# *Oracle*

# *NoSQL Database Administrator's Guide*

*12c Release 1*

**Library Version DRAFT**

ORACLE
NOSQL DATABASE

## Legal Notice

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# Table of Contents

# Preface

This document describes how to install and configure Oracle NoSQL Database (Oracle NoSQL Database).

This book is aimed at the systems administrator responsible for managing 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.

# Chapter 1. Introduction to Oracle NoSQL Database

Welcome to Oracle NoSQL Database. Oracle NoSQL Database provides multi-terabyte distributed key/value pair storage that offers scalable throughput and performance. That is, it services network requests to store and retrieve data which is accessed as tables of information or, optionally, as key-value pairs. Oracle NoSQL Database services these types of data requests with a latency, throughput, and data consistency that is predictable based on how the store is configured.

Oracle NoSQL Database offers full Create, Read, Update and Delete (CRUD) operations with adjustable durability guarantees. Oracle NoSQL Database is designed to be highly available, with excellent throughput and latency, while requiring minimal administrative interaction.

Oracle NoSQL Database provides performance scalability. If you require better performance, you use more hardware. If your performance requirements are not very steep, you can purchase and manage fewer hardware resources.

Oracle NoSQL Database is meant for any application that requires network-accessible data with user-definable read/write performance levels. The typical application is a web application which is servicing requests across the traditional three-tier architecture: web server, application server, and back-end database. In this configuration, Oracle NoSQL Database is meant to be installed behind the application server, causing it to either take the place of the back-end database, or work alongside it. To make use of Oracle NoSQL Database, code must be written (using Java or C) that runs on the application server.

An application makes use of Oracle NoSQL Database by performing network requests against Oracle NoSQL Database's data store, which is referred to as the KVStore. The requests are made using the Oracle NoSQL Database Driver, which is linked into your application as a Java library (.jar file), and then accessed using a series of Java APIs.

The usage of these APIs is introduced in one of two manuals. Most developers will want to read *Oracle NoSQL Database Getting Started with the Tables API*. Developers who want to use the older, legacy Key/Value API should read *Oracle NoSQL Database Getting Started with the Key/Value API*.

### Note

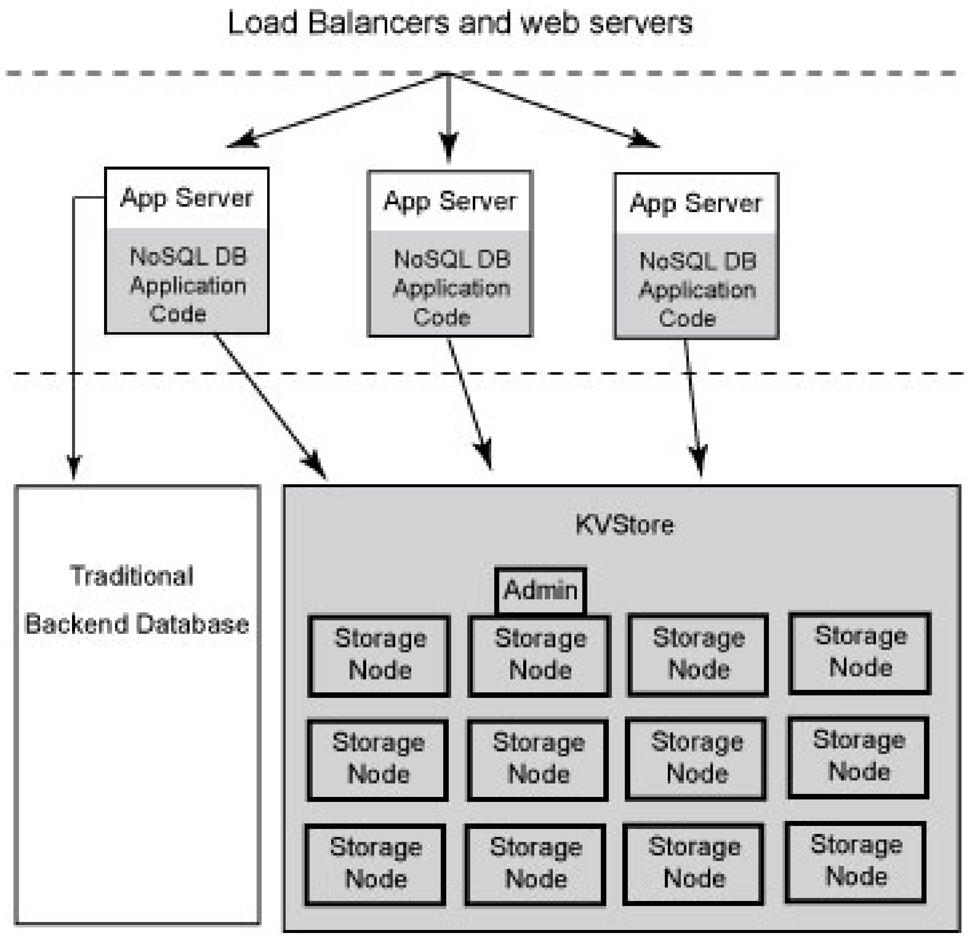
Oracle NoSQL Database is tested using Java 7, and so Oracle NoSQL Database should be used only with that version of Java.

## The KVStore

The KVStore is a collection of Storage Nodes which host a set of Replication Nodes. Data is spread across the Replication Nodes. Given a traditional three-tier web architecture, the KVStore either takes the place of your back-end database, or runs alongside it.

The store contains multiple Storage Nodes. A *Storage Node* is a physical (or virtual) machine with its own local storage. The machine is intended to be commodity hardware. It should be, but is not required to be, identical to all other Storage Nodes within the store.

The following illustration depicts the typical architecture used by an application that makes use of Oracle NoSQL Database:


Load Balancers and web servers
App Server
NoSQL DB Application Code
App Server
NoSQL DB Application Code
App Server
NoSQL DB Application Code
Traditional Backend Database
KVStore
Admin
Storage Node

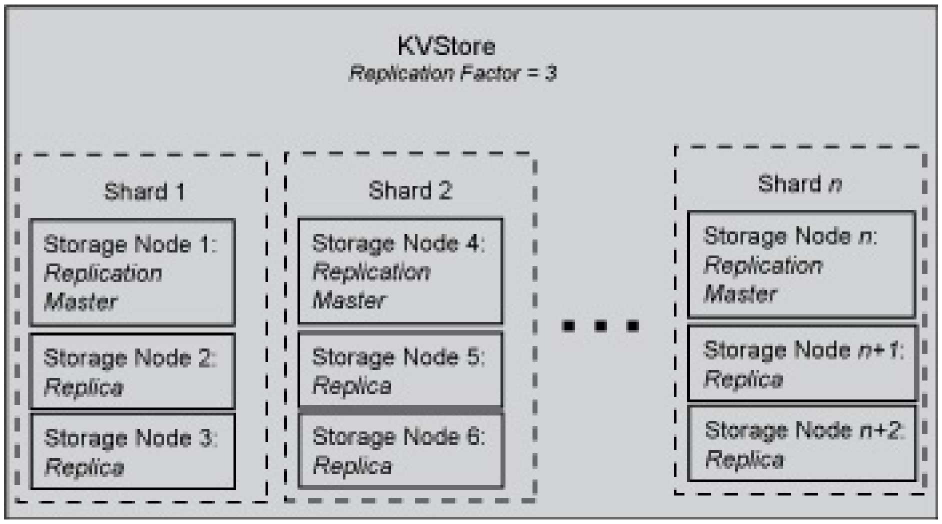
Every Storage Node hosts one or more Replication Nodes as determined by its *capacity*. The capacity of a Storage Node serves as a rough measure of the hardware resources associated with it. A store can consist of Storage Nodes of different capacities. Oracle NoSQL Database will ensure that a Storage Node is assigned a load that is proportional to its capacity. For information on how to associate capacity with a Storage Node, see the discussion of the *capacity* parameter at Installation Configuration (page 12). A Replication Node in turn contains at least one and typically many partitions. (For information on the best way to balance the number of Storage Nodes and Replication Nodes, see Balance a Non-Compliant Topology (page 42).) Also, each Storage Node contains monitoring software that ensures the Replication Nodes which it hosts are running and are otherwise healthy.

## Replication Nodes and Shards

At a very high level, a *Replication Node* can be thought of as a single database which contains key-value pairs.

Replication Nodes are organized into *shards*. A shard contains a single Replication Node, called the *master* node, which is responsible for performing database writes, as well as one or more read-only *replicas*. The *master* node copies all writes to the replicas. These replicas are used to service read-only operations. Although there can be only one master node at any given time, any of the members of the shard (with the exception of nodes in a secondary zone as described below) are capable of becoming a *master* node. In other words, each shard uses a single master/multiple replica strategy to improve read throughput and availability.

The following illustration shows how the KVStore is divided up into shards:


KVStore
Replication Factor = 3
Shard 1
Storage Node 1: Replication Master
Storage Node 2: Replica
Storage Node 3: Replica
Shard 2
Storage Node 4: Replication Master
Storage Node 5: Replica
Storage Node 6: Replica
Shard n
Storage Node n: Replication Master
Storage Node n+1: Replica
Storage Node n+2: Replica

Note that if the machine hosting the master should fail in any way, then the master automatically fails over to one of the other nodes in the shard. That is, one of the replica nodes is automatically promoted to master.

Production KVStores should contain multiple shards. At installation time you provide information that allows Oracle NoSQL Database to automatically decide how many shards the store should contain. The more shards that your store contains, the better your write performance is because the store contains more nodes that are responsible for servicing write requests.

## Replication Factor

The number of nodes belonging to a shard is called its *Replication Factor*. The larger a shard's Replication Factor, the faster its read throughput (because there are more machines to service the read requests) but the slower its write performance (because there are more machines to which writes must be copied). Once you set the Replication Factor for each zone in the store, Oracle NoSQL Database makes sure the appropriate number of Replication Nodes are created for each shard residing in each zone making up your store.

For additional information on how to identify your replication factor and its implications, see Replication Factor (page 126).

## Partitions

Each shard contains one or more *partitions*. Table rows (or key-value pairs) in the store are accessed by the data's key. Keys, in turn, are assigned to a partition. Once a key is placed in a partition, it cannot be moved to a different partition. Oracle NoSQL Database spreads records evenly across all available partitions by hashing each record's key.

As part of your planning activities, you must decide how many partitions your store should have. Note that this is not configurable after the store has been installed.

It is possible to expand and change the number of Storage Nodes in use by the store. When this happens, the store can be reconfigured to take advantage of the new resources by adding new shards. When this happens, partitions are balanced between new and old shards by redistributing partitions from one shard to another. For this reason, it is desirable to have enough partitions so as to allow fine-grained reconfiguration of the store. Note that there is a minimal performance cost for having a large number of partitions. As a rough rule of thumb, there should be at least 10 to 20 partitions per shard, and the number of partitions should be evenly divisible by the number of shards. Since the number of partitions cannot be changed after the initial deployment, you should consider the maximum future size of the store when specifying the number of partitions.

## Zones

A zone is a physical location that supports good network connectivity among the Storage Nodes deployed in it and has some level of physical separation from other zones. A zone generally includes redundant or backup power supplies, redundant data communications connections, environmental controls (for example: air conditioning, fire suppression) and security devices. A zone may represent an actual physical data center building, but could also represent a floor, room, pod, or rack, depending on the particular deployment. Oracle recommends you install and configure your store across multiple zones to guard against systemic failures affecting an entire physical location, such as a large scale power or network outage.

Multiple zones provide fault isolation and increase the availability of your data in the event of a single zone failure.

Zones come in two types. *Primary* zones contain nodes which can serve as masters or replicas. Zones are created as primary zones by default. *Secondary* zones contain nodes which can only serve as replicas. Secondary zones can be used to make a copy of the data available at a distant location, or to maintain an extra copy of the data to increase redundancy or read capacity.

You can use the command line interface to create and deploy one or more `zones`. Each `zone` hosts the deployed storage nodes. For additional information on zones and how to create them see Create a Zone (page 22).

## Topologies

A *topology* is the collection of zones, storage nodes, replication nodes and administration services that make up a NoSQL DB store. A deployed store has one topology that describes its state at a given time.

After initial deployment, the topology is laid out so as to minimize the possibility of a single point of failure for any given shard. This means that while a Storage Node might host more than one Replication Node, those Replication Nodes will never be from the same shard. This improves the chances of the shard continuing to be available for reads and writes even in the face of a hardware failure that takes down the host machine. For more information on the rules that topologies must follow see Determining Your Store's Configuration (page 38).

Topologies can be changed to achieve different performance characteristics, or in reaction to changes in the number or characteristics of the Storage Nodes. Changing and deploying a topology is an iterative process. For information on how to use the command line interface to create, transform, view, validate and preview a topology, see topology (page 117).

## Access and Security

Access to the KVStore and its data is performed in two different ways. Routine access to the data is performed using Java APIs that the application developer uses to allow his application to interact with the Oracle NoSQL Database Driver, which communicates with the store's Storage Nodes in order to perform whatever data access the application developer requires. The Java APIs that the application developer uses are introduced later in this manual.

In addition, administrative access to the store is performed using a command line interface or a browser-based graphical user interface. System administrators use these interfaces to perform the few administrative actions that are required by Oracle NoSQL Database. You can also monitor the store using these interfaces.

For most production stores, authentication over SSL is normally required by both the command line interface and the Java APIs. It is possible to install a store such that authentication is not required, but this is not recommended. For details on Oracle NoSQL Database's security features, see the *Oracle NoSQL Database Security Guide*.

### Note

Oracle NoSQL Database is intended to be installed in a secure location where physical and network access to the store is restricted to trusted users. For this reason, at this time Oracle NoSQL Database's security model is designed to prevent accidental access to the data. It is *not* designed to prevent denial-of-service attacks.

## The Administration Command Line Interface

The Administration command line interface (CLI) is the primary tool used to manage your store. It is used to configure, deploy, and change store components. It can also be used to verify the system, check service status, check for critical events and browse the store-wide log file. Alternatively, you can use a browser-based graphical user interface to do read-only monitoring. (Described in the next section.)

The CLI can also be used to get, put, and delete store records or tables, retrieve schema, and display general information about the store. It can also be used to diagnose problems or potential problems in the system, fix actual problems by adding, removing or modifying store data and/or verify that the store has data. It is particularly well-suited for a developer who is creating a Oracle NoSQL Database application, and who needs to either populate a store a with a small number of records so as to have data to develop against, or to examine the store's state as part of development debugging activities.

The command line interface is accessed using the following command:

```
java -Xmx256m -Xms256m -jar KVHOME/lib/kvstore.jar runadmin
```

### Note

To avoid using too much heap space, you should specify -Xmx and -Xms flags for Java when running administrative and utility commands.

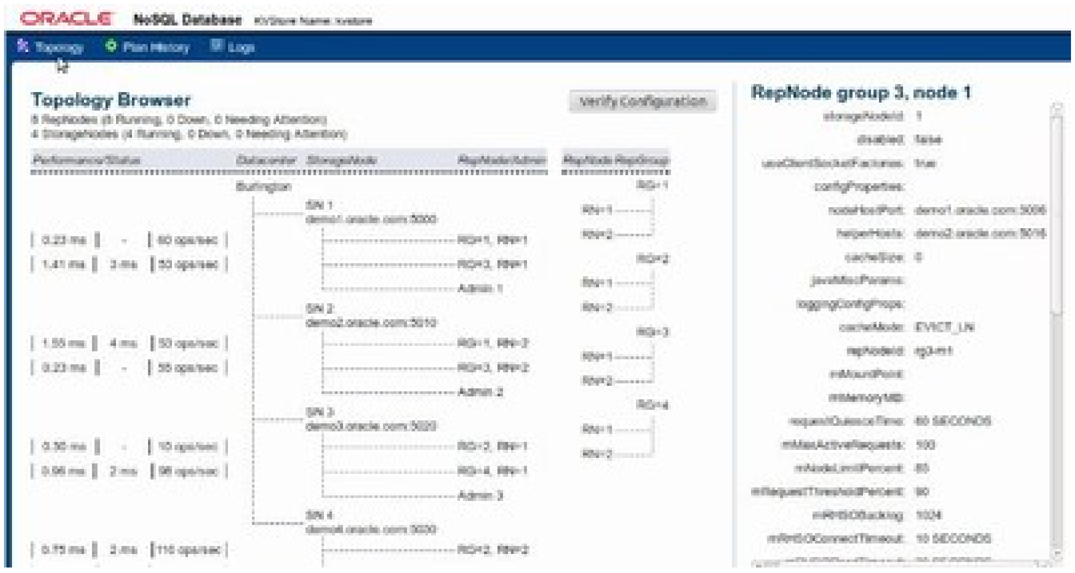
For a complete listing of all the commands available to you in the CLI, see CLI Commands and Subcommands (page 88).

## The Admin Console

Oracle NoSQL Database provides an HTML-based graphical user interface that you can use to monitor your store. It is called the *Admin Console*. To access it, you point your browser to a machine and port where your administration process is running. In the examples used later in this book, we use port 5001 for this purpose.

