAllowed="dnmatch
(CN=myhost, OU=TeamA, O=MyCompany, L=Unknown, ST=California, C=US)" \
-security-param ha:serverIdentityAllowed="dnmatch
(CN=myhost, OU=TeamA, O=MyCompany, L=Unknown, ST=California, C=US)" \
-security-param ha:clientIdentityAllowed="dnmatch
(CN=myhost, OU=TeamA, O=MyCompany, L=Unknown, ST=California, C=US)"
```

4. The `makebootconfig` command automatically generates keystore, server, and client truststore files using self-signed certificates. To use external certificates instead, you need to replace the keystore and truststore files with your own on each server that will host a Storage Node. For example:

```
copy store.keys store.trust client.trust KVROOT/security/
```

5. Use the `securityconfig` tool to verify installation. For example:

```
security-> config verify -secdir KVROOT/security
Security configuration verification passed.
```

 **Note:**

For older releases (prior 4.1), you needed to verify the configuration manually. In that case, the distinguished name of the certificate must match the content inside of `dnmatch` in `security.xml`. Also, the user-generated keystore password must be the same as the one stored in the wallet (`store.wallet`) or the password file (`store.pwd`). Finally, the truststore (`store.trust`) must contain the CA certificates and the one used for Oracle NoSQL Database.

6. Finally, deliver the client.trust or import the CA certificates into the client truststore.

Guidelines for Configuring External Certificates for an Existing Default Secure Installation

Follow these steps to install external certificates in an existing secure NoSQL database installation that uses a default security configuration and a self-signed certificate:

Note:

This procedure assumes you already have a Java keystore and truststore setup. For more information see [Java KeyStore Preparation](#).

1. Create a new security configuration that uses external certificates:

```
security-> config create -root NEW_KVROOT \
-pwdmgr wallet -kspwd password \
-param "client:serverIdentityAllowed=dnmatch
(CN=myhost, OU=TeamA, O=MyCompany, L=Unknown,
ST=California, C=US)" \
-param "internal:serverIdentityAllowed=dnmatch
(CN=myhost, OU=TeamA, O=MyCompany, L=Unknown,
ST=California, C=US)" \
-param "internal:clientIdentityAllowed=dnmatch
(CN=myhost, OU=TeamA, O=MyCompany, L=Unknown,
ST=California, C=US)" \
-param "ha:serverIdentityAllowed=dnmatch
(CN=myhost, OU=TeamA, O=MyCompany, L=Unknown,
ST=California, C=US)" \
-param "ha:clientIdentityAllowed=dnmatch
(CN=myhost, OU=TeamA, O=MyCompany, L=Unknown,
ST=California, C=US)"
```

Note:

NEW_KVROOT should be a temporary directory that only holds the generated security files.

2. Replace the keystore and truststore files with your own on each server that will host a Storage Node. For example:

```
copy store.keys store.trust client.trust NEW_KVROOT/security/
```

3. It is easier to install an external certificate if the existing store does not need to be kept accessible during the certificate installation. To do this, you only need to copy the entire new security configuration to each Storage Node and then restart all of the Storage Nodes.

 **Note:**

Before starting the SNA, set the environment variable `MALLOC_ARENA_MAX` to 1. Setting `MALLOC_ARENA_MAX` to 1 ensures that the memory usage is restricted to the specified heap size.

```
copy -r NEW_KVROOT/security KVROOT
java -Xmx64m -Xms64m -jar <KVHOME>/lib/kvstore.jar stop -root KVROOT
java -Xmx64m -Xms64m -jar <KVHOME>/lib/kvstore.jar start -root
KVROOT&
```

4. If the existing store need to be kept accessible during the credential changes instead, then you should create an interim truststore and modify the security parameters having `dnmatch` field. On the configuration host, merge the truststore entries by using the `config merge-trust` command, and also import the root and intermediate certificate:

```
java -Xmx64m -Xms64m \
-jar <KVHOME>/lib/kvstore.jar securityconfig \
config merge-trust -root KVROOT -source-root NEW_KVROOT
keytool -import -keystore KVROOT/security/store.trust -file
ca.cert.pem -alias root
keytool -import -keystore KVROOT/security/store.trust -file
intermediate.cert.pem -alias intermediate
copy KVROOT/security/store.trust KVROOT/security/client.trust
```

 **Note:**

In a multiple Storage Node deployment, you need to copy the new configuration to each host's new configuration directory and run `merge-trust` on each host like in the example above.

5. Copy the updated `client.trust` file to the security directory on each host so that clients can use it to access the store.
6. To keep the store accessible during the process, change the `dnmatch` value in the security configuration to be a compatible one. The values specified in the various `dnmatch(xxx)` expressions are a regular expression, as specified by `java.util.regex.Pattern`. The compatible "dnmatch" value should be in the form of old certificate DN | new certificate DN. In this case, the `CN=NoSQL|` represents the DN of the original self-signed certificate.