The Admin Console offers the following main functional areas:

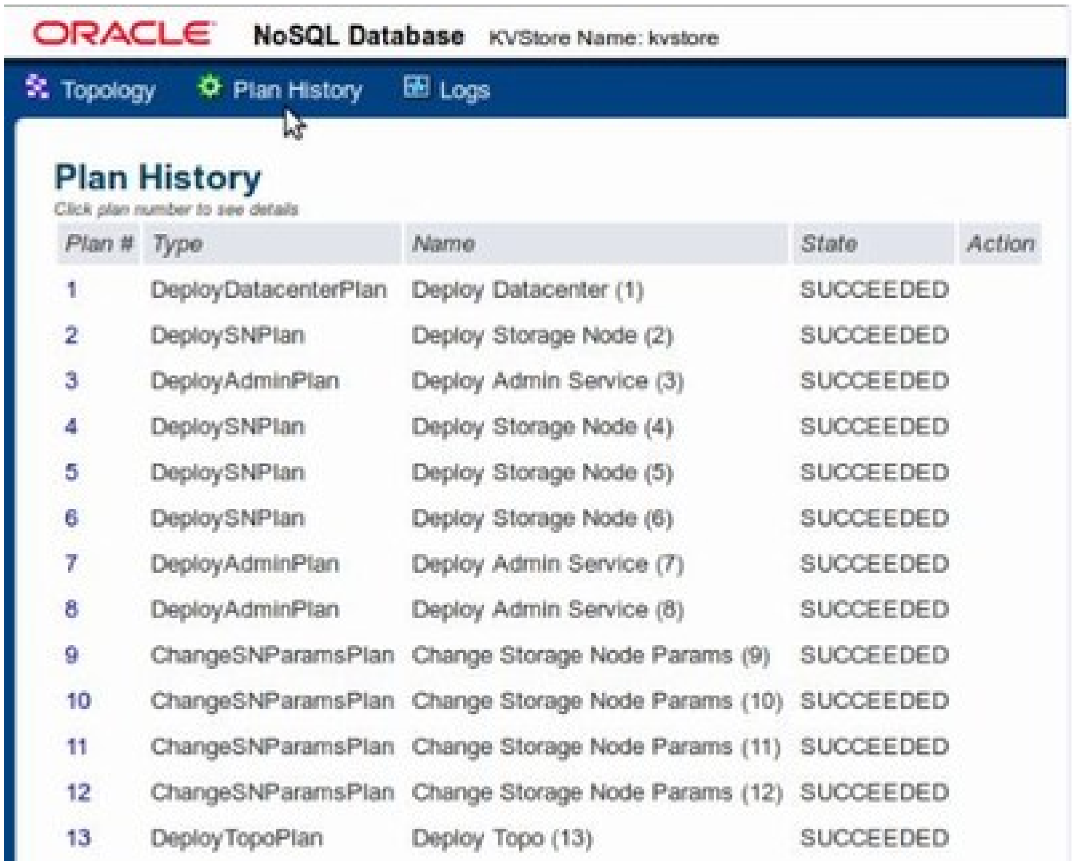
- Topology. Use the Topology screen to see all the nodes that have been installed for your store. This screen also shows you at a glance the health of the nodes in your store.



Topology Browser
6 RepNodes (6 Running, 0 Down, 0 Needing Attention)
4 StorageNodes (4 Running, 0 Down, 0 Needing Attention)

RepNode group 3, node 1

- Plan & History. This screen offers you the ability to view the last twenty plans that have been executed.

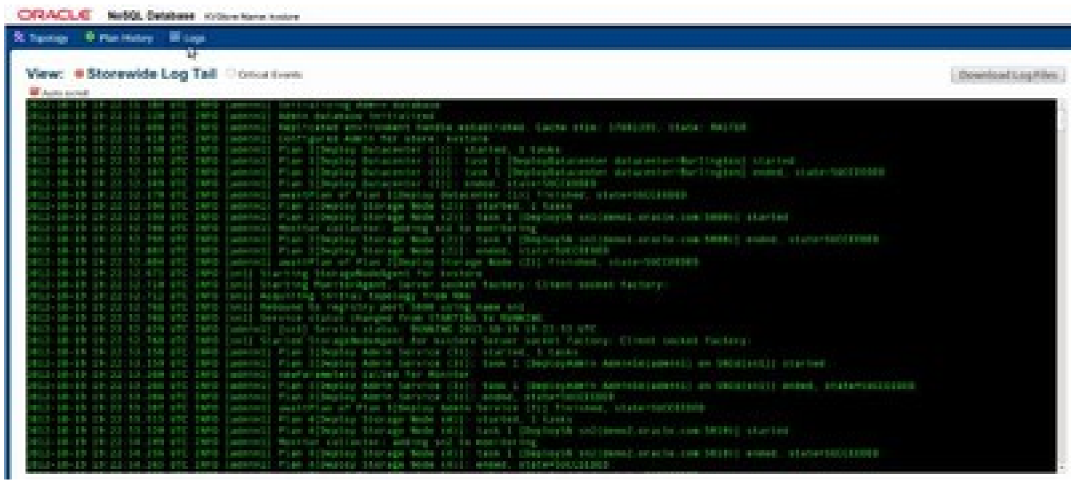


## Plan History

Click plan number to see details

| Plan # | Type | Name | State | Action |
|---|---|---|---|---|
| 1 | DeployDatacenterPlan | Deploy Datacenter (1) | SUCCEEDED | |
| 2 | DeploySNPlan | Deploy Storage Node (2) | SUCCEEDED | |
| 3 | DeployAdminPlan | Deploy Admin Service (3) | SUCCEEDED | |
| 4 | DeploySNPlan | Deploy Storage Node (4) | SUCCEEDED | |
| 5 | DeploySNPlan | Deploy Storage Node (5) | SUCCEEDED | |
| 6 | DeploySNPlan | Deploy Storage Node (6) | SUCCEEDED | |
| 7 | DeployAdminPlan | Deploy Admin Service (7) | SUCCEEDED | |
| 8 | DeployAdminPlan | Deploy Admin Service (8) | SUCCEEDED | |
| 9 | ChangeSNParamsPlan | Change Storage Node Params (9) | SUCCEEDED | |
| 10 | ChangeSNParamsPlan | Change Storage Node Params (10) | SUCCEEDED | |
| 11 | ChangeSNParamsPlan | Change Storage Node Params (11) | SUCCEEDED | |
| 12 | ChangeSNParamsPlan | Change Storage Node Params (12) | SUCCEEDED | |
| 13 | DeployTopoPlan | Deploy Topo (13) | SUCCEEDED | |

- Logs. This screen shows you the contents of the store's log files. You can also download the contents of the log files from this screen.



```
[illegible]
```

## Oracle External Tables Integration

Oracle NoSQL Database data can be accessed using Oracle Database's External Tables feature. This capability allows NoSQL Database data to be read into Oracle Database. NoSQL Database data cannot be modified using the External Tables feature.

Note that this is a feature which is only available to users of the Oracle NoSQL Database Enterprise Edition.

To use the Oracle Database External Table feature to read Oracle NoSQL Database data, you must use the `<KVHOME>/exttab/bin/nosql_stream` preprocessor to populate our Oracle tables with the data. You must then configure your Oracle Database to use the External Tables feature.

For information on how to use the `nosql_stream` preprocessor, and how to configure Oracle Database to use External Tables, see the oracle.kv.exttab package summary.

## Coherence Integration

Oracle Coherence is a middleware application that provides data management support for clustered applications. The data that an application delegates to Oracle Coherence are automatically available to and accessible by all servers in the application cluster. By distributing data across multiple machines, Oracle Coherence solves problems related to achieving availability, reliability, scalability, performance, serviceability and manageability of clustered applications.

Oracle Coherence is described here: http://docs.oracle.com/cd/E24290_01/index.htm

To provide these solutions, Oracle Coherence implements a cache. This cache can be customized to use a number of different data repositories to store the cached data. One such data repository is Oracle NoSQL Database.

Note that this is a feature which is only available to users of the Oracle NoSQL Database Enterprise Edition.

To integrate with Oracle NoSQL Database, Oracle Coherence must be customized using a combination of configuration XML, stock Coherence code, and custom Oracle NoSQL Database code. The Oracle NoSQL Database code is implemented using classes provided by the `oracle.kv.coherence` package.

Oracle NoSQL Database can be used to support two different caching strategies for Oracle Coherence. The first of these is implemented by oracle.kv.coherence.NoSQLBinaryStore. This class allows you to implement cache data that is not meant to be shared with non-cache-based applications, and so uses a data format that is fairly opaque. This is an efficient and easy-to-configure caching option.

Alternatively, you can implement a caching strategy that results in data which is meant to be shared with non-cache-based applications. You do this using oracle.kv.coherence.NoSQLAvroCacheStore. This caching mechanism is Avro-aware, and so any Avro-compliant application will be able to read and write these data records.

In order for Oracle Coherence to use these Avro-based objects, it must be able to serialize the Avro records for transmission over its network. To enable this, you use the oracle.kv.coherence.NoSQLAvroSerializer class.

# Chapter 2. Installing Oracle NoSQL Database

This chapter describes the installation process for Oracle NoSQL Database in a multi-host environment. If you are planning a large system for production use, please read Initial Capacity Planning (page 125) to estimate the number of storage nodes on which you will need to install the software. For simple uses when you already know the storage nodes you intend to use, simply follow the instructions below and Oracle NoSQL Database will make the best use of the storage nodes you provide.

## Installation Prerequisites

Make sure that you have Java SE 7 or later installed on all of the hosts that you are going to use for the Oracle NoSQL Database installation. The command:

```
java -version
```

can be used to verify this.

### Note

Oracle NoSQL Database is compatible with Java SE 7 and later, and has been tested and certified against Oracle Java SE 7, IBM Java SE Version 6 and IBM J9 on the AIX platform. It is recommended that you upgrade to the latest Java releases to take advantage of the latest bug fixes and performance improvements. The release notes included in the Oracle NoSQL Database download specify the exact Java versions that have been used for certification.

Make sure that the `jps` utility is working. Installing the JDK allows the `jps` tools to be available for use by the Storage Node Agent (SNA) in order to optimally manage Oracle NoSQL Database processes. The jps tools also allow you to diagnose any issues that may turn up. While Oracle NoSQL Database can continue to operate in the absence of the `jps` tools, it diminishes its ability to manage its processes.

If the JDK and its tools have been correctly installed, the output from `jps` should list at least one Java process (the jps process itself). Use the following command to verify this:

```
% jps
16216 Jps
```

### Note

You must run the commands listed above as the OS user that will run the Oracle NoSQL Database SNA processes.

Only Linux and Solaris 10 are officially supported platforms for Oracle NoSQL Database. It may be that platforms other than Linux or Solaris 10 could work for your deployment. However, Oracle does not test Oracle NoSQL Database on platforms other than Linux and Solaris 10, and so makes no claims as to the suitability of other platforms for Oracle NoSQL Database deployments.

In addition, it is preferable that virtual machines not be used for any of the Oracle NoSQL Database nodes. This is because the usage of virtual machines makes it difficult to characterize Oracle NoSQL Database performance. For best results, run the Oracle NoSQL Database nodes natively (that is, without VMs) on Linux or Solaris 10 platforms.

You do not necessarily need root access on each node for the installation process.

Finally, **make sure** that some sort of reliable clock synchronization is running on each of the machines. Generally, a synchronization delta of less than half a second is required. Network Time Protocol (`ntp`) is sufficient for this purpose.

## Installation

The following procedures describe how to install Oracle NoSQL Database:

1. Pick a directory where the Oracle NoSQL Database package files (libraries, Javadoc, scripts, and so forth) should reside. It is easiest if that directory has the same path on all nodes in the installation. You should use different directories for the Oracle NoSQL Database package files (referred to as KVHOME in this document) and the Oracle NoSQL Database data (referred to as KVROOT). Both the KVHOME and KVROOT directories should be local to the node (that is, not on a Network File System).

   ### Note

   To make future software upgrades easier, adopt a convention for KVHOME that includes the release number. Always use a KVHOME location such as `/var/kv/kv-M.N.O`, where `M.N.O` are the release.major.minor numbers. This can be easily achieved by simply unzip/untaring the distribution into a common directory (`/var/kv` in this example).

2. Extract the contents of the Oracle NoSQL Database package (kv-M.N.O.zip or kv-M.N.O.tar.gz) to create the KVHOME directory (i.e. KVHOME is the kv-M.N.O/ directory created by extracting the package). If KVHOME resides on a network shared directory (not recommended) then you only need to unpack it on one machine. If KVHOME is local to each machine, then you should unpack the package on each node.

3. Verify the installation by issuing the following command on one of the nodes:

   ```
   java -Xmx256m -Xms256m -jar KVHOME/lib/kvclient.jar
   ```

   You should see some output that looks like this:

   ```
   11gR2.M.N.O (....)
   ```

   where `M.N.O` is the package version number.

   ### Note

   Oracle NoSQL Database is a distributed system and the runtime needs to be installed on every node in the cluster. While the entire contents of the Oracle NoSQL Database package do not need to be installed on every node, the contents of the lib and doc directories must be present. How this distribution is done is beyond the scope of this manual.

## Installation Configuration

Before you configure Oracle NoSQL Database, you should determine the following parameters for each Storage Node in the store:

- *root*

  Where the KVROOT directory should reside. There should be enough disk space on each node to hold the data to be stored in your Oracle NoSQL Database store. The KVROOT disk space requirements can be reduced if the *storagedir* parameter is used to store the data at a different location outside the KVROOT directory. It is best if the KVROOT is the same local directory path on each node (but not a shared or NFS mounted directory). The examples in this book assume that the KVROOT directory already exists.

- *port*

  The TCP/IP port on which Oracle NoSQL Database should be contacted. This port should be free (unused) on each node. It is sometimes referred to as the *registry port*. The examples in this book use port 5000.

- *admin*

  The port on which the Oracle NoSQL Database web-based Admin Console is contacted. This port only needs to be free on the node which runs the administration process. The examples in this book use port 5001. You can also change this port number by modifying the value of the `adminHttpPort` parameter. For more information, see Changing Parameters (page 75).

  ### Note

  Setting the value of -admin or the `adminHttpPort` parameter to 0 disables the web interface.

  The administration process can be replicated across multiple nodes, and so the port needs to be available on all the machines where it runs. In this way, if the administration process fails on one machine, it can continue to use the http web service on a different machine. You can actually use a different port for each node that runs an administration process, but for the sake of simplicity we recommend you be consistent.

- *runadmin*

  Forces an Admin to be included in the boot configuration even if `-admin 0` was specified.

  If `-admin 0` is specified in conjunction with `-runadmin`, the admin web interface will not be started.

  If `-runadmin` is not specified, the admin is included in the boot configuration only if an admin port value greater than 0 is specified.

- *harange*

A range of free ports which the Replication Nodes use to communicate among themselves. These ports must be sequential and there must be at least as many as there are Replication Nodes running on each Storage Node in your store. The Storage Node Agent manages this allotment of ports, reserves one for an Admin service, and uses the rest to allocate one per Replication Node. The port range is specified as "startPort,endPort". "5010,5020" is used by the examples in this book.

- *servicerange*

  A range of ports that may be used for communication among administrative services running on a Storage Node and its managed services. This parameter is optional and is useful when services on a Storage Node must use specific ports for firewall or other security reasons. By default the services use anonymous ports. The format of the value string is "startPort,endPort." The value varies with the capacity of the Storage Node. For more information about the servicePortRange, see Storage Node Parameters (page 77).

- *store-security*

  Specifies if security will be used or not. In the examples in this book, no security is used.

  If `-store-security none` is specified, no security will be used.

  If `-store-security configure` is specified, security will be used and the security configuration utility will be invoked as part of the makebootconfig process.

  If `-store-security enable` is specified, 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.

  For more information on configuring Oracle NoSQL Database securely, see the Oracle NoSQL Database Security Guide.

- *capacity*

  The total number of Replication Nodes a Storage Node can support. Capacity is an optional parameter. Capacity can be set to values greater than 1 when the Storage Node has sufficient disk, cpu, memory and network bandwidth to support multiple Replication Nodes.

  Please keep the following configuration considerations in mind for nodes with capacity greater than one:

  1. It is best if the Storage Node is configured with a capacity equal to the number of disks available on the machine. Such a configuration permits the placement of each Replication Node on its own disk and ensures that the Replication Nodes on the Storage Node are not competing for I/O resources. The location of this directory on its disk can be specified via the *storagedir* parameter.

     For example:

     ```
     > java -jar KVHOME/lib/kvstore.jar makebootconfig \
         -root /opt/ondb/var/kvroot \
     ```

```
     -port 5000 \
     -admin 5001 \
     -host node10
     -harange 5010,5025 \
     -store-security none \
     -capacity 3 \
     -storagedir /disk1/ondb/data \
     -storagedir /disk2/ondb/data \
     -storagedir /disk3/ondb/data \
```

where capacity=3 equals the number of disks (disk1, disk2, disk3) located on the same Storage Node (node10).

2. Increase the *harange* parameter to account for the additional ports required by the Replication Nodes.

3. Increase the *servicerange* parameter to account for the additional ports required by the Replication Nodes.

The value defaults to the number of *storagedir* parameters if they were specified. Otherwise the value defaults to "1". "1" is used as the capacity by the examples in this book.

- *storagedir*

  A path to the directory that will contain the environment associated with a Replication Node. For capacity values greater than one, multiple *storagedir* parameters must be specified, one for each Replication Node that will be hosted on the Storage Node. It is best if each directory path resolves to a separate disk. This is typically accomplished via suitable entries in /etc/fstab that attach the file system on a disk to an appropriate location in the overall directory hierarchy. Placing each environment on a distinct disk ensures that the Relocation Nodes are not competing for I/O resources. It also isolates the impact of a disk failure to a single environment.

  In the absence of explicit directory arguments the environments are located under the KVROOT directory.

- *num_cpus*

  The total number of processors on the machine available to the Replication Nodes. It is used to coordinate the use of processors across Replication Nodes. If the value is 0, the system will attempt to query the Storage Node to determine the number of processors on the machine. This value defaults to "0". "0" numCPUs is used by the examples in this book.

- *memory_mb*

  The total number of megabytes of memory that is available in the machine. It is used to guide the specification of the Replication Node's heap and cache sizes. This calculation becomes more critical if a Storage Node hosts multiple Replication Nodes, and must allocate memory between these processes. If the value is 0, the store will attempt to determine the amount of memory on the machine, but that value is only available when the JVM used is the Oracle Hotspot JVM. The default value is "0". "0" is used by the examples in this book.

Once you have determined this information, configure the installation:

1. Create the initial "boot config" configuration file using the `makebootconfig` utility. You should do this on each Oracle NoSQL Database node. You only need to specify the -admin option (the Admin Console port) on the node which hosts the initial Oracle NoSQL Database administration processes. (At a later point in this installation procedure, you deploy additional administration processes.)

   To create the "boot config" file, issue the following commands:

   ```
   > mkdir -p KVROOT     (if it does not already exist)
   > java -Xmx256m -Xms256m \
   -jar KVHOME/lib/kvstore.jar makebootconfig -root KVROOT \
                                                  -port 5000 \
                                                  -admin 5001 \
                                                  -host <hostname> \
                                                  -harange 5010,5020 \
                                                  -store-security none  \
                                                  -capacity 1 \
                                                  -num_cpus 0 \
                                                  -memory_mb 0
   ```

2. Start the Oracle NoSQL Database Storage Node Agent (SNA) on each of the Oracle NoSQL Database nodes. The SNA manages the Oracle NoSQL Database processes on each node. It also owns and manages the registry port, which is the main way to communicate with Oracle NoSQL Database processes on that node. You can use the `start` utility for this:

   ```
   nohup java -Xmx256m -Xms256m \
   -jar KVHOME/lib/kvstore.jar start -root KVROOT&
   ```

   ### Note

   If the Replication Node or Admin Service crashes, the SNA ensures that the processes restart.

3. Verify that the Oracle NoSQL Database processes are running using the `jps -m` command:

   ```
   > jps -m
   29400 ManagedService -root /tmp -class Admin -service
   BootstrapAdmin.13250 -config config.xml
   29394 StorageNodeAgentImpl -root /tmp -config config.xml
   ```

4. Ensure that the Oracle NoSQL Database client library can contact the Oracle NoSQL Database Storage Node Agent (SNA) by using the `ping` command:

   ```
   > java -Xmx256m -Xms256m \
   -jar KVHOME/lib/kvstore.jar ping -port 5000 -host node01
   ```

   If SNA is running, you see the following output:

   ```
   SNA at hostname: node01, registry port: 5000 is not registered.
   No further information is available
   ```

This message is not an error, but instead it is telling you that only the SN process is running on the local host. Once Oracle NoSQL Database is fully configured, the ping option has more to say.

If the SNA cannot be contacted, you see this instead:

```
Could not connect to registry at node01:5000
Connection refused to host: node01; nested exception is:
java.net.ConnectException: Connection refused
```

If the Storage Nodes do not start up, you can look through the adminboot and snaboot logs in the KVROOT directory in order to identify the problem.

You can also use the -host option to check an SNA on a remote host:

```
> java -Xmx256m -Xms256m \
-jar KVHOME/lib/kvstore.jar ping -port 5000 -host node02
SNA at hostname: node02, registry port: 5000 is not registered.  No
further information is available
```

Assuming the Storage Nodes have all started successfully, you can configure the KVStore. This is described in the next chapter.

### Note

For best results, you should configure your nodes such that the SNA starts automatically when your node boots up. How this is done is a function of how your operating system is designed, and so is beyond the scope of this manual. See your operating system documentation for information on automatic application launch at bootup.

# Chapter 3. Plans

This chapter describes `plans`, which are useful to perform the configuration of your store. If you are installing a store for the first time, you can skip ahead to the next chapter Configuring the KVStore (page 20).

You configure Oracle NoSQL Database with administrative commands called *plans*. A plan is made up of multiple operations. Plans may modify state managed by the Admin service, and may issue requests to kvstore components such as Storage Nodes and Replication Nodes. Some plans are simple state-changing operations, while others may be long-running operations that affect every node in the store over time.

For example, you use a plan to create a Zone or a Storage Node or to reconfigure the parameters on a Replication Node.

## Using Plans

You create and execute plans using the `plan` command in the administrative command line interface. By default, the command line prompt will return immediately, and the plan will execute asynchronously, in the background. You can check the progress of the plan using the show plan id command.

If you use the optional `-wait` flag for the plan command, the plan will run synchronously, and the command line prompt will only return when the plan has completed. The `plan wait` command can be used for the same purpose, and also lets you specify a time period. The -wait flag and the plan wait command are particularly useful when issuing plans from scripts, because scripts often expect that each command is finished before the next one is issued.

You can also create, but defer execution of the plan by using the optional `-noexecute` flag. If -noexecute is specified, the plan can be run later using the `plan execute -id <id>` command.

### Feedback While a Plan is Running

There are several ways to track the progress of a plan.

- The `show plan -id` command provides information about the progress of a running plan. Note that the `-verbose` optional plan flag can be used to get more detail.
- The Admin Console's Topology tab refreshes as Oracle NoSQL Database services are created and brought online.
- You can issue the `verify` command using the Topology tab or the CLI as plans are executing. The `verify` plan provides service status information as services come up.

#### Note

The Topology tab and verify command are really only of interest for topology-related plans. For example, if the user is modifying parameters, the changes may not be visible via the topology tab or verify command.

- You can follow the store-wide log using the Admin Console's Logs tab, or by using the CLI's `logtail` command.

## Plan States

Plans can be in these states:

1. `APPROVED`

   The plan has been created, but is not yet running.

2. `RUNNING`

   The plan is currently executing.

3. `SUCCEEDED`

   The plan has completed successfully.

4. `INTERRUPTED`

   A `RUNNING` plan has been manually interrupted, using the `interrupt` command in the CLI.

5. `INTERRUPT REQUESTED`

   A plan has been manually interrupted, but is still processing the interrupt request. A plan may have to cleanup or reverse steps take during plan execution to be sure that the store remains in a consistent state.

6. `ERROR`

   A `RUNNING` plan has encountered a problem, and has ended without successfully completing.

7. `CANCELED`

   An `INTERRUPTED` or `ERROR` plan has been terminated using the CLI. To cancel a plan using the CLI, use the `cancel` command.

Plans in `INTERRUPTED`, `INTERRUPT REQUESTED` or `ERROR` state can be retried using the the `plan execute` command. Retrying may be an appropriate approach when the underlying problem was transient or has been rectified. Plans that are retried simply re-execute the same steps. Each step is idempotent, and can be safely repeated.

Note that Storage Nodes and Replication Nodes may encounter errors which are detected by the Admin Console and are displayed in an error dialog before the plan has processed the information. Because of that, the user may learn of the error while the Admin service still considers the plan to be `RUNNING` and active. The plan eventually sees the error and transitions to an `ERROR` state.

## Reviewing Plans

You can find out what state a plan is in using the `show plans` command in the CLI. Use the `show plan -id <plan number>` command to see more details on that plan. Alternatively, you can see the state of your plans in the `Plan History` section in the Admin Console. Click on the plan number in order to see more details on that plan.

You can review the execution history of a plan by using the CLI `show plan` command. (How to use the CLI is described in detail in Configuring the KVStore (page 20).)

This example shows the output of the show plan command. The plan name, attempt number, started and ended date, status, and the steps, or tasks that make up the plan are displayed. In this case, the plan was executed once. The plan completed successfully.

```
kv-> show plan
1 Deploy KVLite        SUCCEEDED
2 Deploy Storage Node  SUCCEEDED
3 Deploy Admin Service SUCCEEDED
4 Deploy KVStore       SUCCEEDED
kv-> show plan -id 3
Plan Deploy Admin Service
State:          SUCCEEDED
Attempt number: 1
Started:        2012-11-22 22:05:31 UTC
Ended:          2012-11-22 22:05:31 UTC
Total tasks:    1
Successful:     1
```

# Chapter 4. Configuring the KVStore

Once you have installed Oracle NoSQL Database on each of the nodes that you could use in your store (see Installing Oracle NoSQL Database (page 10), you must configure the store. To do this, you use the command line administration interface. In this chapter, we describe the command line tool.

To configure your store, you create and then execute *plans*. Plans describe a series of operations that Oracle NoSQL Database should perform for you. You do not need to know what those internal operations are in detail. Instead, you just need to know how to use and execute the plans.

## Configuration Overview

At a high level, configuring your store requires these steps:

1. Configure and Start a Set of Storage Nodes (page 21)
2. Name your KVStore (page 21)
3. Create a Zone (page 22)
4. Create an Administration Process on a Specific Host (page 22)
5. Create a Storage Node Pool (page 23)
6. Create the Remainder of your Storage Nodes (page 24)
7. Create and Deploy Replication Nodes (page 25)

You perform all of these activities using the Oracle NoSQL Database command line interface (CLI). The remainder of this chapter shows you how to perform these activities. Examples are provided that show you which commands to use, and how. For a complete listing of all the commands available to you in the CLI, see CLI Commands and Subcommands (page 88).

## Start the Administration CLI

To perform store configuration, you use the `runadmin` utility, which provides a command line interface (CLI). The `runadmin` utility can be used for a number of purposes. In this chapter, we want to use it to administer the nodes in our store, so we have to tell `runadmin` what node and registry port it can use to connect to the store.

In this book, we have been using `5000` as the registry port. For this example, we use the string `node01` to represent the network name of the node to which `runadmin` connects.

### Note

You should think about the name of the node to which the runadmin connects. The node used for initial configuration of the store, during store creation, cannot be changed.

The most important thing about this node is that it must have the Storage Node Agent running on it. All your nodes should have an SNA running on them at this point. If not, you need to go follow the instructions in Installing Oracle NoSQL Database (page 10) before proceeding with the steps provided in this chapter.

Beyond that, be aware that if this is the very first node you have ever connected to the store using the CLI, then it becomes the node on which the master copy of the administration database resides. If you happen to care about which node serves that function, then make sure you use that node at this time.

To start `runadmin` for administration purposes:

```
> java -Xmx256m -Xms256m \
-jar KVHOME/lib/kvstore.jar runadmin \
-port 5000 -host node01
```

Note that once you have started the CLI, you can use its `help` command in order to discover all the administration commands available to you.

Also note that the configuration steps described in this chapter can be collected into a script file, and then that file can be passed to the utility using its `-script` command line option. See Using a Script to Configure the Store (page 32) for more information.

## The plan Commands

Some of the steps described in this chapter make heavy use of the CLI's `plan` command. This command identifies a configuration action that you want to perform on the store. You can either run that action immediately or you can create a series of plans with the `-noexecute` flag and then execute them later by using the `plan execute` command.

You can list all available plans by using the `plan` command without arguments.

For a high-level description of plans, see Plans (page 17).

## Configure and Start a Set of Storage Nodes

You should already have configured and started a set of Storage Nodes to host the KVStore cluster. If not, you need to follow the instructions in Installing Oracle NoSQL Database (page 10) before proceeding with this step.

## Name your KVStore

When you start the command line interface, the `kv->` prompt appears. Once you see this, you can name your KVStore by using the `configure -name` command. The only information this command needs is the name of the KVStore that you want to configure.

Note that the name of your store is essentially used to form a path to records kept in the store. For this reason, you should avoid using characters in the store name that might interfere with its use within a file path. The command line interface does not allow an invalid store name. Valid characters are alphanumeric, '-', '_', and '.'.

For example:

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

## Create a Zone

Once you have started the command line interface and configured a store name, you can create at least one Zone. It is possible, and even desirable, to create more than one Zone. Multiple Zones are used to improve the availability of your store. These instructions describe the installation using a single Zone. For a complete walk-through of a store deployment with multiple Zones, see Configuring with Multiple Zones (page 26).

### Note

Once you have added Storage Nodes to a Zone, you cannot remove the Zone from your store.

When you execute the `plan deploy-zone` command, the CLI returns the plan number and whatever additional information it has about plan status. This command takes the following arguments:

- *zone name*

  A string to identify the name of the Zone.

- *replication factor*

  A number specifying the replication factor.

For additional information on how to identify your replication factor and its implications, see Replication Factor (page 126).

When you execute the `plan deploy-zone` command, the CLI returns the plan number. It also returns instructions on how to check the plan's status, or to wait for it to complete. For example:

```
kv-> plan deploy-zone -name "Boston" -rf 3 -wait
Executed plan 1, waiting for completion...
Plan 1 ended successfully
kv->
```

You can show the plans and their status by using the `show plans` command.

```
kv-> show plans
1 Deploy Zone (1)          SUCCEEDED
```

## Create an Administration Process on a Specific Host

Every KVStore has an administration database. You must deploy the Storage Node to which the command line interface is currently connecting to, in this case, "node01", and then deploy an

Administration process on that same node, in order to proceed to configure this database. Use the `deploy-sn` and `deploy-admin` commands to complete this step.

Note that `deploy-sn` requires you to provide a Zone ID. You can get this ID by using the `show topology` command:

```
kv-> show topology
store=mystore numPartitions=0 sequence=1
 zn: id=zn1 name=Boston repFactor=3 type=PRIMARY
kv->
```

The Zone ID is "zn1" in the above output.

When you deploy the node, provide the Zone ID, the node's network name, and its registry port number. For example:

```
kv-> plan deploy-sn -zn zn1 -host node01 -port 5000 -wait
Executed plan 2, waiting for completion...
Plan 2 ended successfully
kv->
```

Having done that, create the administration process on the node that you just deployed. You do this using the `deploy-admin` command. This command requires the Storage Node ID (which you can obtain using the `show topology` command), the administration port number and an optional plan name. You defined the administration port number during the installation process. This book is using `5001` as an example.

```
kv-> plan deploy-admin -sn sn1 -port 5001 -wait
Executed plan 3, waiting for completion...
Plan 3 ended successfully
kv->
```

### Note

At this point you have a single administration process deployed in your store. This is enough to proceed with store configuration. However, to increase your store's reliability, you should deploy multiple administration processes, each running on a different storage node. In this way, you are able to continue to administer your store even if one Storage Node goes down, taking an administration process with it. It also means that you can continue to monitor your store, even if you lose a node running an administration process.

Oracle strongly recommends that you deploy three administration processes for a production store. The additional administration processes do not consume many resources.

Before you can deploy any more administration processes, you must first deploy the rest of your Storage Nodes. This is described in the following sections.

## Create a Storage Node Pool

Once you have created your Administration process, you must create a Storage Node Pool. This pool is used to contain all the Storage Nodes in your store. A Storage Node pool is used for resource distribution when creating or modifying a store. You use the `pool create` command to create this pool. Then you join Storage Nodes to the pool using the `pool join` command.

### Note

You may have multiple kinds of storage nodes in different zones that vary by processor type, speed and/or disk capacity. So the storage node pool lets you define a logical grouping of storage nodes by whatever specification you pick.

Remember that we already have a Storage Node created. We did that when we created the Administration process. Therefore, after we add the pool, we can immediately join that first SN to the pool.

The `pool create` command only requires you to provide the name of the pool.

The `pool join` command requires the name of the pool to which you want to join the Storage Node, and the Storage Node's ID. You can obtain the Storage Node's ID using the `show topology` command.

For example:

```
kv-> pool create -name BostonPool
kv-> show topology
store=mystore numPartitions=0 sequence=2
 zn: id=zn1 name=Boston repFactor=3 type=PRIMARY
 sn=[sn1] zn:[id=zn1 name=Boston] node1:5000 capacity=1 RUNNING
kv-> pool join -name BostonPool -sn sn1
Added Storage Node(s) [sn1] to pool BostonPool
kv->
```

## Create the Remainder of your Storage Nodes

Having created your Storage Node Pool, you can create the remainder of your Storage Nodes. Storage Nodes host the various Oracle NoSQL Database processes for each of the nodes in the store. Consequently, you must do this for each node that you use in your store. Use the `deploy-sn` command in the same way as you did in Create an Administration Process on a Specific Host (page 22). As you deploy each Storage Node, join it to your Storage Node Pool as described in the previous section.

**Hint:** Storage Node IDs increase by one as you add each Storage Node. Therefore, you do not have to keep looking up the IDs with `show topology`. If the Storage Node that you created last had an ID of `10`, then the next Storage Node that you create has an ID of `11`.

```
kv-> plan deploy-sn -zn zn1 -host node02 -port 5000 -wait
Executed plan 4, waiting for completion...
Plan 4 ended successfully
kv-> pool join -name BostonPool -sn sn2
Added Storage Node(s) [sn2] to pool BostonPool
kv-> plan deploy-sn -zn zn1 -host node03 -port 5000 -wait
Executed plan 5, waiting for completion...
Plan 5 ended successfully
```

```
kv-> pool join -name BostonPool -sn sn3
Added Storage Node(s) [sn3] to pool BostonPool
kv->
....
```

Continue this process until you have created Storage Nodes on every node in your store.

### Note

Having deployed all your Storage Nodes, you can now deploy additional administration processes using the `deploy-admin` plan. See Create an Administration Process on a Specific Host (page 22) for details.

## Create and Deploy Replication Nodes

The final step in your configuration process is to create Replication Nodes on every node in your store. You do this using the `topology create` and `plan deploy-topology` commands in its place. The `topology create` command takes the following arguments:

- *topology name*

  A string to identify the topology.

- *pool name*

  A string to identify the pool.

- *number of partitions*

  The initial configuration is based on the storage nodes specified by pool. This number is fixed once the topology is created and it cannot be changed. The command will automatically create an appropriate number of shards and replication nodes based upon the storage nodes in the pool.

  You should make sure the number of partitions you select is more than the largest number of shards you ever expect your store to contain, because the total number of partitions is static and cannot be changed. For simpler use cases, you can use the following formula to arrive at a very rough estimate for the number of partitions:

  ```
  (Total number of disks hosted by the storage nodes  \
   Replication Factor) * 10
  ```

  To get a more accurate estimate for production use see Number of Partitions (page 133).

The `plan deploy-topology` command requires a topology name.

Once you issue the following commands, your store is fully installed and configured:

```
kv-> topology create -name topo -pool BostonPool -partitions 300
Created: topo
kv-> plan deploy-topology -name topo -wait
Executed plan 6, waiting for completion...
```

```
Plan 6 ended successfully
```

As a final sanity check, you can confirm that all of the plans succeeded using the `show plans` command:

```
kv-> show plans
1 Deploy Zone (1)          SUCCEEDED
2 Deploy Storage Node (2)  SUCCEEDED
3 Deploy Admin Service (3) SUCCEEDED
4 Deploy Storage Node (4)  SUCCEEDED
5 Deploy Storage Node (5)  SUCCEEDED
6 Deploy-RepNodes          SUCCEEDED
```

Having done that, you can exit the command line interface.

```
kv-> exit
```

## Configuring with Multiple Zones

Optimal use of available physical facilities is achieved by deploying your store across multiple Zones. This provides fault isolation and availability for your data if a single zone fails. Each Zone has a copy of your complete store, including a copy of all the shards. With this configuration, reads are always possible, so long as your data's consistency guarantees can be met, because at least one replica is located in every Zone. Writes can also occur in the event of a Zone loss so long as quorum can be maintained.

You can specify a different replication factor to each Zone. The total replication factor of the store is the sum of the replication factor of all the Zones.

Zones located nearby have the benefit of avoiding bottlenecks due to throughput limitations, as well as reducing latency during elections and commits.

### Note

Zones come in two types. *Primary* zones contain nodes which can serve as masters or replicas. Zones are created as primary zones by default. For good performance, primary zones should be connected by low latency networks so that they can participate efficiently in master elections and commit acknowledgments.