```
security-> config update \
-secdir KVROOT/security \
-param "client:serverIdentityAllowed=dnmatch
(CN=NoSQL|CN=myhost, OU=TeamA, O=MyCompany, L=Unknown,
ST=California, C=US)" \
-param "internal:serverIdentityAllowed=dnmatch
(CN=NoSQL|CN=myhost, OU=TeamA, O=MyCompany, L=Unknown,
ST=California, C=US)" \
```



```
-param "internal:clientIdentityAllowed=dnmatch
(CN=NoSQL|CN=myhost, OU=TeamA, O=MyCompany, L=Unknown,
ST=California, C=US)" \
-param "ha:serverIdentityAllowed=dnmatch
(CN=NoSQL|CN=myhost, OU=TeamA, O=MyCompany, L=Unknown,
ST=California, C=US)" \
-param "ha:clientIdentityAllowed=dnmatch
(CN=NoSQL|CN=myhost, OU=TeamA, O=MyCompany, L=Unknown,
ST=California, C=US)"
```

If clients set the login property `oracle.kv.ssl.hostnameVerifier`, change the value of the `dnmatch` field. For example:

```
oracle.kv.ssl.trustStore=client.trust
oracle.kv.transport=ssl
oracle.kv.ssl.protocols=TLSv1.2,TLSv1.1,TLSv1
oracle.kv.ssl.hostnameVerifier=dnmatch(CN\=NoSQL|CN\=myhost,
OU\=TeamA, O\=MyCompany, L\=Unknown, ST\=California, C\=US)
```

7. Check that all Replication Nodes are online and then restart each Storage Node one by one using the following commands:

```
java -Xmx64m -Xms64m -jar <KVHOME>/lib/kvstore.jar stop -root
KVROOT
```

```
java -Xmx64m -Xms64m -jar <KVHOME>/lib/kvstore.jar start -root
KVROOT&
```

8. Copy the updated `store.keys` file to the security directory on each host. Then, check that all Replication Nodes are online and restart each Storage Node one by one using the following commands:

```
java -Xmx64m -Xms64m -jar <KVHOME>/lib/kvstore.jar stop -root
KVROOT
```

```
java -Xmx64m -Xms64m -jar <KVHOME>/lib/kvstore.jar start -root
KVROOT&
```

9. For all Storage Nodes, remove the obsolete certificate `mykey` in `store.trust`. Also, rename the new certificate `mykey_2` to `mykey` using the following command:

```
keytool -delete -keystore KVROOT/security/store.trust \
-alias mykey
```

```
keytool -changealias -keystore \
KVROOT/security/store.trust -alias mykey_2 -destalias mykey
```

Guidelines for Updating the External Certificates

Follow these steps to update the external certificates for a secure installation that is already using external certificates.

 **Note:**

This procedure assumes you already have a Java keystore and truststore setup having the updated external certificates. For more information see [Java KeyStore Preparation](#).

1. Create a new security configuration that uses external certificates.

```
security-> config create -root NEW_KVROOT \  
-pwdmgr wallet -kspwd password \  
-param "client:serverIdentityAllowed=dnmatch  
(CN=myhost, OU=TeamA, O=MyCompany, L=Unknown,  
ST=California, C=US)" \  
-param "internal:serverIdentityAllowed=dnmatch  
(CN=myhost, OU=TeamA, O=MyCompany, L=Unknown,  
ST=California, C=US)" \  
-param "internal:clientIdentityAllowed=dnmatch  
(CN=myhost, OU=TeamA, O=MyCompany, L=Unknown,  
ST=California, C=US)" \  
-param "ha:serverIdentityAllowed=dnmatch  
(CN=myhost, OU=TeamA, O=MyCompany, L=Unknown,  
ST=California, C=US)" \  
-param "ha:clientIdentityAllowed=dnmatch  
(CN=myhost, OU=TeamA, O=MyCompany, L=Unknown,  
ST=California, C=US)"
```

2. Replace the keystore and server truststores with your own:

```
copy store.keys store.trust NEW_KVROOT/security/
```

3. On the configuration host, merge the truststore entries with the NEW_KVROOT directory. Check that all Replication Nodes are online and then restart each Storage Node one by one using the following commands. If the updated external certificate uses a different distinguished name, update the dnmatch value in the security configuration to a compatible one using the procedures found in [Guidelines for Configuring External Certificates for an Existing Default Secure Installation](#).

 **Note:**

Before starting the SNA, set the environment variable `MALLOC_ARENA_MAX` to 1. Setting `MALLOC_ARENA_MAX` to 1 ensures that the memory usage is restricted to the specified heap size.