*Secondary* zones contain nodes which can only serve as replicas. Secondary zones can be used to provide low latency read access to data at a distant location, or to maintain an extra copy of the data to increase redundancy or increase read capacity. Because the nodes in secondary zones do not participate in master elections or commit acknowledgments, secondary zones can be connected to other zones by higher latency networks, because additional latency will not interfere with those time critical operations.

Using high throughput and low latency networks to connect primary zones leads to better results and improved performance. You can use networks with higher latency to connect to secondary zones so long as the connections provide sufficient throughput to support replication and sufficient reliability that temporary interruptions do not interfere with network throughput.

### Note

Because any primary zone can host master nodes, write performance may be reduced if primary zones are connected through a limited throughput and/or high latency network link.

The following steps walk you through the process of deploying six Storage Nodes across three primary zones. You can then verify that each shard has a replica in every Zone; service can be continued in the event of a Zone failure.

### Note

In following examples six Storage Node Agents are started on the same host, but in a production environment one Storage Node Agent should be hosted per physical machine.

1. For a new store, create the initial "boot config" configuration files using the makebootconfig utility:

```
> java -Xmx256m -Xms256m \
-jar KVHOME/lib/kvstore.jar makebootconfig \
-root KVROOT -host localhost -config config1.xml \
-port 5010 -admin 5011 -harange 5012,5015 \
-memory_mb 0 -store-security none

java -Xmx256m -Xms256m \
-jar KVHOME/lib/kvstore.jar makebootconfig \
-root KVROOT -host localhost -config config2.xml \
-port 5020 -admin 5021 -harange 5022,5025 \
-memory_mb 0 -store-security none

java -Xmx256m -Xms256m \
-jar KVHOME/lib/kvstore.jar makebootconfig \
-root KVROOT -host localhost -config config3.xml \
-port 5030 -admin 5031 -harange 5032,5035 \
-memory_mb 0 -store-security none

java -Xmx256m -Xms256m \
-jar KVHOME/lib/kvstore.jar makebootconfig \
-root KVROOT -host localhost -config config4.xml \
-port 5040 -harange 5042,5045 \
-memory_mb 0 -store-security none

java -Xmx256m -Xms256m \
-jar KVHOME/lib/kvstore.jar makebootconfig \
-root KVROOT -host localhost -config config5.xml \
-port 5050 -harange 5052,5055 \
-memory_mb 0 -store-security none

java -Xmx256m -Xms256m \
-jar KVHOME/lib/kvstore.jar makebootconfig \
-root KVROOT -host localhost -config config6.xml \
-port 5060 -harange 5062,5065 \
-memory_mb 0 -store-security none
```

2. Using each of the configuration files, start all of the Storage Node Agents:

```
> nohup java -Xmx256m -Xms256m \
-jar KVHOME/lib/kvstore.jar \
start -root KVROOT -config config1.xml
> [1] 12019

> nohup java -Xmx256m -Xms256m \
-jar KVHOME/lib/kvstore.jar \
start -root KVROOT -config config2.xml
> [2] 12020

> nohup java -Xmx256m -Xms256m \
-jar KVHOME/lib/kvstore.jar \
start -root KVROOT -config config3.xml
> [3] 12021

> nohup java -Xmx256m -Xms256m \
-jar KVHOME/lib/kvstore.jar \
start -root KVROOT -config config4.xml
> [4] 12022

> nohup java -Xmx256m -Xms256m \
-jar KVHOME/lib/kvstore.jar \
start -root KVROOT -config config5.xml
> [5] 12023

> nohup java -Xmx256m -Xms256m \
-jar KVHOME/lib/kvstore.jar \
start -root KVROOT -config config6.xml
> [6] 12024
```

3. Start the CLI:

```
> java -Xmx256m -Xms256m \
-jar KVHOME/lib/kvstore.jar runadmin -host \
localhost -port 5010
kv->
```

4. Name your store:

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

5. Deploy the first Storage Node with administration process in the Manhattan Zone:

```
kv-> plan deploy-zone -name Manhattan -rf 1 -wait
Executed plan 1, waiting for completion...
Plan 1 ended successfully
kv-> plan deploy-sn -zn 1 -host localhost -port 5010 -wait
Executed plan 2, waiting for completion...
Plan 2 ended successfully
kv-> plan deploy-admin -sn sn1 -port 5011 -wait
Executed plan 3, waiting for completion...
Plan 3 ended successfully
kv-> pool create -name SNs
kv-> pool join -name SNs -sn sn1
Added Storage Node(s) [sn1] to pool SNs
```

6. Deploy a second Storage Node in Manhattan Zone:

```
kv-> plan deploy-sn -znname Manhattan -host localhost \
-port 5020 -wait
kv-> Executed plan 4, waiting for completion...
Plan 4 ended successfully
kv-> pool join -name SNs -sn sn2
Added Storage Node(s) [sn2] to pool SNs
```

7. Deploy the first Storage Node with administration process in the Jersey City Zone:

```
kv-> plan deploy-zone -name JerseyCity -rf 1 -wait
Executed plan 5, waiting for completion...
Plan 5 ended successfully
kv-> plan deploy-sn -znname JerseyCity -host localhost \
-port 5030 -wait
Executed plan 6, waiting for completion...
Plan 6 ended successfully
kv-> plan deploy-admin -sn sn3 -port 5031 -wait
Executed plan 7, waiting for completion...
Plan 7 ended successfully
kv-> pool join -name SNs -sn sn3
Added Storage Node(s) [sn3] to pool SNs
```

8. Deploy a second Storage Node in Jersey City Zone:

```
kv-> plan deploy-sn -znname JerseyCity -host localhost \
-port 5040 -wait
kv-> Executed plan 8, waiting for completion...
Plan 8 ended successfully
kv-> pool join -name SNs -sn sn4
Added Storage Node(s) [sn4] to pool SNs
```

9. Deploy the first Storage Node with administration process in the Queens Zone:

```
kv-> plan deploy-zone -name Queens -rf 1 -wait
Executed plan 9, waiting for completion...
Plan 9 ended successfully
```

```
kv-> plan deploy-sn -znname Queens -host localhost -port 5050 -wait
Executed plan 10, waiting for completion...
Plan 10 ended successfully
kv-> plan deploy-admin -sn sn5 -port 5051 -wait
Executed plan 11, waiting for completion...
Plan 11 ended successfully
kv-> pool join -name SNs -sn sn5
Added Storage Node(s) [sn5] to pool SNs
```

10. Deploy a second Storage Node in Queens Zone:

```
kv-> plan deploy-sn -znname Queens -host localhost \
-port 5060 -wait
kv-> Executed plan 12, waiting for completion...
Plan 12 ended successfully
kv-> pool join -name SNs -sn sn6
Added Storage Node(s) [sn6] to pool SNs
```

11. Create and deploy a topology:

```
kv-> topology create -name Topo1 -pool SNs -partitions 100
Created: Topo1
kv-> plan deploy-topology -name Topo1 -wait
kv-> Executed plan 13, waiting for completion...
Plan 13 ended successfully
```

12. Check service status with the `show topology` command:

```
kv->kv-> show topology
store=MetroArea numPartitions=100 sequence=117
zn: id=zn1 name=Manhattan repFactor=1 type=PRIMARY
zn: id=zn2 name=JerseyCity repFactor=1 type=PRIMARY
zn: id=zn3 name=Queens repFactor=1 type=PRIMARY

sn=[sn1] zn=[id=zn1 name=Manhattan] localhost:5010 capacity=1 RUNNING
  [rg1-rn2] RUNNING
     No performance info available
sn=[sn2] zn=[id=zn1 name=Manhattan] localhost:5020 capacity=1 RUNNING
  [rg2-rn2] RUNNING
     No performance info available
sn=[sn3] zn=[id=zn2 name=JerseyCity] localhost:5030 capacity=1 RUNNING
  [rg1-rn3] RUNNING
     No performance info available
sn=[sn4] zn=[id=zn2 name=JerseyCity] localhost:5040 capacity=1 RUNNING
  [rg2-rn3] RUNNING
     No performance info available
sn=[sn5] zn=[id=zn3 name=Queens] localhost:5050 capacity=1 RUNNING
  [rg1-rn1] RUNNING
     No performance info available
sn=[sn6] zn=[id=zn3 name=Queens] localhost:5060 capacity=1 RUNNING
  [rg2-rn1] RUNNING
```

```
     No performance info available

shard=[rg1] num partitions=50
  [rg1-rn1] sn=sn5
  [rg1-rn2] sn=sn1
  [rg1-rn3] sn=sn3
shard=[rg2] num partitions=50
  [rg2-rn1] sn=sn6
  [rg2-rn2] sn=sn2
  [rg2-rn3] sn=sn4
```

13. Verify that each shard has a replica in every zone:

```
kv-> verify configuration
Verify: starting verification of MetroArea based
upon topology sequence #117
100 partitions and 6 storage nodes.
Version: 12.1.3.0.1 Time: 2014-01-07 20:10:45 UTC
See localhost:/tm/kvroot/MetroArea/log/MetroArea_{0..N}.log
for progress messages
Verify: == checking storage node sn1 ==
Verify: Storage Node [sn1] on localhost:5010
Zone: [name=Manhattan id=zn1 type=PRIMARY]
Status: RUNNING
Ver: 12cR1.3.0.1 2013-12-18 06:35:02 UTC  Build id: 8e70b50c0b0e
Verify: Admin [admin]
Status: RUNNING
Verify: Rep Node [rg1-rn2]
Status: RUNNING, REPLICA at sequence number: 121 haPort: 5013
Verify: == checking storage node sn2 ==
Verify: Storage Node [sn2] on localhost:5020
Zone: [name=Manhattan id=zn1 type=PRIMARY]
Status: RUNNING
Ver: 12cR1.3.0.1 2013-12-18 06:35:02 UTC  Build id: 8e70b50c0b0e
Verify: Rep Node [rg2-rn2]
Status: RUNNING, REPLICA at sequence number: 121 haPort: 5022
Verify: == checking storage node sn3 ==
Verify: Storage Node [sn3] on localhost:5030
Zone: [name=JerseyCity id=zn2 type=PRIMARY]
Status: RUNNING
Ver: 12cR1.3.0.1 2013-12-18 06:35:02 UTC  Build id: 8e70b50c0b0e
Verify: Admin [admin2]
Status: RUNNING
Verify: Rep Node [rg1-rn3]
Status: RUNNING, REPLICA at sequence number: 121 haPort: 5033
Verify: == checking storage node sn4 ==
Verify: Storage Node [sn4] on localhost:5040
Zone: [name=JerseyCity id=zn2 type=PRIMARY]
Status: RUNNING
Ver: 12cR1.3.0.1 2013-12-18 06:35:02 UTC  Build id: 8e70b50c0b0e
```

```
Verify: Rep Node [rg2-rn3]
Status: RUNNING, REPLICA at sequence number: 121 haPort: 5042
Verify: == checking storage node sn5 ==
Verify: Storage Node [sn5] on localhost:5050
Zone: [name=Queens id=zn3 type=PRIMARY]
Status: RUNNING
Ver: 12cR1.3.0.1 2013-12-18 06:35:02 UTC  Build id: 8e70b50c0b0e
Verify: Admin [admin3]
Status: RUNNING
Verify: Rep Node [rg1-rn1]
Status: RUNNING, MASTER at sequence number: 121 haPort: 5053
Verify: == checking storage node sn6 ==
Verify: Storage Node [sn6] on localhost:5060
Zone: [name=Queens id=zn3 type=PRIMARY]
Status: RUNNING
Ver: 12cR1.3.0.1 2013-12-18 06:35:02 UTC  Build id: 8e70b50c0b0e
Verify: Rep Node [rg2-rn2]
Status: RUNNING, MASTER at sequence number: 121 haPort: 5062
Verification complete, no violations.
```

In the previous example there are three zones (zn1 = Manhattan, zn2 = JerseyCity, zn3=Queens) with six Replication Nodes (two masters and four replicas) in this cluster. This means that this topology is not only highly available because you have three replicas within each shard, but it is also able to recover from a single zone failure. If any zone fails, the other two zones are enough to elect the new master, so service continues without any interruption.

## Using a Script to Configure the Store

Up to this point, we have shown how to configure a store using an interactive command line interface session. However, you can collect all of the commands used in the prior sections into a script file, and then run them in a single batch operation. To do this, use the `load` command in the command line interface. For example:

Using the `load -file` command line option:

```
 java -Xmx256m -Xms256m \
-jar KVHOME/lib/kvstore.jar runadmin -port 5000 -host node01 \
load -file scrpt.txt
kv->
```

Using directly the `load -file` command:

```
kv->load -file <path to file>
```

Using this command you can load the named file and interpret its contents as a script of commands to be executed.

The file, `scrpt.txt`, would then contain content like this:

```
### Begin Script ###
configure -name mystore
```

```
plan deploy-zone -name "Boston" -rf 3 -wait
plan deploy-sn -zn zn1 -host node01 -port 5000 -wait
plan deploy-admin -sn sn1 -port 5001 -wait
pool create -name BostonPool
pool join -name BostonPool -sn sn1
plan deploy-sn -zn zn1 -host node02 -port 5000 -wait
pool join -name BostonPool -sn sn2
plan deploy-sn -zn zn1 -host node03 -port 5000 -wait
pool join -name BostonPool -sn sn3
topology create -name topo -pool BostonPool -partitions 300
plan deploy-topology -name topo -wait
exit
### End Script ###
```

## Smoke Testing the System

There are several things you can do to ensure that your KVStore is up and fully functional.

1. Run the ping command.

```
> java -Xmx256m -Xms256m \
-jar KVHOME/lib/kvstore.jar ping -port 5000 -host node01
Pinging components of store mystore based upon topology sequence #107
mystore comprises 300 partitions on 3 Storage Nodes
Storage Node [sn1] on node01:5000
Zone: [name=Boston id=zn1 type=PRIMARY]
Status: RUNNING Ver: 12cR1.3.0.1 2013-12-18 06:35:02 UTC
Build id: 8e70b50c0b0e
       Rep Node [rg1-rn1] Status:RUNNING,MASTER at sequence number:31
haPort:5011
Storage Node [sn2] on node02:5000
Zone: [name=Boston id=zn1 type=PRIMARY]
Status: RUNNING Ver: 12cR1.3.0.1 2013-12-18 06:35:02 UTC
Build id: 8e70b50c0b0e
       Rep Node [rg1-rn2] Status:RUNNING,REPLICA at sequence number:31
haPort:5011
Storage Node [sn3] on node03:5000
Zone: [name=Boston id=zn1 type=PRIMARY]
Status: RUNNING Ver: 12cR1.3.0.1 2013-12-18 06:35:02 UTC
Build id: 8e70b50c0b0e
       Rep Node [rg1-rn3] Status:RUNNING,REPLICA at sequence number:31
haPort:5011
```

2. Run the simple "hello world" example. Go to the KVHOME directory and compile the example:

```
javac -cp lib/kvclient.jar:examples examples/hello/*.java
```

Then run the example (from any directory):

```
java -Xmx256m -Xms256m \
-cp KVHOME/lib/kvclient.jar:KVHOME/examples \
     hello.HelloBigDataWorld \
     -host <hostname> -port <hostport> -store <kvstore name>
```

This should write the following line to stdout:

```
Hello Big Data World!
```

3. Look through the Javadoc. You can access it from the documentation index page, which can be found at `KVHOME/doc/index.html`.

If you run into installation problems or want to start over with a new store, then on every node in the system:

1. Stop the node using:

   ```
   java -Xmx256m -Xms256m \
   -jar KVHOME/lib/kvstore.jar stop -root KVROOT
   ```

2. Remove the contents of the KVROOT directory:

   ```
   rm -rf KVROOT
   ```

3. Start over with the steps described in Installation Configuration (page 12).

## Troubleshooting

Typical errors when bringing up a store are typos and misconfiguration. It is also possible to run into network port conflicts, especially if the deployment failed and you are starting over. In that case be sure to remove all partial store data and configuration and kill any remnant processes. Processes associated with a store as reported by "jps -m" are one of these:

StorageNodeAgentImpl
ManagedService

If you kill the StorageNodeAgentImpl it should also kill its managed processes.

You can use the monitoring tab in the Admin Console to look at various log files.

There are detailed log files available in `KVROOT/storename/log` as well as logs of the bootstrap process in `KVROOT/*.log`. The bootstrap logs are most useful in diagnosing initial startup problems. The logs in `storename/log` appear once the store has been configured. The logs on the host chosen for the admin process are the most detailed and include a store-wide consolidated log file: `KVROOT/storename/log/storename_*.log`

Each line in a log file is prefixed with the date of the message, its severity, and the name of the component which issued it. For example:

```
2012-10-25 14:28:26.982 UTC INFO [admin1] Initializing Admin for store:
kvstore
```

When looking for more context for events at a given time, use the timestamp and component name to narrow down the section of log to peruse.

Error messages in the logs show up with "SEVERE" in them so you can grep for that if you are troubleshooting. SEVERE error messages are also displayed in the Admin's Topology tab, in the CLI's `show events` command, and when you use the `ping` command.

In addition to log files, these directories may also contain *.perf files, which are performance files for the Replication Nodes.

## Where to Find Error Information

As your store operates, you can discover information about any problems that may be occurring by looking at the plan history and by looking at error logs.

The plan history indicates if any configuration or operational actions you attempted to take against the store encountered problems. This information is available as the plan executes and finishes. Errors are reported in the plan history each time an attempt to run the plan fails. The plan history can be seen using the CLI `show plan` command, or in the Admin's `Plan History` tab.

Other problems may occur asynchronously. You can learn about unexpected failures, service downtime, and performance issues through the Admin's critical events display in the Logs tab, or through the CLI's `show events` command. Events come with a time stamp, and the description may contain enough information to diagnose the issue. In other cases, more context may be needed, and the administrator may want to see what else happened around that time.

The store-wide log consolidates logging output from all services. Browsing this file might give you a more complete view of activity during the problem period. It can be viewed using the Admin's Logs tab, by using the CLI's `logtail` command, or by directly viewing the <storename>_N.log file in the <KVHOME>/<storename>/log directory. It is also possible to download the store-wide log file using the Admin's Logs tab.

## Service States

Oracle NoSQL Database uses three different types of services, all of which should be running correctly in order for your store to be in a healthy state. The three service types are the Admin, Storage Nodes, and Replication Nodes. You should have multiple instances of these services running throughout your store.

Each service has a status that can be viewed using any of the following:

- The Topology tab in the Admin Console
- The `show topology` command in the Administration CLI.
- Using the `ping` command.

The status values can be one of the following:

- `STARTING`

  The service is coming up.

- `RUNNING`

  The service is running normally.

- `STOPPING`

  The service is stopping. This may take some time as some services can be involved in time-consuming activities when they are asked to stop.

- `WAITING_FOR_DEPLOY`

  The service is waiting for commands or acknowledgments from other services during its startup processing. If it is a Storage Node, it is waiting for the initial deploy-SN command. Other services should transition out of this phase without any administrative intervention from the user.

- `STOPPED`

  The service was stopped intentionally and cleanly.

- `ERROR_RESTARTING`

  The service is in an error state. Oracle NoSQL Database attempts to restart the service.

- `ERROR_NO_RESTART`

  The service is in an error state and is not automatically restarted. Administrative intervention is required.

- `UNREACHABLE`

  The service is not reachable by the Admin. If the status was seen using a command issued by the Admin, this state may mask a STOPPED or ERROR state.

A healthy service begins with `STARTING`. It may transition to `WAITING_FOR_DEPLOY` for a short period before going on to `RUNNING`.

`ERROR_RESTARTING` and `ERROR_NO_RESTART` indicate that there has been a problem that should be investigated. An `UNREACHABLE` service may only be in that state temporarily, although if that state persists, the service may be truly in an `ERROR_RESTARTING` or `ERROR_NO_RESTART` state.

Note that the Admin's Topology tab only shows abnormal service statuses. A service that is `RUNNING` does not display its status in that tab.

## Useful Commands

The following commands may be useful to you when troubleshooting your KVStore:

- `java -Xmx256m -Xms256m -jar KVHOME/lib/kvstore.jar ping -host <host> -port <registryport>`

Reports the status of the store running on the specified host and port. This command can be used against any of the host and port pairs used for Storage Nodes.

- `jps -m`

  Reports the Java processes running on a machine. If the Oracle NoSQL Database processes are running, they are reported by this command.

In addition you can use the administration console to investigate the state of the KVStore. Point your browser to the administration port chosen on the administration host.

# Chapter 5. Determining Your Store's Configuration

A store consists of a number of Storage Nodes. Each Storage Node can host one or more Replication Nodes, based on its capacity value. The term `topology` is used to describe the distribution of Replication Nodes. A topology is derived from the number and capacity of available Storage Nodes, the number of partitions in the store, and the replication factors of the store's zones. Topology layouts are also governed by a set of rules that maximize the availability of the store.

All topologies must obey the following rules:

1. Each Replication Node from the same shard must reside on a different Storage Node. This rule prevents a single Storage Node failure from causing multiple points of failure for a single shard.
2. The number of Replication Nodes assigned to a Storage Node must be less than or equal to the capacity of Storage Nodes.
3. A zone must have one or more Replication Nodes from each shard.

The initial configuration, or topology of the store is set when the store is created. Over time, it may be necessary to change the topology of the store. There are several reasons for such a change:

1. You need to replace or upgrade an existing Storage Node.
2. You need to increase read throughput. This is done by increasing the replication factor and creating more copies of the store's data which can be used to service read only requests.
3. You need to increase write throughput. Since each shard has a single master node, distributing the data in the store over a larger number of shards provides the store with more nodes that can execute write operations.

You change the store's configuration by changing the the number or capacity of Storage Nodes available, or the replication factor of a zone. To change from one configuration to another, you either create a new initial topology, or you `clone` an existing topology and modify it into your target topology. You then deploy this target topology.

## Note

The deployment of the target topology is potentially a long-running operation and the time required scales with the amount of data that must be moved. During the deployment, the system updates the topology at each step. Because of that, the store passes through intermediate topologies which were not explicitly created by the user.

This chapter discusses how configuration, or topological changes are made in a store.

## Note

Configuration changes should not be made while a snapshot is being taken and vice versa. When making configuration changes it is safest to first create a snapshot as a backup and then make the changes. For additional information on creating snapshots, see Taking a Snapshot (page 57).

## Steps for Changing the Store's Topology

When you change your topology, you should go through these steps:

1. Make the Topology Candidate (page 39)
2. Transform the Topology Candidate (page 40)
3. View the Topology Candidate (page 43)
4. Validate the Topology Candidate (page 43)
5. Preview the Topology Candidate (page 44)
6. Deploy the Topology Candidate (page 44)
7. Verify the Store's Current Topology (page 46)

Creating a new topology may be an iterative process. You may want to try different options to see what may be best before the changes are deployed. In the end, examine the topology candidate and decide if it is satisfactory. If not, apply more transformations, or start over with different parameters. You can view and validate topology candidates to decide if they are appropriate.

The possible transformations include redistributing data, increasing replication factor, and rebalancing. These are described in Transform the Topology Candidate (page 40).

The following sections walk you through the process of changing the configuration for your store using the Administration Command Line Interface.

### Make the Topology Candidate

To create the first topology candidate for an initial deployment, before any Replication Nodes exist, you use the `topology create` command. The `topology create` command takes a topology name, a pool name and the number of partitions as arguments.

For example:

```
kv-> topology create -name firstTopo -pool BostonPool -partitions 300
Created: firstTopo
```

This initial topology candidate can be deployed, without any further transformations, using the `plan deploy-topology` command.

After the store is deployed, topology candidates are created with the topology clone command. A clone's source can be another topology candidate, or the current, deployed topology. The `topology clone` command takes the following arguments:

- `-from <from topology>`

  The name of the source topology candidate.

- `-name <to topology>`

  The name of the clone.

For example:

```
kv-> topology clone -from topo -name CloneTopo
Created CloneTopo
```

Also, there is a variant of the topology create command that takes the following arguments:

- `-current`

  If specified, use the current, deployed topology as a source.

- `-name <to topology>`

  The name of the clone.

For example:

```
kv-> topology clone -current -name ClonedTopo
Created ClonedTopo
```

## Transform the Topology Candidate

After the initial deployment, the store is changed by deploying a topology candidate that differs from the topology currently in effect. This target topology is generated by transforming a topology candidate using the `topology redistribute, rebalance, or change-repfactor` command.

Transformations follow the topology rules described in the previous section.

The topology rebalance, redistribute or change-repfactor commands can only make changes to the topology candidate if there are additional, or changed, Storage Nodes available. It uses the new resources to rearrange Replication Nodes and partitions so the topology complies with the topology rules and the store improves on read or write throughput.

The following are scenarios in how you might expand the store.

### Increase Data Distribution

You can increase data distribution in order to enhance write throughput by using the `topology redistribute` command. The redistribute command only works if new Storage Nodes are added to permit the creation of new shards. Partitions are distributed across the new shards, resulting in more Replication Nodes to service write operations.

The following example demonstrates adding a set of Storage Nodes and redistributing the data to those nodes. In this example four nodes are added because the zone's replication factor is four and the new partition requires four nodes to satisfy the replication requirements:

```
kv-> plan deploy-sn -zn zn1 -host node04 -port 5000 -wait
Executed plan 7, waiting for completion...
Plan 7 ended successfully
```

```
kv-> plan deploy-sn -zn zn1 -host node05 -port 5000 -wait
Executed plan 8, waiting for completion...
Plan 8 ended successfully
kv-> plan deploy-sn -zn zn1 -host node06 -port 5000 -wait
Executed plan 9, waiting for completion...
Plan 9 ended successfully
kv-> plan deploy-sn -zn zn1 -host node07 -port 5000 -wait
Executed plan 10, waiting for completion...
Plan 10 ended successfully
kv-> pool join -name BostonPool -sn sn4
Added Storage Node(s) [sn4] to pool BostonPool
kv-> pool join -name BostonPool -sn sn5
Added Storage Node(s) [sn5] to pool BostonPool
kv-> pool join -name BostonPool -sn sn6
Added Storage Node(s) [sn6] to pool BostonPool
kv-> pool join -name BostonPool -sn sn7
Added Storage Node(s) [sn7] to pool BostonPool
kv-> topology clone -current -name newTopo
Created newTopo
kv-> topology redistribute -name newTopo -pool BostonPool
Redistributed: newTopo
kv-> plan deploy-topology -name newTopo -wait
Executed plan 11, waiting for completion...
Plan 11 ended successfully
```

The redistribute command uses added capacity to create new shards and to migrate partitions to those shards. The command fails if the number of new shards is not greater than the current number of shards.

### Note

Redistribute commands should not issued against a mixed shard store. A mixed shard store has shards whose Replication Nodes are operating with different software versions of Oracle NoSQL Database.

The system goes through these steps when it is redistributing a topology candidate:

1. New Replication Nodes are created for each shard and are assigned to Storage Nodes following the topology rules described earlier. It may be necessary to move existing Replication Nodes to different Storage Nodes to best use available resources while still complying with the topology rules.
2. Partitions are distributed evenly among all shards. Partitions that are in shards that are over populated will move to the shards with the least number of partitions.
3. You do not specify which partitions are moved.

## Increase Replication Factor

You can increase the replication factor and create more copies of the data to improve read throughput and availability by using the `topology change-repfactor` command. More

Replication Nodes are added to each shard so that it has the requisite number of nodes. The new Replication Nodes are populated from existing nodes in the shard. Since every shard in a zone has the same replication factor, if there are a large number of shards, this command may require a significant number of new Storage Nodes to be successful.

For additional information on how to identify your replication factor and its implications, see Replication Factor (page 126).

The following example increases the replication factor of the store to 4. The administrator deploys a new Storage Node and adds it to the Storage Node pool. The admin then clones the existing topology and transforms it to use a new replication factor of 4.

```
kv-> plan deploy-sn -zn zn1 -host node08 -port 5000 -wait
Executed plan 12, waiting for completion...
Plan 12 ended successfully
kv-> pool join -name BostonPool -sn sn8
Added Storage Node(s) [sn8] to pool BostonPool
kv-> topology clone -current -name repTopo
Created repTopo
kv-> topology change-repfactor -name repTopo -pool BostonPool -rf 4 -zn zn1
Changed replication factor in repTopo
kv-> plan deploy-topology -name repTopo -wait
Executed plan 13, waiting for completion...
Plan 13 ended successfully
```

The change-repfactor command fails if:

1. The new replication factor is less than or equal to the current replication factor.
2. The Storage Nodes specified by the storage node pool do not have enough capacity to host the required new Replication Nodes.

## Balance a Non-Compliant Topology

Topologies must obey the rules described in Determining Your Store's Configuration (page 38). Changes to the physical characteristics of the store can make the current topology of the store violate those rules. For example, after performance tuning, you may want to decrease the capacity of a Storage Node. If that node was already hosting the maximum permissible number of Replication Nodes, reducing the capacity will put the store out of compliance with the capacity rules.

You can balance a non-compliant configuration by using the `topology rebalance` command. This command requires a topology candidate name and a Storage Node pool name.

The following example examines the topology candidate named `repTopo` for any violations to the topology rules. If no improvements are needed as a result of this examination, the topology candidate is unchanged. However, if improvements are needed, then the `topology rebalance` command will move or create Replication Nodes, using the Storage Nodes in the BostonPool pool, in order to correct any violations. The command does not under any circumstances create additional shards.

```
kv-> topology rebalance -name repTopo -pool BostonPool
```

```
Rebalanced: repTopo
```

If there are an insufficient number of Storage Nodes, the `topology rebalance` command may not be able to correct all violations. In that case, the command makes as much progress as possible, and warns of remaining issues.

## View the Topology Candidate

You can view details of the topology candidate or a deployed topology by using the `topology view` command. The command takes a topology name as an argument. With the topology view command, you can view all at once: the store name, number of partitions, shards, replication factor, host name and capacity in the specified topology.

For example:

```
kv-> topology view -name repTopo
store=mystore  numPartitions=300 sequence=315
  zn: id=zn1 name=Boston repFactor=4 type=PRIMARY

  sn=[sn1]  zn:[id=zn1 name=Boston] node01:5000 capacity=1
    [rg1-rn1]
  sn=[sn2]  zn:[id=zn1 name=Boston] node02:5000 capacity=1
    [rg1-rn2]
  sn=[sn3]  zn:[id=zn1 name=Boston] node03:5000 capacity=1
    [rg1-rn3]
  sn=[sn4]  zn:[id=zn1 name=Boston] node04:5000 capacity=1
    [rg1-rn4]
  sn=[sn5]  zn:[id=zn1 name=Boston] node05:5000 capacity=1
  sn=[sn6]  zn:[id=zn1 name=Boston] node06:5000 capacity=1
  sn=[sn7]  zn:[id=zn1 name=Boston] node07:5000 capacity=1
  sn=[sn8]  zn:[id=zn1 name=Boston] node08:5000 capacity=1

  shard=[rg1] num partitions=300
    [rg1-rn1] sn=sn1
    [rg1-rn2] sn=sn2
    [rg1-rn3] sn=sn3
    [rg1-rn4] sn=sn4
```

## Validate the Topology Candidate

You can validate the topology candidate or a deployed topology by using the `topology validate` command. The topology validate command takes a topology name as an argument. If no topology is specified, the current topology is validated. Validation makes sure that the topology candidate obeys the topology rules described in Determining Your Store's Configuration (page 38). Validation generates "violations" and "notes".

Violations are issues that can cause problems and should be investigated.

Notes are informational and highlight configuration oddities that may be potential issues, but may be expected.

For example:

```
kv-> topology validate -name repTopo
Validation for topology candidate "repTopo":
4 warnings.
sn7 has 0 RepNodes and is under its capacity limit of 1
sn8 has 0 RepNodes and is under its capacity limit of 1
sn5 has 0 RepNodes and is under its capacity limit of 1
sn6 has 0 RepNodes and is under its capacity limit of 1
```

## Preview the Topology Candidate

You should preview the changes that would be made for the specified topology candidate relative to a starting topology. You use the `topology preview` command to do this. This command takes the following arguments:

- *name*

  A string to identify the topology.

- *start <from topology>*

  If -start topology name is not specified, the current topology is used. This command should be used before deploying a new topology.

For example:

```
kv-> topology clone -current -name redTopo
Created redTopo
kv-> topology redistribute -name redTopo -pool BostonPool
Redistributed: redTopo
kv-> topology preview -name redTopo
Topology transformation from current deployed topology to redTopo:
Create 1 shard
Create 4 RNs
Migrate 150 partitions

shard rg2
  4 new RNs: rg2-rn1 rg2-rn2 rg2-rn3 rg2-rn4
  150 partition migrations
kv-> topology validate -name redTopo
Validation for topology candidate "redTopo":
No problems
```

## Deploy the Topology Candidate

With a satisfactory topology candidate, you can use the admin service to generate and execute a plan which migrates the store to the new topology.

You can deploy the topology candidate by using the `plan deploy-topology` command. This command takes a topology name as an argument.

While the plan is executing, you can monitor the plan's progress. You have several options:

- The plan can be interrupted then retried, or canceled.
- Other, limited plans may be executed while a transformation plan is in progress to deal with ongoing problems or failures.

By default, the `plan deploy-topology` command refuses to deploy a topology candidate if it introduces new violations of the topology rules. This behavior can be overridden by using the `-force` optional plan flag on that command.

For example:

```
kv-> show topology
store=mystore  numPartitions=300 sequence=315
  zn: id=zn1 name=Boston repFactor=4 type=PRIMARY

  sn=[sn1]  zn=[id=zn1 name=Boston] node01:5000 capacity=1 RUNNING
    [rg1-rn1] RUNNING
           No performance info available
  sn=[sn2]  zn=[id=zn1 name=Boston] node02:5000 capacity=1 RUNNING
    [rg1-rn2] RUNNING
           No performance info available
  sn=[sn3]  zn=[id=zn1 name=Boston] node03:5000 capacity=1 RUNNING
    [rg1-rn3] RUNNING
           No performance info available
  sn=[sn4]  zn=[id=zn1 name=Boston] node04:5000 capacity=1 RUNNING
    [rg1-rn4] RUNNING
           No performance info available
  sn=[sn5]  zn=[id=zn1 name=Boston] node05:5000 capacity=1
  sn=[sn6]  zn=[id=zn1 name=Boston] node06:5000 capacity=1
  sn=[sn7]  zn=[id=zn1 name=Boston] node07:5000 capacity=1
  sn=[sn8]  zn=[id=zn1 name=Boston] node08:5000 capacity=1

  shard=[rg1] num partitions=300
    [rg1-rn1] sn=sn1
    [rg1-rn2] sn=sn2
    [rg1-rn3] sn=sn3
    [rg1-rn4] sn=sn4
kv-> plan deploy-topology -name redTopo -wait
Executed plan 14, waiting for completion...
Plan 14 ended successfully
kv-> show topology
store=mystore  numPartitions=300 sequence=470
  zn: id=zn1 name=Boston repFactor=4 type=PRIMARY

  sn=[sn1]  zn:[id=zn1 name=Boston] node01:5000 capacity=1 RUNNING
    [rg1-rn1] RUNNING
          No performance info available
  sn=[sn2]  zn:[id=zn1 name=Boston] node02:5000 capacity=1 RUNNING
```

```
    [rg1-rn2] RUNNING
          No performance info available
  sn=[sn3]  zn:[id=zn1 name=Boston] node03:5000 capacity=1 RUNNING
    [rg1-rn3] RUNNING
          No performance info available
  sn=[sn4]  zn:[id=zn1 name=Boston] node04:5000 capacity=1 RUNNING
    [rg1-rn4] RUNNING
          No performance info available
  sn=[sn5]  zn:[id=zn1 name=Boston] node05:5000 capacity=1 RUNNING
    [rg2-rn1] RUNNING
          No performance info available
  sn=[sn6]  zn:[id=zn1 name=Boston] node06:5000 capacity=1 RUNNING
    [rg2-rn2] RUNNING
          No performance info available
  sn=[sn7]  zn:[id=zn1 name=Boston] node07:5000 capacity=1 RUNNING
    [rg2-rn3] RUNNING
          No performance info available
  sn=[sn8]  zn:[id=zn1 name=Boston] node08:5000 capacity=1 RUNNING
    [rg2-rn4] RUNNING
          No performance info available

  shard=[rg1] num partitions=150
    [rg1-rn1] sn=sn1
    [rg1-rn2] sn=sn2
    [rg1-rn3] sn=sn3
    [rg1-rn4] sn=sn4
  shard=[rg2] num partitions=150
    [rg2-rn1] sn=sn5
    [rg2-rn2] sn=sn6
    [rg2-rn3] sn=sn7
    [rg2-rn4] sn=sn8
```

## Verify the Store's Current Topology

You can verify the store's current topology by using the `verify` command. The verify command checks the current, deployed topology to make sure it obeys the topology rules described in Determining Your Store's Configuration (page 38).