```
java -Xmx64m -Xms64m \  
-jar <KVHOME>/lib/kvstore.jar securityconfig \  
config merge-trust -root KVROOT \  
-source-root <NEW_KVROOT>
```

```
java -Xmx64m -Xms64m -jar <KVHOME>/lib/kvstore.jar stop -root KVROOT  
java -Xmx64m -Xms64m -jar <KVHOME>/lib/kvstore.jar start -root  
KVROOT&
```

 **Note:**

You do not need to update the client truststore if the new certificates are signed by the same Certificate Authority (CA).

4. Copy the updated `store.keys` file to the security directory on each host. Then, check that all Replication Nodes are online and restart each Storage Node one by one using the following commands:

```
java -Xmx64m -Xms64m -jar <KVHOME>/lib/kvstore.jar stop -root KVROOT  
java -Xmx64m -Xms64m -jar <KVHOME>/lib/kvstore.jar start -root  
KVROOT&
```

5. For all Storage Nodes, remove the obsolete certificate `mykey` in `store.trust`. Also, rename the new certificate `mykey_2` to `mykey` using the following command:

```
keytool -delete -keystore KVROOT/security/store.trust \  
-alias mykey
```

```
keytool -changealias -keystore \  
KVROOT/security/store.trust -alias mykey_2 -destalias mykey
```

Guidelines for Operating System Security

Follow these guidelines regarding operating system security:

- There should be a single user identity that runs the KVStore software.
- The KVStore user should be in its own group, independent of other users.
- JE log files, audit log files, and password stores should have mode 0600 on Linux/UNIX platforms with equivalent settings for Windows systems. The simplest way to achieve this on Linux/UNIX is to set an `umask` of 0077.

- Security configuration files must be write-protected.
- The KVRTX directory and the security directory must be protected from modification by other users. On UNIX/Linux this should include having the sticky bit (01000) set in order to prevent renaming and deletion of files/directories.
- Access to the systems that are running KVStore should be limited in order to avoid the risk of tampering.

 **Note:**

Access protections do not guard against users who have sufficiently elevated access rights (for example, the UNIX root user).

A

Password Complexity Policies

A set of default rules should be followed when creating or updating a user password in order to enhance security. Password complexity policies do not apply to the SSL keystore password.

Any user that has the SYSOPER privilege can customize the global password policies and control the password complexity when creating or updating the passwords for users. Oracle NoSQL Database checks if the new passwords are sufficiently complex to prevent attackers to break into the system.

When using the `CREATE USER` and `ALTER USER` commands, Oracle NoSQL Database will check if the passwords set comply with the password complexity policies. Otherwise, a message will be shown with all the violating policies. For example:

```
kv-> exec "create user test identified by \"password\""  
Error handling command  
exec "create user test identified by \"password\"":  
Error: User error in query: CreateUser failed for:  
Password must have at least 9 characters
```

You can enable or disable the password complexity policy like this:

```
kv-> change-policy -params passwordComplexityCheck=true
```

Then, you can change the password complexity policies by using the `change-policy` command. For example:

```
kv-> change-policy -params  
passwordMinLength=20 passwordMaxLength=50 passwordMinUpper=3  
passwordMinLower=3 passwordMinDigit=3 passwordMinSpecial=3
```

The following password security parameters can be set:

| Parameter Name | Value Range and Type | Description |
|--------------------------------------|--|--|
| <code>passwordAllowedSpecial</code> | Sub set or full set of #\$\$%&'()*+,-./:;<=>?@[^_`{} (string)~ | Lists the allowed special characters. |
| <code>passwordComplexityCheck</code> | [true false] (boolean) | Whether to enable the password complexity checking. The default value is true. |
| <code>passwordMaxLength</code> | 1 - 2048 (integer) | The maximum length of a password. The default value is 256. |

| Parameter Name | Value Range and Type | Description |
|----------------------|---|---|
| passwordMinDigit | 0 - 2048 (integer) | The minimum required number of numeric digits. The default value is 2. |
| passwordMinLength | 1 - 2048 (integer) | The Minimum length of a password. The default value is 9. |
| passwordMinLower | 0 - 2048 (integer) | The minimum required number of lower case letters. The default value is 2. |
| passwordMinSpecial | 0 - 2048 (integer) | The minimum required number of special characters. The default value is 2. |
| passwordMinUpper | 0 - 2048 (integer) | The minimum required number of upper case letters. The default value is 2. |
| passwordNotStoreName | [true false] (boolean) | If true, password should not be the same as current store name, nor is it the store name spelled backwards or with the numbers 1–100 appended. The default value is true. |
| passwordNotUserName | [true false] (boolean) | If true, password should not be the same as current user name, nor is it the user name spelled backwards or with the numbers 1-100 appended. The default value is true. |
| passwordProhibited | list of strings separated by comma (string) | Simple list of words that are not allowed to be used as a password. The default reserved words are: oracle,password,user,nosql. |
| passwordRemember | 0 - 256 (integer) | The maximum number of passwords to be remembered that are not allowed to be reused when setting a new password. The default value is 3. |

Most of the special characters in the standard US keyboard are allowed to be used in a password with exception of " (double quote) and \ (back slash).

If you want to allow certain special characters use the `passwordAllowedSpecial` parameter. For example:

```
kv-> change-policy -params passwordAllowedSpecial="@# $"
```

If you want to enforce the password complexity for existing users, then you need to set the existing user's password to expired, like this:

1. Review the existing users in the system:

```
kv-> exec "show users"
user:id=u1 name=root
user:id=u3 name=user1
user:id=u4 name=user2
user:id=u5 name=user3
```

2. Set the new password complexity policies:

```
kv-> change-policy -params
passwordComplexityCheck=true passwordMinLength=9
passwordMinUpper=2 passwordMinLower=2
passwordMinSpecial=2 passwordMinDigit=2
```

3. Finally, change the existing user's password life time to be expired:

```
kv-> exec "alter user user1 password expire"
Statement completed successfully
kv-> exec "alter user user2 password expire"
Statement completed successfully
kv-> exec "alter user user3 password expire"
Statement completed successfully
```

In this case, user 1, 2, and 3 will need to re-new their password according to the new policy. For example, when trying to login with user 1, the system will prompt to change the password:

```
java -Xmx64m -Xms64m \
-jar kvstore.jar runadmin -host localhost \
-port 5000 -security login_file
user1's password:
The password of user1 has expired, it is required to
change the password.
Enter the new password:
Re-enter the new password:
```

If the new password violates any password complexity policies, an exception with a violation message will be thrown. For example:

```
user1's password:
The password of user1 has expired, it is required to
change the password.
Enter the new password: password
Re-enter the new password: password
Exception in thread "main" oracle.kv.AuthenticationFailureException:
Renew password failed:
Password must have at least 9 characters
Password must contain at least 2 upper case letters
Password must contain at least 2 lower case letters
...
```

 **Note:**

After the password is reset, if you're using Oracle Wallet for external password storage, you must recreate the wallet files for all your Oracle NoSQL Database user accounts. See [Oracle Wallet](#).

B

SSL keystore generation

The keystores (store.keys and store.trust) that are automatically generated by makebootconfig or securityconfig can also be manually created using the following keytool (Java built-in key and certificate management tool) commands:

To generate the keypair, use the `keytool -genkeypair` command:

```
keytool -genkeypair \  
-keystore store.keys \  
-storepass <passwd> \  
-keypass <passwd> \  
-alias shared \  
-dname "CN=NoSQL" \  
-keyAlg RSA \  
-keysize 1024 \  
-validity 365
```

To export the keypair, use the `keytool -export` command:

```
keytool -export \  
-file <temp file> \  
-keystore store.keys \  
-storepass <passwd> \  
-alias shared
```

To import the keypair, use the `keytool -import` command:

```
keytool -import \  
-file <temp file> \  
-keystore store.keys \  
-storepass <passwd> \  
-noprompt
```

You can also use the `keytool` commands described above to manually generate other keystore and truststore keys and substitute them for the ones that Oracle NoSQL Database generates, provided you adhere to the following rules:

- The store.keys file should have a key pair with the alias "shared".
- The store.keys store password (-storepass) must match the key password (-keypass)
- If a subject distinguished name other than CN=NoSQL is chosen for the self-signed certificate, then you must specify the following options to the makebootconfig or securityconfig command:

```
-param "ha:serverIdentityAllowed=dnmatch(SOMEDN)"  
-param "ha:clientIdentityAllowed=dnmatch(SOMEDN)"
```

```
-param "internal:serverIdentityAllowed=dnmatch(SOMEDN)"  
-param "internal:clientIdentityAllowed=dnmatch(SOMEDN)"  
-param "client:serverIdentityAllowed=dnmatch(SOMEDN)"
```

where SOMEDN is the distinguished name (-dname) chosen.

- The store password for store.trust should match the store password for store.keys.

C

Java KeyStore Preparation

The following example demonstrates how to use `keytool` to prepare keystore and truststore with external certificate. If you want to import an existing private/public key pair generated by an external tool instead, see [Import Key Pair to Java Keystore](#).

1. Generate a keypair and store it into `store.keys`

```
keytool -genkeypair -keystore store.keys \  
-alias shared -keyAlg RSA -keySize 2048 \  
-validity 365 -dname <xxx> \  
-storepass <sslPwd>  
...  
Enter key password for <shared>  
(RETURN if same as keystore password):
```

Note:

`store.keys` is the default name of Oracle NoSQL Database keystore and `shared` is the default alias of the Oracle NoSQL Database certificate. You can customize the name by specifying a security parameter in the `makebootconfig` command or the `securityconfig` utility. Additionally, you can specify the algorithm, size and validity of key.

2. Generate a certificate request and send to CA.