You should examine the new topology and decide if it is satisfactory, and if not apply more transformations, or start over with different parameters.

For example:

```
kv-> verify configuration
Verify: starting verification of mystore based upon topology sequence #470
300 partitions and 8 storage nodes.
Version: 12.1.3.0.0 Time: 2014-01-07 17:34:23 UTC
See localhost:KVROOT/mystore/log/mystore_{0..N}.log
for progress messages
Verify: == checking storage node sn1 ==
Verify: Storage Node [sn1] on node01:5000
Zone: [name=Boston id=zn1 type=PRIMARY]  Status: RUNNING
Ver: 12cR1.3.0.0 2013-12-18 06:35:02 UTC  Build id: 8e70b50c0b0e
Verify: Admin [admin1] Status: RUNNING
Verify: Rep Node [rg1-rn1] Status: RUNNING,MASTER at sequence ....
Verify: == checking storage node sn2 ==
Verify: Storage Node [sn2] on node02:5000
Zone: [name=Boston id=zn1 type=PRIMARY]  Status: RUNNING
Ver: 12cR1.3.0.0 2013-12-18 06:35:02 UTC  Build id: 8e70b50c0b0e
Verify: Rep Node [rg1-rn2]  Status: RUNNING,REPLICA at sequence ....
Verify: == checking storage node sn3 ==
Verify: Storage Node [sn3] on node03:5000
Zone: [name=Boston id=zn1 type=PRIMARY]  Status: RUNNING
Ver: 12cR1.3.0.0 2013-12-18 06:35:02 UTC  Build id: 8e70b50c0b0e
Verify: Rep Node [rg1-rn3]  Status: RUNNING,REPLICA at sequence ....
Verify: == checking storage node sn4 ==
Verify: Storage Node [sn4] on node04:5000
Zone: [name=Boston id=zn1 type=PRIMARY]  Status: RUNNING
Ver: 12cR1.3.0.0 2013-12-18 06:35:02 UTC  Build id: 8e70b50c0b0e
Verify: Rep Node [rg1-rn4]  Status: RUNNING,REPLICA at sequence ....
Verify: == checking storage node sn5 ==
Verify: Storage Node [sn5] on node05:5000
Zone: [name=Boston id=zn1 type=PRIMARY]  Status: RUNNING
Ver: 12cR1.3.0.0 2013-12-18 06:35:02 UTC  Build id: 8e70b50c0b0e
Verify: Rep Node [rg2-rn1]  Status: RUNNING,MASTER at sequence ....
Verify: == checking storage node sn6 ==
Verify: Storage Node [sn6] on node06:5000
Zone: [name=Boston id=zn1 type=PRIMARY]  Status: RUNNING
Ver: 12cR1.3.0.0 2013-12-18 06:35:02 UTC  Build id: 8e70b50c0b0e
Verify: Rep Node [rg2-rn2]  Status: RUNNING,REPLICA at sequence ....
Verify: == checking storage node sn7 ==
Verify: Storage Node [sn7] on node07:5000
Zone: [name=Boston id=zn1 type=PRIMARY]  Status: RUNNING
Ver: 12cR1.3.0.0 2013-12-18 06:35:02 UTC  Build id: 8e70b50c0b0e
Verify: Rep Node [rg2-rn3]  Status: RUNNING,REPLICA at sequence ....
Verify: == checking storage node sn8 ==
Verify: Storage Node [sn8] on node08:5000
Zone: [name=Boston id=zn1 type=PRIMARY]  Status: RUNNING
Ver: 12cR1.3.0.0 2013-12-18 06:35:02 UTC  Build id: 8e70b50c0b0e
Verify: Rep Node [rg2-rn4] Status: RUNNING,REPLICA at sequence ....
Verification complete, no violations.
```

# Chapter 6. Upgrading an Existing Oracle NoSQL Database Deployment

This section describes how to upgrade the software of your Oracle NoSQL Database deployment.

Installing new software requires that each node be restarted. Depending on the configuration of your store, it may be possible to upgrade it while the store continues to remain online and available to clients. Online upgrade can succeed if the store's replication factor is greater than 2, and the upgrade is not being performed on a release 2.0 store whose topology contains only a single zone.

For stores with a replication factor greater than two, the shards can maintain their majorities and continue reading and writing data on behalf of clients while their components are restarted, one at a time. If the replication factor is 2 or 1, then the majorities cannot be maintained across the restart of a single node, and each shard will become unavailable for a short time.

## Preparing to Upgrade

Before beginning the upgrade process, you should take a backup of the store by creating a snapshot. See Taking a Snapshot (page 57).

In Oracle NoSQL Database, configuration changes and other administrative activities involve `plans`. In NoSQL DB release 3.0, the execution or restarting of plans that were created in NoSQL DB release 1.0 is not supported. Any plans that are not in a completed state should be canceled before the upgrade begins. For information about plans, see Plans (page 17).

### Note

During the upgrade process, you should not create any plans until all services in the store have been upgraded.

Application programs that use the kvstore client library should be upgraded to the new software version as soon as possible after the service components have been upgraded. New clients can also be used with an old store, so it is possible to test upgraded clients before upgrading the store services.

## General Upgrade Notes

This section contains upgrade information that is generally true for all versions of Oracle NoSQL Database. Upgrade instructions and notes for specific releases are given in sections following this one.

When Oracle NoSQL Database is first installed, it is placed in a KVHOME directory, which may be per-machine, or optionally be shared by multiple Storage Nodes (for example, using NFS). Here, we call this existing KVHOME location, `OLD_KVHOME`.

### Note

It is useful for installations to adopt a convention for KVHOME that includes the release number. That is, always use a KVHOME location such as `/var/kv/kv-M.N.O`, where `M.N.O` are the release.major.minor numbers. This can be easily achieved by simply unzip/untarring the distribution into a common directory (/var/kv in this example).

Installing new software requires that each node be restarted. Oracle NoSQL Database is a replicated system, so to avoid excessive failover events it is recommended that any node that is running as a MASTER be restarted after all those marked REPLICA. This command tells you which nodes are MASTER and REPLICA:

```
java -Xmx256m -Xms256m \
-jar KVHOME/lib/kvstore.jar ping -host <hostname> -port <port>
```

Use the host and registry port for any active node in the store. For example, in the following example, rg1-rn1 and rg2-rn1 are running as MASTER and should be restarted last (note that only part of the `ping` output is presented here so as to allow it to fit in the available space):

```
java -Xmx256m -Xms256m \
-jar KVHOME/lib/kvstore.jar ping -port 5000 -host node01
Pinging components of store mystore based upon topology sequence #315
mystore comprises 300 partitions and 6 Storage Nodes
Storage Node [sn1] on node01:5000  Zone: [name=Boston id=zn1 type=PRIMARY]
    Status: RUNNING   Ver: 12cR1.3.0.1 2013-12-18 06:35:02 UTC  ....
    Rep Node [rg1-rn1]  Status: RUNNING,MASTER at ....
Storage Node [sn2] on node02:5000  Zone: [name=Boston id=zn1 type=PRIMARY]
    Status: RUNNING   Ver: 12cR1.3.0.1 2013-12-18 06:35:02 UTC  ....
    Rep Node [rg1-rn2]  Status: RUNNING,REPLICA at ....
Storage Node [sn3] on node03:5000  Zone: [name=Boston id=zn1 type=PRIMARY]
    Status: RUNNING   Ver: 12cR1.3.0.1 2013-12-18 06:35:02 UTC  ....
    Rep Node [rg1-rn3]  Status: RUNNING,REPLICA at ....
Storage Node [sn4] on node04:5000  Zone: [name=Boston id=zn1 type=PRIMARY]
    Status: RUNNING   Ver: 12cR1.3.0.1 2013-12-18 06:35:02 UTC  ....
    Rep Node [rg2-rn1]  Status: RUNNING,MASTER at ....
Storage Node [sn5] on node05:5000  Zone: [name=Boston id=zn1 type=PRIMARY]
    Status: RUNNING   Ver: 12cR1.3.0.1 2013-12-18 06:35:02 UTC  ....
    Rep Node [rg2-rn2]  Status: RUNNING,REPLICA at ....
Storage Node [sn6] on node06:5000  Zone: [name=Boston id=zn1 type=PRIMARY]
    Status: RUNNING   Ver: 12cR1.3.0.1 2013-12-18 06:35:02 UTC  ....
    Rep Node [rg2-rn3]  Status: RUNNING,REPLICA at ....
```

## Upgrade from Release 2.0 to Release 3.0

Upgrading a store from release 2 to release 3 can be accomplished one Storage Node at a time because a mix of release 2 and 3 Storage Nodes are permitted to run simultaneously in the same store. This allows you to strategically upgrade Storage Nodes in the most efficient manner.

### Note

Upgrading a 1.0 store directly to release 3 is not supported. You must upgrade your store from 1.0 to 2.0 before upgrading to release 3. For instructions on how to upgrade your 1.0 store, see Upgrade from NoSQL DB Release 1.0 to NoSQL DB Release 2.0 (page 55).

### Note

If your store contains more than a handful of Storage Nodes, you may want to perform your upgrade using a script. See Using a Script to Upgrade to Release 3 (page 54) for more information.

To avoid potential problems, new CLI commands are available to identify when nodes can be upgraded at the same time. These commands are described in the following procedure.

To upgrade your store, start by installing the release 3 software on a Storage Node that is running an admin service. The new CLI commands require an updated admin service in order to function.

Do the following:

1. On a Storage Node running a release 2 admin service:

   a. Place the updated software in a new KVHOME directory on a Storage Node running the admin service. The new KVHOME directory is referred to here as NEW_KVHOME. If nodes share this directory using NFS, this only needs to be done once for each shared directory.

   b. Stop the Storage Node using the release 2 CLI. When you do this, this shuts down the admin service on that Storage Node.

      If you have configured the node to automatically start the Storage Node Agent on reboot using /etc/init.d, Upstart, or some other mechanism first modify that script to point to NEW_KVHOME.

      Once you have modified that script, shutdown the Storage Node:

      ```
      java -Xmx256m -Xms256m \
      -jar KVHOME/lib/kvstore.jar stop -root <kvroot>
      ```

   c. Restart the Storage Node using the release 3 code:

      ```
      nohup java -Xmx256m -Xms256m \
      -jar NEW_KVHOME/lib/kvstore.jar start -root <kvroot>&
      ```

      (If the system is configured to automatically restart the Storage Node Agent, this step may not be necessary.)

   d. Use the CLI to connect to the Storage Node which is now running the release 3 code:

      ```
      java -Xmx256m -Xms256m \
      -jar NEW_KVHOME/lib/kvstore.jar runadmin -port 5000 -host node1
      ```

```
kv->
```

e. Verify that all the Storage Nodes in the store are running the proper software level required to upgrade to release 3. Note that any patch release level of 2.0 or 2.1 meets the minimum software level requirements.

```
kv-> verify prerequisite
Verify: starting verification of mystore based upon topology
sequence #315
300 partitions and 6 storage nodes. Version: 12.1.3.0.1 Time:
2014-01-07 08:19:15 UTC
See node1:<KVROOT>/mystore/log/mystore_{0..N}.log for progress
messages
Verify prerequisite: Storage Node [sn3] on node3:5000
Zone: [name=Boston id=zn1 type=PRIMARY]   Status: RUNNING
Ver: 12cR1.2.1.54 2013-11-11 12:09:35 UTC  Build id: 921c25300b5e

...

Verification complete, no violations.
```

Note that only a partial sample of the verification command's output is shown here. The important part is the last line, which shows no violations.

The most likely reason for a violation is if you are (accidentally) attempting a release level downgrade. For example, it is illegal to downgrade from a higher minor release to a lower minor release. Possibly this is occurring simply because you are running the CLI using a package at a minor release level that is lower than the release level at other nodes in the store.

### Note

It is legal to downgrade from a higher *patch* level to a lower patch level. So, for example downgrading from 2.1.4 to 2.1.3 would be legal, while downgrading from 2.1.3 to 2.0.39 would not be legal.

Also, a violation will occur if you attempt to upgrade 1.0 nodes directly to release 3. When upgrading a 1.0 store, you must first upgrade to 2.0, and then upgrade to release 3. For more information on upgrading a 1.0 store, see Upgrade from NoSQL DB Release 1.0 to NoSQL DB Release 2.0 (page 55).

In any case, if the `verify prerequisite` command shows violations, resolve the situation before you attempt to upgrade the identified nodes.

f. Obtain an ordered list of the nodes to upgrade.

```
kv-> show upgrade-order
sn3 sn4
sn2 sn5
sn6
```

The Storage Nodes combined together on a single line should be upgraded together. Therefore, for this output, you would upgrade sn3 and sn4. Then upgrade sn2 and sn5. And, finally, upgrade sn6.

Note that you must completely upgrade a group of nodes before continuing to the next group. That is, upgrade sn3 and sn4 before you proceed to upgrading sn2, sn5, or sn6.

2. For each of the Storage Nodes in the first group of Storage Nodes to upgrade (sn3 and sn4, in this example):

   a. Place the release 3 software in a new KVHOME directory. The new KVHOME directory is referred to here as NEW_KVHOME. If nodes share this directory using NFS, this only needs to be done once for each shared directory.

   b. Stop the Storage Node using the release 2 utility.

      If you have configured the node to automatically start the Storage Node Agent on reboot using /etc/init.d, Upstart, or some other mechanism first modify that script to point to NEW_KVHOME.

      Once you have modified that script, shutdown the Storage Node using the old code:

      ```
      java -Xmx256m -Xms256m \
      -jar KVHOME/lib/kvstore.jar stop -root <kvroot>
      ```

   c. Restart the Storage Node using the new code:

      ```
      nohup java -Xmx256m -Xms256m \
      -jar NEW_KVHOME/lib/kvstore.jar start -root <kvroot>&
      ```

      (If the system is configured to automatically restart the Storage Node Agent, this step may not be necessary.)

3. Verify the upgrade before upgrading your next set of nodes. This command shows which nodes have been successfully upgraded, and which nodes still need to be upgraded:

   ```
   kv-> verify upgrade
   Verify: starting verification of mystore based upon topology
   sequence #315
   300 partitions and 6 storage nodes. Version: 12.1.3.0.1 Time:  ....
   See node1:<KVROOT>/mystore/log/mystore_{0..N}.log for progress
   messages
   Verify upgrade: Storage Node [sn3] on node3:5000
   Zone: [name=Boston id=zn1 type=PRIMARY]    Status: RUNNING
   Ver: 12cR1.3.0.1 2013-12-18 06:35:02 UTC  Build id: 8e70b50c0b0e

   ...

   Verify: sn2: Node needs to be upgraded from 12.1.2.1.54 to
   version 12.1.3.0.0 or newer
   ```

```
...

Verification complete, 0 violations, 3 notes found.
Verification note: [sn2]    Node needs to be upgraded from
12.1.2.1.54 to version 12.1.3.0.0 or newer
Verification note: [sn5]    Node needs to be upgraded from
12.1.2.1.54 to version 12.1.3.0.0 or newer
Verification note: [sn6]    Node needs to be upgraded from
12.1.2.1.54 to version 12.1.3.0.0 or newer
```

For brevity and space, we only show part of the output generated by the `verify upgrade` command. Those nodes which have been upgraded are identified with a verification message that includes the current software version number:

```
 Verify upgrade: Storage Node [sn3] on node3:5000
Zone: [name=Boston id=zn1 type=PRIMARY]
Status: RUNNING
Ver: 12cR1.3.0.1 2013-12-18 06:35:02 UTC  Build id: 8e70b50c0b0e
```

Those nodes which still need to be upgraded are identified in two different ways. First, the verification message for the node indicates that an upgrade is still necessary:

```
Verify: sn2: Node needs to be upgraded from 12.1.2.1.54 to
version 12.1.3.0.0 or newer
```

Second, the very end of the verification output identifies all the nodes that still need to be upgraded:

```
Verification complete, 0 violations, 3 notes found.
Verification note: [sn2]    Node needs to be upgraded from
12.1.2.1.54 to version 12.1.3.0.0 or newer
Verification note: [sn5]    Node needs to be upgraded from
12.1.2.1.54 to version 12.1.3.0.0 or newer
Verification note: [sn6]    Node needs to be upgraded from
12.1.2.1.54 to version 12.1.3.0.0 or newer
```

### Note

If the verification shows nodes you thought were upgraded as being still in need of an upgrade, you *must* resolve that problem before upgrading the other nodes in your store. As a kind of a sanity check, you can verify just those nodes you just finished upgrading:

```
kv-> verify upgrade -sn sn3 -sn sn4
Verify: starting verification of mystore based upon topology
sequence #315
...
Verification complete, no violations.
```

4. You can continue upgrading groups of Storage Nodes, as identified by the `show upgrade-order` command. Follow the procedure outlined above. Stop the release 2 Storage Node using the release 2 stop command, then restart the Storage Node using the release 3 start command. Continue doing this until all Storage Nodes have been upgraded.

   If at some point you lose track of which group of nodes should be upgraded next, you can always run the `show upgrade-order` command again:

   ```
   kv-> show upgrade-order
   Calculating upgrade order, target version: 12.1.3.0.1,
   prerequisite: 11.2.2.0.23
   sn2 sn5
   sn6
   ```

5. When you are all done upgrading your Storage Nodes, the `verify upgrade` command will show no verification notes at the end of its output:

   ```
   kv-> verify upgrade
   Verify: starting verification of mystore based upon topology
   sequence #315
   ...
   Verification complete, no violations.
   kv->
   ```

## Using a Script to Upgrade to Release 3

For any deployments with more than a handful of Storage Nodes, the manual upgrade procedure described above becomes problematic. In that case, you should probably upgrade your store using a script.

An example script (bash shell script) is available for you to examine in the release 3 distribution. It can be found here:

```
<KVROOT>/examples/upgrade/onlineUpgrade
```

This script has the same upgrade restrictions as was described earlier in this section: it will only upgrade a release 2 installation to release 3, and your store must have a replication factor of at least 3 in order for your store to be available during the upgrade process.

The provided script is an example only. It must be modified in order for it to properly function for your installation.

Note that the script does not perform any software provisioning for you. This means you are responsible for placing the release 3 package on your host machines in whatever location you are using for your installation software. That said, the script communicates with your host machines using ssh, so you could potentially enhance the script to provision your machines using scp.

Because the script uses ssh, in order for it to function you must configure your machines to allow automatic login (that is, login over ssh without a password). ssh supports public/private key authentication, so this is generally a secure way to operate.

For information on how to configure ssh in this way, see http://www.linuxproblem.org/art_9.html. For information on how to install and configure ssh and the ssh server, see your operating system's documentation.

## Upgrade from NoSQL DB Release 1.0 to NoSQL DB Release 2.0

NoSQL DB release 2.0 changes the internal protocols by which the components of a store communicate with one other. Limited cross-version compatibility has been implemented. Components (including applications that use the embedded client library) running NoSQL DB release 1.0 and components running NoSQL DB release 2.0 can communicate with one another, so that a store can remain running and available to clients during the upgrade. However, operations that change the configuration of the store should not be attempted while the upgrade is in progress.

Similarly, NoSQL DB release 2.0 changes the persistent meta-data that is kept by the components of the store. When a component, such as the Admin or the Replication Node, first starts on the new software, it will automatically convert its meta-data to the new format. Therefore it is not possible to downgrade to the older NoSQL DB release without restoring the store from a previous backup.

### Note

Online upgrade is not supported for a store with a NoSQL DB release 1.0 topology that contains multiple zones. If your store has such a topology, please contact technical support before attempting to upgrade.

### Note

The NoSQL DB release 1.0 administrative CLI program is not compatible with a NoSQL DB release 2.0 Admin service, nor vice-versa. Make sure that you are using the compatible library when running the CLI. It may be necessary to clear the cache of your web browser when you first connect to the NoSQL DB release 2. Admin Console.

To upgrade your release 1.0 installation to release 2.0, perform the following steps for each node (machine) in your store:

1. Place the 2.0 software in a new KVHOME directory — referred to here as NEW_KVHOME. If nodes share this directory using NFS, this only needs to be done once for each shared directory.

2. If you have configured the node to automatically start the Storage Node Agent on reboot using /etc/init.d, Upstart, or some other mechanism for example, using the command:

   ```
   nohup java -Xmx256m -Xms256m \
   -jar KVHOME/lib/kvstore.jar start -root <kvroot> ...&
   ```

   First modify that script to point to NEW_KVHOME.

3. For each KVROOT (usually, once per node):

   a. Stop the Storage Node using the old code:

```
java -Xmx256m -Xms256m \
-jar OLD_KVHOME/lib/kvstore.jar stop -root <kvroot> \
[-config <configfile>]
```

   b. Restart the Storage Node using the new code:

```
nohup java -Xmx256m -Xms256m \
-jar NEW_KVHOME/lib/kvstore.jar start -root <kvroot> \
[-config <configfile>] &
```

   If the system is configured to automatically restart the Storage Node Agent, this step may not be necessary.

4. Make sure that any administrative scripts or other files that reference OLD_KVHOME have been changed.

Once you are done, OLD_KVHOME can be removed.

# Chapter 7. Administrative Procedures

This chapter contains procedures that may be generally useful to the Oracle NoSQL Database administrator.

### Note

Oracle NoSQL Database Storage Nodes and Admins make use of an embedded database (Oracle Berkeley DB, Java Edition). You should never directly manipulate the files maintained by this database. In general it is a bad idea to move, delete or modify the files and directories located under KVROOT unless you are asked to do so by Oracle Customer Support. But in particular, *never* move or delete any file ending with a `jdb` suffix. These will all be found in an `env` directory somewhere under KVROOT.

## Backing Up the Store

To back up the KVStore, you take snapshots of nodes in the store and optionally copy the resulting snapshots to a safe location. Note that the distributed nature and scale of Oracle NoSQL Database makes it unlikely that a single machine can hold the backup for the entire store. These instructions do not address where and how snapshots are stored.

### Taking a Snapshot

To create a backup, you take a snapshot of the store. A snapshot provides consistency across all records within the same partition, but not across partitions in independent shards. The underlying snapshot operations are performed in parallel to the extent possible in order to minimize any potential inconsistencies.

To take a snapshot from the admin CLI, use the `snapshot create` command:

```
kv-> snapshot create -name <snapshot name>
```

Using this command, you can create or remove a named snapshot. (The name of the snapshot is provided using the <name> parameter.) You can also remove all snapshots currently stored in the store.

For example, to create and remove a snapshot:

```
kv-> snapshot create -name thursday
Created snapshot named 110915-153514-thursday on all 3 nodes
kv-> snapshot remove -name 110915-153514-thursday
Removed snapshot 110915-153514-thursday
```

You can also remove all snapshots currently stored in the store:

```
kv-> snapshot create -name thursday
Created snapshot named 110915-153700-thursday on all 3 nodes
kv-> snapshot create -name later
Created snapshot named 110915-153710-later on all 3 nodes
kv-> snapshot remove -all
Removed all snapshots
```

### Note

Snapshots should not be taken while any configuration (topological) changes are being made, because the snapshot might be inconsistent and not usable.

## Snapshot Management

When you run a snapshot, data is collected from every Replication Node in the system, including both masters and replicas. If the operation does not succeed for at least one of the nodes in a shard, it fails.

If you decide to create an off-store copy of the snapshot, you should copy the snapshot data for only one of the nodes in each shard. If possible, copy the snapshot data taken from the node that was serving as the master at the time the snapshot was taken.

You can identify which nodes are currently running as the master using the ping command. There is a master for each shard in the store and they are identified by the keyword: MASTER. For example, in the following example, replication node rg1-rn1, running on Storage Node sn1, is the current master:

```
java -Xmx256m -Xms256m \
-jar KVHOME/lib/kvstore.jar ping -port 5000 -host node01
Pinging components of store mystore based upon topology sequence #107
Time: 2013-12-18 21:07:44 UTC
mystore comprises 300 partitions on 3 Storage Nodes
Storage Node [sn1] on node01:5000
Zone: [name=Boston id=zn1 type=PRIMARY]
Status: RUNNING   Ver: 12cR1.3.0.1 2013-12-18 06:35:02 UTC
Build id: 8e70b50c0b0e
    Rep Node [rg1-rn1] Status: RUNNING,MASTER at sequence number: 31
haPort: 5011
Storage Node [sn2] on node02:5000
Zone: [name=Boston, id=zn1 type=PRIMARY]
Status: RUNNING   Ver: 12cR1.3.0.1 2013-12-18 06:35:02 UTC
Build id: 8e70b50c0b0e
    Rep Node [rg1-rn2] Status: RUNNING,REPLICA at sequence number: 31
haPort: 5011
Storage Node [sn3] on node03:5000
Zone: [name=Boston, id=zn1 type=PRIMARY]
Status: RUNNING   Ver: 12cR1.3.0.1 2013-12-18 06:35:02 UTC
 Build id: 8e70b50c0b0e
    Rep Node [rg1-rn3] Status: RUNNING,REPLICA at sequence number: 31
haPort:5011
```

### Note

Snapshots include the admin database. Depending on how the store might need to be restored, the admin database may or may not be useful.

Snapshot data for the local Storage Node is stored in a directory inside of the `KVROOT` directory. For each Storage Node in the store, you have a directory named:

```
KVROOT/<store>/<SN>/<resource>/snapshots/<snapshot_name>/files
```

where:

- <store> is the name of the store.
- <SN> is the name of the Storage Node.
- <resource> is the name of the resource running on the Storage Node. Typically this is the name of a replication node.
- <snapshot_name> is the name of the snapshot.

Snapshot data consists of a number of files, and they all are important. For example:

```
 > ls /var/kvroot/mystore/sn1/rg1-rn1/snapshots/110915-153828-later
00000000.jdb 00000002.jdb 00000004.jdb 00000006.jdb
00000001.jdb 00000003.jdb 00000005.jdb 00000007.jdb
```

## Recovering the Store

There are two ways to recover your store from a previously created snapshot. The first mechanism allows you to use a backup to create a store with any desired topology. The second method requires you to restore the store using the *exact same* topology as was in use when the snapshot was taken.

### Note

If you had to replace a failed Storage Node, that qualifies as a topology change. In that case, you must use the `Load` program to restore your store.

For information on how to replace a failed Storage Node, see Replacing a Failed Storage Node (page 63).

### Using the Load Program

You can use the `oracle.kv.util.Load` program to restore a store from a previously created snapshot. You can run this program directly, or you can access it using `kvstore.jar`, as shown in the examples in this section.

By using this tool, you can restore the store to any topology, not just the one that was in use when the snapshot was created.

This mechanism works by iterating through all records in a snapshot, putting each record into the target store as it proceeds through the snapshot. It should be used only to restore to a new, empty store. Do not use this with an existing store because it only writes records if they do not already exist.

Note that to recover the store, you must load records from snapshot data captured for each shard in the store. For best results, you should load records using snapshot data captured from the replication nodes that were running as Master at the time the snapshot was taken. (If you have three shards in your store, then there are three Masters at any given time, and so you need to load data from three sets of snapshot data.)

You should use snapshot data taken at the same point in time; do not, for example, use snapshot data for shard 1 that was taken on Monday, and snapshot data for shard 2 that was taken on Wednesday because this can cause your store to be restored in an inconsistent state.

This mechanism can only go at the speed of insertion of the new store. Because you probably have multiple shards in your store, you should be restoring your store from data taken from each shard. To do this, run the `Load` program in parallel, with each instance operating on data captured from different replication nodes.

The program's usage is:

```
java -Xmx256m -Xms256m \
-jar KVHOME/lib/kvstore.jar load -source <backupDir> \
-store <storeName> -host <hostname> -port <port> \
[-status <pathToFile>][-verbose]
```

where:

- `-source <backupDir>` identifies the on-disk location where the snapshot data is stored.
- `-store <storeName>` identifies the name of the store.
- `-host <hostname>` identifies the host name of a node in your store.
- `-port <port>` identifies the registry port in use by the store's node.
- `-status <pathToFile>` is an optional parameter that causes the status of the load operation to be saved in the named location on the local machine.

For example, suppose there is a snapshot in `/var/backups/snapshots/110915-153828-later`, and there is a new store named "NewStore" on host "NewHost" using registry port 12345. Run the `Load` program on the host that has the `/var/backups/snapshots` directory:

```
java -Xmx256m -Xms256m \
-jar KVHOME/lib/kvstore.jar load \
-source /var/backups/snapshots/110915-153828-later -store NewStore \
-host NewHost -port 12345
```

### Note

If the load fails part way through the restore, it can start where it left off by using the status file. The granularity of the status file is per-partition in this NoSQL DB release. If a status file is not used and there is a failure, the load needs to start over from the beginning. The target store does not need to be re-created if this happens, existing records are skipped.

## Restoring Directly from a Snapshot

You can restore a store directly from a snapshot. This mechanism is faster than using the `Load` program described in the previous section, but it can be used only to restore to the *exact same* topology as was used when the snapshot was taken. This means that all ports and host names or IP addresses (depending on your configuration) must be exactly the same as when the snapshot was taken.

You must perform this procedure for each Storage Node in your store, and for each service running on each Storage Node.

1. Put the to-be-recovered snapshot data in the recovery directory for the service corresponding to the snapshot data. For example, if you are recovering Storage Node sn1, service rg1-rn1 in store `mystore` , then log in to the node where that service is running and:

   ```
   > mkdir KVROOT/mystore/sn1/rg1-sn1/recovery
   > mv /var/kvroot/mystore/sn1/rg1-rn1/snapshots/110915-153828-later \
   KVROOT/mystore/sn1/rg1-sn1/recovery/110915-153828-later
   ```

   Do this for each service running on the Storage Node. Production systems should have only one resource running on a given Storage Node, but it is possible to deploy, for example, multiple replication nodes on a single Storage Node. A Storage Node can also have an administration process running on it, and this also needs to be restored.

2. Having done this, restart the Storage Node

   ```
   java -Xmx256m -Xms256m \
   -jar KVHOME/lib/kvstore.jar stop -root /var/kvroot \
   > nohup java -Xmx256m -Xms256m \
   -jar KVHOME/lib/kvstore.jar start -root /var/kvroot&
   ```

On startup, the Storage Node notices the recovery directory, and moves that directory to the resource's environment directory and use it.

### Note

Remember that this procedure recovers the store to the time of the snapshot. If your store was active since the time of the snapshot, then all data modifications made since the time of the last snapshot are lost.

## Managing Avro Schema

Avro is a data format that can be used by values in your store's records. Whether a record's value uses the Avro data format is determined by your development team. However, the usage of the Avro data format is strongly recommended, so chances are good that your store uses Avro.

When store records use the Avro data format, your development team must define schema for their usage of that format. This schema is provided in flat-text files in JSON format, and must then be added to the store using the CLI. Schema can also be enabled and disabled, and multiple versions of the schema can exist at the same time. The ability to support multiple versions of the schema is required in order to support the ability to change (or evolve) schema.

### Adding Schema

Avro schema is defined in a flat-text file, and then added to the store using the command line interface. For example, suppose you have schema defined in a file called `my_schema.avsc`.

Then (assuming your store is running) you start your command line interface and add the schema like this:

```
> java -Xmx256m -Xms256m \
-jar <kvhome>/lib/kvstore.jar runadmin -port <port> -host <host>
kv-> ddl add-schema -file my_schema.avsc
```

Note that when adding schema to the store, some error checking is performed to ensure that the schema is correctly formed. Errors are problems that must be addressed before the schema can be added to the store. Warnings are problems that should be addressed, but are not so serious that the CLI refuses to add the schema. However, to add schema with Warnings, you must use the `-force` switch.

If you see any Errors or Warnings when you add schema to your store, you should discuss the problem with your development team so as to decide what to do about it.

## Changing Schema

To change (evolve) existing schema, use the `-evolve` flag:

```
kv-> ddl add-schema -file my_schema.avsc -evolve
```

Note that when changing schema in the store, some error checking is performed to ensure that schema evolution can be performed correctly. This error checking consists of comparing the new schema to all currently enabled versions of that schema.

This error checking can result in either Errors or Warnings. Errors are fatal problems that must be addressed before the modified schema can be added to the store. Errors represent situations where data written with an old version of the schema cannot be read by clients using a new version of the schema.

Warnings are problems that can be avoided using a a two-phase upgrade process. In a two-phase upgrade, all clients begin using the schema only for reading in phase I (the old schema is still used for writing), and then use the new schema for both reading and writing in phase II. Phase II may not be begun until phase I is complete; that is, no client may use the new schema for writing until all clients are using it for reading.

If you see any Errors or Warnings when you attempt to evolve schema in your store, you should discuss the problem with your development team so as to decide what to do about it.

## Disabling and Enabling Schema

You cannot delete schema, but you can disable it:

```
kv-> ddl disable-schema -name avro.MyInfo.1
```

To enable schema that has been disabled:

```
kv-> ddl enable-schema -name avro.MyInfo.1
```

## Showing Schema

To see all the schemas currently enabled in your store:

```
kv-> show schemas
```

To see all schemas, including those which are currently disabled:

```
kv-> show schemas -disabled
```

## Replacing a Failed Storage Node

If a Storage Node has failed, or is in the process of failing, you can replace the Storage Node. Upgrading a healthy machine to another one with better specifications is also a common Storage Node replacement scenario. Generally, you should repair the underlying problem (be it hardware or software related) before proceeding with this procedure.

There are two ways to replace a failed Storage Node.

To replace a failed Storage Node by using a new, different Storage Node (node uses different host name, IP address, and port as the failed host):

1. If you are replacing hardware, bring it up and make sure it is ready for your production environment.

2. On the new, replacement node, create a "boot config" configuration file using the `makebootconfig` utility. Do this on the hardware where your new Storage Node runs. You only need to specify the -admin option (the Admin Console's port) if the hardware hosts the Oracle NoSQL Database administration processes.

   To create the "boot config" file, issue the following commands:

   ```
   > mkdir -p KVROOT     (if it doesn't already exist)
   > java -Xmx256m -Xms256m \
   -jar KVHOME/lib/kvstore.jar makebootconfig -root KVROOT \
                                               -port 5000 \
                                               -admin 5001 \
                                               -host <hostname> \
                                               -harange 5010,5020
                                               -store-security none
   ```

3. Start the Oracle NoSQL Database software on the new node.

   ```
   > nohup java -Xmx256m -Xms256m \
   -jar KVHOME/lib/kvstore.jar start -root KVROOT&
   ```

4. Deploy the new Storage Node to the new node. You use an existing administrative process to do this, either using the CLI or the Admin Console. To do this using the CLI:

   ```
   > java -Xmx256m -Xms256m \
   -jar KVHOME/lib/kvstore.jar runadmin  \
   -port <port> -host <host>
   kv-> plan deploy-sn -zn <id> -host <host> -port <port> -wait
   kv->
   ```

5. Add the new Storage Node to the Storage Node pool. (You created a Storage Node pool when you installed the store, and you added all your Storage Nodes to it, but it is otherwise not used in this version of the product.)

   ```
   kv-> show pools
   AllStorageNodes: sn1, sn2, sn3, sn4 ... sn25, sn26
   BostonPool: sn1, sn2, sn3, sn4 ... sn25
   kv-> pool join -name BostonPool -sn sn26
   ```

```
AllStorageNodes: sn1, sn2, sn3, sn4 ... sn25, sn26
BostonPool: sn1, sn2, sn3, sn4 ... sn25, sn26
kv->
```

6. Make sure the old Storage Node is not running. If the problem is with the hardware, then turn off the broken machine. You can also stop just the Storage Node software by:

   ```
   > java -Xmx256m -Xms256m \
   -jar KVHOME/lib/kvstore.jar stop -root KVROOT
   ```

7. Migrate the services from one Storage Node to another. If the old node hosted an admin service, the -admin-port argument is required. The syntax for this plan is:

   ```
   plan migrate-sn -from <old SN ID> -to <new SN ID> \
   -admin-port <admin port>
   ```

   Assuming that you are migrating from Storage Node 25 to 26 on port 5000, you would use:

   ```
   kv-> plan migrate-sn -from sn25 -to sn26 -admin-port 5000
   ```

8. The old Storage Node is shown in the topology and is reported as UNREACHABLE. The source SNA should be removed and its rootdir should be hosed out. Bringing up the old SNA will also bring up the old Replication Nodes and admins, which are no longer members of their replication groups. This should be harmless to the rest of the store, but it produces log error messages that might be misinterpreted as indicating a problem with the store. Use the `plan remove-sn` command to remove the old and unused Storage Node in your deployment.