```
keytool -certreq -keystore store.keys -alias  
shared -file myhost.csr  
Enter keystore password:
```

3. A public trusted CA usually signs the certificate after receiving your csr file. A pem file is generated (`myhost.cert.pem`).
4. Import certificates that are part of a certificate chain in order. If there are multiple intermediate certificates, they also need to be imported in order.

```
keytool -import -file ca.cert.pem  
-keystore store.keys -alias root  
keytool -import -file intermediate.cert.pem -keystore store.keys  
-alias intermediate  
# After importing the root and intermediate certificates,  
# install the signed certificate for this server. The alias name  
# must be specified.  
keytool -import -file myhost.cert.pem -keystore store.keys  
-alias shared  
Certificate reply was installed in keystore
```

5. Verify the installation by checking the certificate content in `store.keys`:

```
keytool -list -v -keystore store.keys -alias shared
Certificate chain length: 3
Certificate[1]:
Owner: CN=myhost, OU=TeamA, O=MyCompany, L=Unknown,
ST=California, C=US
Issuer: CN=intermediate CA, OU=CA, O=MyCompany,
ST=California, C=US
```

The certificate chain length should match the number of certificates in the chain that were imported, in this case, three.

6. Build server truststore (`store.trust`). The server truststore must contain the signed certificate as well as the root and intermediate certificate. Note that the server and client truststores need to use the same password as that of the keystore.

```
keytool -export -file store.tmp
-keystore store.keys -alias shared
keytool -import -keystore store.trust -file store.tmp
keytool -import -keystore store.trust -file ca.cert.pem
-alias root
keytool -import -keystore store.trust -file intermediate.cert.pem
-alias intermediate
```

7. Create client truststore (`client.trust`). In this case, import the root and intermediate certificates into the client truststore.

```
keytool -import -keystore client.trust
-file ca.cert.pem -alias root
keytool -import -keystore client.trust -file intermediate.cert.pem
-alias intermediate
```

Import Key Pair to Java Keystore

This section describes how to import an existing private/public key pair into Java keystore. This is useful if you have your own tools for generating a CA signed key pair. The procedure assumes you already have the root and intermediate certificates as well as the private key and its signed certificate.

To import an existing key pair:

1. Build the certificate chain and convert the private key and certificate files into a PKCS12 file.

```
cat myhost.pem intermediate.pem root.pem > import.pem
openssl pkcs12 -export -in import.pem -inkey myhost.key.pem
-name shared > server.p12
```

2. Import the PKCS12 file into Java keystore:

```
keytool -importkeystore -srckeystore server.p12
-destkeystore store.keys -srcstoretype pkcs12 -alias shared
```

3. Finally, to complete the preparation of the Java keystore, perform the procedures for creating the server and client truststore described in the previous section.

D

KVStore Required Privileges

This section lists the user required privileges to access specific KVStore APIs as well as CLI commands.

Privileges for Accessing CLI Commands

READ_ANY:

- get kv

READ_ANY_TABLE or READ_TABLE (on \$table_name):

- get table --name table_name

WRITE_ANY:

- delete kv
- put kv

INSERT_ANY_TABLE or INSERT_TABLE (on \$table_name):

- put table --name table_name

DELETE_ANY_TABLE or DELETE_TABLE (on \$table_name):

- delete table --name table_name

SYSDBA:

- ddl
- plan add-index
- plan add-table
- plan evolve-table
- plan remove-index
- plan remove-table

CREATE_ANY_TABLE:

- plan add-table

DROP_ANY_TABLE:

- plan remove-table

EVOLVE_ANY_TABLE or EVOLVE_TABLE (on \$table_name):

- plan evolve-table --name table_name

CREATE_ANY_INDEX or CREATE_INDEX (on \$table_name):

- plan add-index --table table_name

DROP_ANY_INDEX or DROP_INDEX (on \$table_name):

- plan remove-index –table table_name

SYSVIEW:

- await-consistency
- logtail
- ping
- show admins
- show events
- show topology
- show upgrade-order
- show users (all users)
- show zones
- verify
- show parameters
- show perf
- show plans (plans created by all users)
- show pools
- show snapshots

DBVIEW:

- show indexes
- show tables

USRVIEW:

- show users (for self)
- show plans (plans created by self)
- plan change-user (for self)

DBVIEW and READ_ANY:

- aggregate

SYSOPER:

- change-policy
- configure
- plan change-parameters
- plan change-storagedir
- plan change-user (for all users)
- plan deploy-admin
- plan deploy-datacenter
- plan deploy-sn
- plan deploy-topology

- plan deploy-zone
- plan drop-user
- plan failover
- plan grant
- plan migrate-sn
- plan remove-admin
- plan remove-sn
- plan remove-zone
- plan repair-topology
- plan revoke
- plan start-service
- plan stop-service
- pool (all sub-commands)
- repair-admin-quorum
- snapshot (all sub-commands)
- topology (all sub-commands)

No privilege is required for the following commands:

- connect
- exit
- help
- hidden
- history
- verbose
- show faults
- table (all sub-commands)

Privilege required depends on the command being timed:

- time

Privilege required depends on the commands contained in the script file:

- load

Privilege required depends on the privilege needed for the plan being referred to:

- plan cancel
- plan execute
- plan interrupt
- plan wait

Privileges for DDL Commands

SYSDBA:

- CREATE TABLE
- CREATE INDEX
- DROP INDEX
- DROP TABLE
- ALTER TABLE

CREATE_ANY_TABLE:

- CREATE TABLE

DROP_ANY_TABLE:

- DROP TABLE

EVOLVE_ANY_TABLE or EVOLVE_TABLE (on \$table_name):

- ALTER TABLE table_name

CREATE_ANY_INDEX or CREATE_INDEX (on \$table_name):

- CREATE INDEX ON table_name

DROP_ANY_INDEX or DROP_INDEX (on \$table_name):

- DROP INDEX ON table_name

SYSOPER:

- CREATE USER
- CREATE ROLE
- DROP USER
- DROP ROLE
- ALTER USER
- GRANT
- REVOKE

DBVIEW:

- SHOW TABLE
- SHOW INDEX
- DESCRIBE TABLE
- DESCRIBE INDEX

SYSVIEW:

- SHOW USERS
- SHOW ROLES

USRVIEW:

- SHOW USERS (for self only)

Privileges for Accessing KVStore APIs

Privilege(s) required: READ_ANY, or READ_TABLE/READ_ANY_TABLE if accessing key-values are in tables.

- get
- multiGet
- multiGetIterator
- multiGetKeys
- multiGetKeysIterator

Note:

For multi-XYZ and storeXYZIterator APIs, the parentKey may be null for scanning the whole store. In this case, if the user has no required roles, an empty result set will be returned rather than throwing the UnauthorizedException.

- storeIterator
- storeKeysIterator

Privilege(s) required: WRITE_ANY, or DELETE_TABLE/DELETE_ANY_TABLE if accessing key-values are in tables:

- delete
- deleteIfVersion
- multiDelete

Privilege(s) required: WRITE_ANY, or INSERT_TABLE/INSERT_ANY_TABLE if accessing key-values are in tables:

- put
- putIfAbsent
- putIfPresent
- putIfVersion

Privilege(s) required: DBVIEW

- getAvroCatalog

Privilege(s) required: None:

- getOperationFactory
- getStats

Privilege(s) required: Union of all required roles of each single operation in the operation list:

- execute

Privilege required depends on the privilege needed for the statement being executed:

- execute(String statement)
- executeSync(String statement)

Privileges for Accessing KVStore TableAPIs

Privilege(s) required: READ_TABLE/READ_ANY_TABLE:

- get
- multiGet
- multiGetKeys
- tableIterator
- tableKeysIterator

Privilege(s) required: DELETE_TABLE/DELETE_ANY_TABLE:

- delete
- deleteIfVersion
- multiDelete

Privilege(s) required: INSERT_TABLE/INSERT_ANY_TABLE:

- put
- putIfAbsent
- putIfPresent
- putIfVersion

Privilege(s) required: USRVIEW:

- getTable
- getTables

Privilege(s) required: None:

- getTableOperationFactory

Privilege(s) required: Union of all required roles of each single operation in the operation list:

- execute

Privileges for Accessing KvLargeObject APIs

Privilege(s) required: READ_ANY:

- getLOB

Privilege(s) required: READ_ANY and WRITE_ANY:

- appendLOB
- deleteLOB
- putLOB

- putLOBIfAbsent
- putLOBIfPresent

Privileges for Running XRegion Service

Privilege(s) required:

- WRITE_SYSTEM_TABLE
- READ_ANY_TABLE
- INSERT_ANY_TABLE

E

Configuring the Kerberos Administrative Utility

Before using `kadmin`, you first need to configure permissions on the KDC. Kerberos uses an Access Control List (ACL) file to determine which principals have administrative access to the Kerberos database and their level of access.

The default location of the Kerberos ACL file is `<LOCALSTATEDIR>/krb5kdc/kadm5.acl`, where `LOCALSTATEDIR` is the directory prefix where the KDC databases are located. This location can be modified by the `acl_file` variable in `kdc.conf`.

Lines containing ACL entries have this format:

```
principal permissions [target_principal [restrictions] ]
```

Note:

Line order in the ACL file is important. The first matching entry will control access for an actor principal on a target principal.

To configure `kadmin`, perform the following steps:

1. Create an access control list file and put the Kerberos principal of at least one of the administrators into it. For example:

```
*/admin@EXAMPLE.COM *
```

In this case, any principal in the `EXAMPLE.COM` realm with an `admin` instance has all administrative privileges on the KDC.

For example, `joe/admin@EXAMPLE.com` has all privileges over the realm's Kerberos database.

2. Create the first principal before accessing the KDC remotely:

```
kadmin.local: addprinc -randkey admin/admin  
kadmin.local: ktadd -k kadm5.keytab admin/admin
```

Note:

To enable passwordless authentication, copy `kadm5.keytab` to any client machine.

Kadmin can also be used to perform security maintenance. For more information, see [Guidelines for Updating Kerberos Passwords](#).

F

Manually Registering Oracle NoSQL Database Service Principal

The securityconfig tool allows you to create service principals and generate keytabs assuming that each Storage Node is able to access the Kerberos admin interface remotely. Although this is the typical configuration most Kerberos deployments have, you may want to use a non-standard configuration. You can manage service principals by using only kadmin.local or ktutil utility on the KDC host.

To register Oracle NoSQL Database service principal by using kadmin.local:

1. Register the service principal:

```
kadmin.local: addprinc -randkey nosql/abc.example.com
```

2. Extract the keytab file using the ktadd command:

```
kadmin.local: ktadd -norandkey -k keytab nosql/abc.example.com
```

3. Verify the entries of the generated keytab using the klist tool:

```
klist -k -e /tmp/keytab
Keytab name: FILE:keytab
KVNO Principal
-----
12  nosql/abc.example.com@EXAMPLE.COM
    (AES-128 CTS mode with 96-bit SHA-1 HMAC)
12  nosql/abc.example.com@EXAMPLE.COM
    (AES-256 CTS mode with 96-bit SHA-1
HMAC)
```

4. Copy the keytab of Oracle NoSQL Database server principal to each Storage Node. The default location is under kvroot/security. You need to create the security directory.
5. Run makebootconfig or securityconfig utility to complete the rest of the Kerberos security configuration.

To register Oracle NoSQL Database service principal by using ktutil utility:

1. Add principal entries:

```
ktutil: add_entry -password -p \
nosql/abc.example.com -k 1 -e aes128-cts-hmac-sha1-96
Password for nosql/abc.example.com@EXAMPLE.COM:
ktutil:add_entry -password -p nosql/abc.example.com \
-k 1 -e aes256-cts-hmac-sha1-96
Password for nosql/abc.example.com@EXAMPLE.COM
```

2. Write the current keylist into the keytab file:

```
Ktutil: write_kt keytab
```

3. Verify the entries of the generated keytab using the `klist` tool:

```
klist -k -e /tmp/keytab
Keytab name: FILE:keytab
KVNO Principal
-----
12  nosql/abc.example.com@EXAMPLE.COM
    (AES-128 CTS mode with 96-bit SHA-1 HMAC)
12  nosql/abc.example.com@EXAMPLE.COM
    (AES-256 CTS mode with 96-bit SHA-1
HMAC)
```

4. Copy the keytab of Oracle NoSQL Database server principal to each Storage Node. The default location is under `kvroot/security`. You need to create the security directory.
5. Run `makebootconfig` or `securityconfig` utility to complete the rest of the Kerberos security configuration.

G

Generating Certificate and Private Key for the Oracle NoSQL Database Proxy

Topics

- [Guidelines for Generating Self-Signed Certificate and Private Key using OpenSSL](#)
- [Guidelines for Generating Certificate Chain and Private Key using OpenSSL](#)

Guidelines for Generating Self-Signed Certificate and Private Key using OpenSSL

Self-signed certificates can be used to securely connect to the Oracle NoSQL Database Proxy. This section provides the steps to generate the self-signed certificate and other required files for a secure connection using OpenSSL.

As a pre-requisite, download and install OpenSSL on the host machine. See [OpenSSL](#).

To generate a self-signed certificate and private key using the OpenSSL, complete the following steps:

1. On the configuration host, navigate to the directory where the certificate file is required to be placed.
2. Use the following OpenSSL command to generate the self-signed certificate and private key. When prompted, provide a secure password of your choice for the certificate file.



Note:

All prompt password will use 123456 in this example.

```
openssl req -x509 -days 365 -newkey rsa:4096 \  
-keyout key.pem -out certificate.pem \  
-subj "/C=US/ST=CA/L=San/CN=localhost/  
emailAddress=localhost@oracle.com"
```

where, CN in the subj should map the proxy domain name.

3. Convert the private key to PKCS#8 format. When prompted, provide a secure password of your choice for the encryption.

```
openssl pkcs8 -topk8 \  
-inform PEM -outform PEM \  
-in key.pem -out key-pkcs8.pem
```

The following files are generated in the directory:

- `key.pem` is the private key.
- `key-pkcs8.pem` is the private key in PKCS#8 format.
- `certificate.pem` is the SSL certificate file in pem format.

 **Note:**

The below conversion should be done if your key is encrypted with the PKCS#5 v2.0 algorithm. Otherwise, you might encounter `IllegalArgumentException` exception that indicates the file does not contain a valid private key due to the unsupported algorithm. The encryption algorithm can be converted via OpenSSL `pkcs8` utility by specifying PKCS#5 v1.5 or PKCS#12 algorithms with `-v1` flag. The following command converts the encryption algorithm of a key to PBE-SHA1-3DES.

```
openssl pkcs8 -topk8 -in <PKCS#5v2.0_key_file> -out
<new_key_file> -v1 PBE-SHA1-3DES
```

Additionally, a `driver.trust` file is also required if you are using the Java driver. This `driver.trust` file is not required for other language drivers. To generate the `driver.trust` file, import the certificate to the Java keystore. When prompted, provide the keystore password.

```
keytool -import -alias example -keystore driver.trust -file
certificate.pem
```

Guidelines for Generating Certificate Chain and Private Key using OpenSSL

Certificate chains can be used to securely connect to the Oracle NoSQL Database Proxy. This section provides the steps to generate certificate chains and other required files for a secure connection using OpenSSL.

A certificate chain is provided by a Certificate Authority (CA). There are many CAs. Each CA has a different registration process to generate a certificate chain. Follow the steps provided by your CA for the process to obtain a certificate chain from them.

As a pre-requisite, download and install OpenSSL on the host machine. See [OpenSSL](#).

To generate a certificate chain and private key using the OpenSSL, complete the following steps:

1. On the configuration host, navigate to the directory where the certificate file is required to be placed.

2. Create a 2048 bit server private key.

```
openssl genrsa -out key.pem 2048
```

The following output is displayed.

```
Generating RSA private key, 2048 bit long modulus
.....+++
.....+++
e is 65537 (0x10001)
```

3. This step is required only when your server private key is not in PKCS#8 format. Convert the private key to PKCS#8 format. When prompted, provide a secure password of your choice for the encryption.

```
openssl pkcs8 -topk8 \
-inform PEM -outform PEM \
-in key.pem -out key-pkcs8.pem
```

The following output is displayed.

```
Enter Encryption Password:
Verifying - Enter Encryption Password:
```

Note:

The below conversion should be done if your key is encrypted with the PKCS#5 v2.0 algorithm. Otherwise, you might encounter `IllegalArgumentException` exception that indicates the file does not contain a valid private key due to the unsupported algorithm. The encryption algorithm can be converted via OpenSSL `pkcs8` utility by specifying PKCS#5 v1.5 or PKCS#12 algorithms with `-v1` flag. The following command converts the encryption algorithm of a key to PBE-SHA1-3DES.

```
openssl pkcs8 -topk8 -in <PKCS#5v2.0_key_file> -out
<new_key_file> -v1 PBE-SHA1-3DES
```

4. Create a Certificate Signing Request (CSR).

```
openssl req -new -key key.pem -out request.csr \
-subj "/C=US/ST=CA/L=San/CN=localhost/
emailAddress=localhost@oracle.com"
```

where, CN in the `subj` should map the proxy domain name.

5. Send Certificate Signing Request (CSR) data file to CA. CA will use CSR data to issue a SSL certificate.

6. CA returns a signed certificate `certificate.pem`. If it is not yet chained up with CA's certificate (`rootCA.crt`), you need to manually chain up.

```
cat rootCA.crt >> certificate.pem
```

The following files are generated in the directory:

- `key.pem` is the server private key.
- `key-pkcs8.pem` is the server private key in PKCS#8 format.
- `certificate.pem` is the certificate chain file in pem format. It includes the server certificate issued by CA and CA intermediate or root certificate.
- `request.csr` is the server certificate request file.
- `rootCA.crt` is the root certificate provided by the CA.

Additionally, a `driver.trust` file is also required if you are using the Java driver, and if the `rootCA.crt` is not listed in Java default trust store `JAVA_HOME/jre/lib/security/cacerts`. This `driver.trust` file is not required for other language drivers. To generate the `driver.trust` file, import the `rootCA.crt` certificate to the Java keystore. When prompted, provide the keystore password.

```
keytool -import -alias example -keystore driver.trust -file rootCA.crt
```

For the Python driver, if your selected CA is not trusted by default, you need to get the `rootCA.crt` from CA and set the system environment variable:

```
REQUESTS_CA_BUNDLE=PATH_OF_CA_FILE/rootCA.crt
```