   ```
   kv-> plan remove-sn sn25 -wait
   ```

### Note

Replacing a Storage Node qualifies as a topology change. This means that if you want to restore your store from a snapshot taken before the Storage Node was replaced, you must use the `Load` program. See Using the Load Program (page 59) for more information.

To replace a failed Storage Node by using an identical node (node uses the same host name, internet address, and port as the failed host):

1. Prerequisite information:

   a. A running Admin process on a known host, with a known registry port.

   b. The ID of the Storage Node to replace (e.g. "sn1").

   c. Before starting the new Storage Node, the SN to be replaced must be taken down. This can be done administratively or via failure.

   ### Note

   It is recommended that the KVROOT is empty and that you do a full network recovery of data before proceeding.

The instructions below assume that the KVROOT is empty and has no valid data. When the new Storage Node Agent begins it starts the services it hosts, which recovers their data from other hosts. This recovery may take some time, depending on the size of the shards involved and it happens in the background.

2. Create the configuration using the `generateconfig` command:

   The generateconfig's usage is:

   ```
   > java -Xmx256m -Xms256m \
   -jar KVHOME/lib/kvstore.jar generateconfig \
   -host <hostname> -port <port> -sn <StorageNodeId> -target <zipfile>
   ```

   For example:

   ```
   > java -Xmx256m -Xms256m \
   -jar KVHOME/lib/kvstore.jar generateconfig -host adminhost \
   -port 13230 -sn sn1 -target /tmp/sn1.config.zip
   ```

   The command above creates the target "/tmp/sn1.config.zip" which is a zip file with the required configuration to re-create that Storage Node. The top-level directory in the zip file is the store's KVROOT.

3. Restore the Storage Node configuration on the target host:

   a. Copy the zip file to the target host.

   b. Unzip the archive into your KVROOT directory. That is, if KVROOT is `/opt/kvroot`, then do the following:

      ```
      > cd/opt
      > unzip <path-to-sn1.config.zip>
      ```

4. Restart the Storage Node on the new host.

   ```
   > java -Xmx256m -Xms256m \
   -jar KVHOME/lib/kvstore.jar start -root KVROOT
   ```

## Replacing a Failed Disk

If a disk has failed, or is in the process of failing, you can replace the disk. Disk replacement procedures are necessary to keep the store running. This section walks you through the steps of replacing a failed disk, to preserve data availability.

The following example deploys a KVStore to a set of three machines, each with 3 disks. Use the `storagedir` flag of the `makebootconfig` command to specify the storage location of the other two disks.

```
> java -jar KVHOME/lib/kvstore.jar makebootconfig \
    -root /opt/ondb/var/kvroot \
    -port 5000  \
    -admin 5001 \
```

```
     -host node09
     -harange 5010,5020 \
     -num_cpus 0  \
     -memory_mb 0 \
     -store-security none \
     -capacity 2  \
     -storagedir /disk1/ondb/data \
     -storagedir /disk2/ondb/data
```

With a boot configuration such as that shown above, the directory structure that is created and populated on each machine would then be:

```
  - Machine 1 (SN1) -      - Machine 2 (SN2) -     - Machine 3 (SN3) -
 /opt/ondb/var/kvroot   /opt/ondb/var/kvroot  /opt/ondb/var/kvroot
   log files              log files             log files
   /store-name           /store-name           /store-name
     /log                  /log                  /log
     /sn1                  /sn2                  /sn3
       config.xml            config.xml            config.xml
       /admin1               /admin2               /admin3
         /env                  /env                  /env

 /disk1/ondb/data         /disk1/ondb/data        /disk1/ondb/data
   /rg1-rn1                 /rg1-rn2                /rg1-rn3
     /env                     /env                    /env

 /disk2/ondb/data         /disk2/ondb/data        /disk2/ondb/data
   /rg2-rn1                 /rg2-rn2                /rg2-rn3
     /env                     /env                    /env
```

In this case, configuration information and administrative data is stored in a location that is separate from all of the replication data. The replication data itself is stored by each distinct Replication Node service on separate, physical media as well. Storing data in this way provides failure isolation and will typically make disk replacement less complicated and time consuming.

To replace a failed disk:

1. Determine which disk has failed. To do this, you can use standard system monitoring and management mechanisms. In the previous example, suppose disk2 on Storage Node 3 fails and needs to be replaced.

2. Then given a directory structure, determine which Replication Node service to stop. With the structure described above, the store writes replicated data to disk2 on Storage Node 3, so `rg2-rn3` must be stopped before replacing the failed disk.

3. Use the `plan stop-service` command to stop the affected service (rg2-rn3) so that any attempts by the system to communicate with it are no longer made; resulting in a reduction in the amount of error output related to a failure you are already aware of.

   ```
   kv-> plan stop-service -service rg2-rn3
   ```

4. Remove the failed disk (disk2) using whatever procedure is dictated by the operating system, disk manufacturer, and/or hardware platform.

5. Install a new disk using any appropriate procedures.

6. Format the disk to have the same storage directory as before; in this case, `/disk2/ondb/var/kvroot`.

7. With the new disk in place, use the `plan start-service` command to start the `rg2-rn3` service.

   ```
   kv-> plan start-service -service rg2-rn3
   ```

   ### Note

   It can take a considerable amount of time for the disk to recover all of its data; depending on the amount of data that previously resided on the disk before failure. It is also important to note that the system may encounter additional network traffic and load while the new disk is being repopulated.

## Repairing a Failed Zone

If all of the machines belonging to a `zone` fail, you can replace them by using new, different Storage Nodes deployed to the same zone.

For example, suppose a store consists of three `zones`; `zn1`, deployed to the machines on the first floor of a physical data center, `zn2`, deployed to the machines on the second floor, and `zn3`, deployed to the third floor. Additionally, suppose that a fire destroyed all of the machines on the second floor, resulting in the failure of all of the associated Storage Nodes. In this case, you need to replace the machines in the `zn2` zone; which can be accomplished by doing the following:

1. Replace each individual Storage Node in the failed Zone with new, different Storage Nodes belonging to same Zone (zn2), although located in a new physical location. To do this, follow the instructions in Replacing a Failed Storage Node (page 63). Make sure to remove each old Storage Node after performing the replacement.

2. After replacing and then removing each of the targeted SNs, the zone to which those SNs belonged should now contain the new SNs.

## Addressing Lost Admin Service Quorum

If quorum is lost as a result of the failure of one or more of the admin service instance(s), the store cannot be administered; although it can still be used to read and write key/value pairs. Because the admin service employs quorum based replication for high availability of the administrative data, the number of admins deployed should be large enough to make quorum loss unlikely; typically an odd number such as 3.

Usually, the Storage Node Agent (SNA) will automatically restart its failed admin service; preserving quorum and the ability to administer the store. But if the SN (specifically, the SNA) fails, then the admin service will remain unavailable.

In that case, the following procedure allows you to reconfigure the store so that the remaining admin service(s) can be used to perform administrative tasks:

For the following example, assume all of the following:

- A store has 3 Storage Nodes (sn1, sn2, sn3) deployed on hosts (host-sn1, host-sn2, host-sn3) respectively.
- An admin service is deployed to two of the three machines; admin 1 is deployed to host-sn1 and admin2 is deployed to host-sn2.
- Admin2 service fails so quorum is lost.

To address the lost admin service quorum:

1. Verify that admin service quorum has been lost. If a command that requires quorum is executed in the CLI, a timeout should occur if quorum has been lost. For example:

   ```
   kv-> pool create -name new-pool
   Transaction retry limit exceeded (12.1.3.0.1)
   ```

2. Use the `show admins` command to determine the names of the admin services that were deployed:

   ```
   kv-> show admins
   admin1: Storage Node sn1, HTTP port 13231 (master)
   admin2: Storage Node sn2, HTTP port 13231
   ```

3. Identify the remaining healthy admin service(s) so quorum can be reconfigured for those service(s). Login to `sn1` and run the following command:

   ```
   > jps -m | grep Admin
   12276 ManagedService -root /opt/ondb/var/kvroot -class Admin -service
   BootstrapAdmin.13230 -config config1.xml
   ```

   which means that only the first admin service (the bootstrap admin) that was deployed to the store is still healthy and running on host-sn1.

   ### Note

   If a given admin service is down, either the Storage Node itself is down and cannot be accessed, or the command above will produce no output for the associated admin service. In this case, `admin2` is down and thus omitted in the output.

4. Once the healthy admin service(s) have been identified, the configuration file for each of the corresponding SN(s) should be modified so that the `je.rep.electableGroupSizeOverride` configuration property of the admin component equals the number of remaining healthy admin services. In this example, the configuration file (`config.xml`) corresponding to `sn1` must be modified. The file has the following structure:

   ```
   <config version="1">
   ```

```
<component name="storageNodeParams"
                         type="storageNodeParams" validate="true">
  <property name="storageNodeId" value="1" type="INT"/>
  <property name="rootDirPath"
                         value="/opt/ondb/var/kvroot" type="STRING"/>
  <property name="haHostname" value="host-sn1" type="STRING"/>
  <property name="registryPort" value="13230" type="INT"/>
  ..........
</component>
<component name="mountPoints" type="bootstrapParams"
                                                  validate="false">
  <property name="/disk1/ondb/data" value="" type="STRING">
</component>
<component name="globalParams" type="globalParams" validate="true">
  <property name="storeName" value="example-store" type="STRING">
  <property name="isLoopback" value="false" type="BOOLEAN">
</component>
<component name="admin1" type="adminParams" validate="true">
  <property name="adminHttpPort" value="13231" type="INT">
  <property name="storageNodeId" value="1" type="INT"/>
  ..........
</component>
<component name="rg1-rn1" type="repNodeParams" validate="true">
  <property name="repNodeId" value="rg1-rn1" type="STRING"/>
  <property name="repNodeType" value="ELECTABLE" type="STRING">
  <property name="storageNodeId" value="1" type="INT"/>
  ..........
</component>
```

In the component named `admin1`, add (or modify) the property named `configProperties` and set the value to 1. For example:

```
<component name="admin1" type="adminParams" validate="true">
<property name="configProperties"
value="je.rep.electableGroupSizeOverride 1;" type="STRING">
..........
</component>
```

5. Kill each of the healthy admin service process(es) for which a configuration file was modified. To kill the healthy admin service (admin1) on host-sn1 run:

```
> kill 11762
```

where 11762 is the process id of the single healthy admin service, identified in step 2.

## Note

The SNA will automatically restart the killed admin service; which, for this example, will then be configured to operate with a quorum size of 1 rather than 2.

6. Use the single healthy admin service (admin1) to perform the necessary failure recovery administration tasks on the store.

7. Once the failed admin service(s) are recovered (admin2), repeat steps 4 and 5 to reconfigure the admin service(s) to their original notion of quorum. For this example, `je.rep.electableGroupSizeOverride` should be set to 2.

## Verifying the Store

Verification is a tool you can use to:

- Perform general troubleshooting of the store.

  Verification inspects all components of the store. It also checks whether all store services are available, and for those services it checks whether there are any version or metadata mismatches.

- Check the status of a long-running plan

  Some plans require many steps and may take some time to execute. The administrator can verify plans to check on progress of the plan, or as an aid to diagnose a plan that is in an ERROR state. For example, if you can verify a `Deploy Store` plan while it is running against many Storage Nodes. You can watch the verify report at each iteration to see that more and more nodes have created and have come online.

  For more information on how to manage plans, see Plans (page 17).

- Provide additional information about a plan that is in an ERROR state.

You run store verification using the `verify` command in the CLI. It requires no parameters, and by default it runs in verbose mode. For example:

```
> java -Xmx256m -Xms256m \
-jar KVHOME/lib/kvstore.jar runadmin -port <registry port>> \
-host <hostname>
kv-> verify configuration
Verify: starting verification of mystore based upon topology sequence #1008
1000 partitions and 3 storage nodes. Version: 12.1.3.0.1
Time: 2014-01-07 21:16:02 UTC
See <nodeHostname>:/KVRT1/mystore/log/mystore_{0..N}.log for progress
messages
Verify: == checking storage node sn1 ==
Verify: Storage Node [sn1] on <nodeHostname>:5000
Zone: [name=baskin id=zn1 type=PRIMARY]    Status: RUNNING
Ver: 12cR1.3.0.1 2013-12-18 06:35:02 UTC  Build id: 8e70b50c0b0e
Verify:         Admin [admin1]          Status: RUNNING
Verify:         Rep Node [rg1-rn1]      Status: RUNNING,REPLICA at
sequence number:2,025 haPort:5011
Verify: == checking storage node sn2 ==
Verify: Storage Node [sn2] on <nodeHostname>:5100
Zone: [name=baskin id=zn1 type=PRIMARY]    Status: RUNNING
Ver: 12cR1.3.0.1 2013-12-18 06:35:02 UTC  Build id: 8e70b50c0b0e
```

```
Verify:         Rep Node [rg1-rn2]      Status: RUNNING,REPLICA at
sequence number:2,025 haPort:5110
Verify: == checking storage node sn3 ==
Verify: Storage Node [sn3] on <nodeHostname>:5200
Zone: [name=baskin id=zn1 type=PRIMARY]    Status: RUNNING
Ver: 12cR1.3.0.1 2013-12-18 06:35:02 UTC  Build id: 8e70b50c0b0e
Verify:         Rep Node [rg1-rn3]      Status: RUNNING,MASTER at
sequence number:2,025 haPort:5210
Verification complete, no violations.
```

A silent mode is available which shows only problems.

```
kv-> verify configuration -silent
Verify: starting verification of mystore based upon topology sequence #1008
1000 partitions and 3 storage nodes. Version: 12.1.3.0.1
Time: 2014-01-07 21:16:02 UTC
See <nodeHostname>:/KVRT1/mystore/log/mystore_{0..N}.log for progress
messages
Verification complete, no violations.
```

Problems with the store are clearly reported. For example, if a Storage Node is unavailable, then in silent mode that problem is displayed in the following way:

```
kv-> verify -silent
Verify: starting verification of mystore based upon topology sequence #1008
1000 partitions and 3 storage nodes. Version: 12.1.3.0.1
Time: 2014-01-07 21:16:02 UTC
See <nodeHostname>:/KVRT1/mystore/log/mystore_{0..N}.log for progress
messages
Verification complete, 2 violations, 0 notes found.
Verification violation: [sn2]
ping() failed for sn2 : Connection refused to host:
<nodeHostname>; nested exception is:
        java.net.ConnectException: Connection refused
Verification violation: [rg1-rn2]
ping() failed for rg1-rn2 : Connection refused to
host: <nodeHostname>; nested exception is:
        java.net.ConnectException: Connection refused
```

In verbose mode, the above problem is shown in the following way:

```
kv-> verify configuration
Verify: starting verification of mystore based upon topology sequence #1008
1000 partitions and 3 storage nodes. Version: 12.1.3.0.1
Time: 2013-12-18 21:16:02 UTC
See <nodeHostname>:/KVRT1/mystore/log/mystore_{0..N}.log for progress
messages
Verify: == checking storage node sn1 ==
Verify: Storage Node [sn1] on <nodeHostname>:5000
Zone: [name=baskin id=zn1 type=PRIMARY]    Status: RUNNING
Ver: 12cR1.3.0.1 2013-12-18 06:35:02 UTC  Build id: 8e70b50c0b0e
Verify:     Admin [admin1]          Status: RUNNING
```

```
Verify:     Rep Node [rg1-rn1]  Status: RUNNING,REPLICA at sequence
number:2,025 haPort:5011
Verify: == checking storage node sn2 ==
Verify: sn2: ping() failed for sn2 : Connection refused to host:
<nodeHostname>; nested exception is:
        java.net.ConnectException: Connection refused
Verify: Storage Node [sn2] on <nodeHostname>:5100
Zone: [name=baskin id=zn1 type=PRIMARY] UNREACHABLE
Verify: rg1-rn2: ping() failed for rg1-rn2 : Connection refused to
host: <nodeHostname>; nested exception is:
        java.net.ConnectException: Connection refused
Verify:     Rep Node [rg1-rn2]  Status: UNREACHABLE
Verify: == checking storage node sn3 ==
Verify: Storage Node [sn3] on <nodeHostname>:5200
Zone: [name=baskin id=zn1 type=PRIMARY]    Status: RUNNING
Ver: 12cR1.3.0.1 2013-12-18 06:35:02 UTC  Build id: 8e70b50c0b0e
Verify:     Rep Node [rg1-rn3]  Status: RUNNING,MASTER at sequence
number:2,025 haPort:5210
Verification complete, 2 violations, 0 notes found.
Verify: sn2:    ping() failed for sn2 : Connection refused to host:
<nodeHostname>; nested exception is:
        java.net.ConnectException: Connection refused
Verify: rg1-rn2:    ping() failed for rg1-rn2 : Connection refused to
host: <nodeHostname>; nested exception is:
        java.net.ConnectException: Connection refused
```

### Note

The verify output is only displayed in the shell when the command is finished. You can tail or grep the Oracle NoSQL Database log file in order to get a sense of how the verify is progressing. Look for the string `Verify`. For example:

```
grep Verify /KVRT1/mystore/log/mystore_0.log
```

## Monitoring the Store

Information about the performance and availability of your store can be obtained both from a server side and client side perspective:

- Your Oracle NoSQL Database applications can obtain performance statistics using the `oracle.kv.KVStore.getStats()` class. This provides a client side view of the complete round trip performance for Oracle NoSQL Database operations.

- Oracle NoSQL Database automatically captures Replication Node performance statistics into a log file that can easily be imported and analyzed with spreadsheet software. Statistics are tracked, logged and written at a user specified interval to a CSV file ( `je.stat.csv`) in the Environment directory. The logging occurs per-Environment when the Environment is opened in read/write mode.

  Configuration parameters control the size and number of rotating log files used (similar to java logging, see java.util.logging.FileHandler). For a rotating set of files, as each file reaches a given size limit, it is closed, rotated out, and a new file is opened. Successively older files are named by adding "0", "1", "2", etc. into the file name. The format is `je.stat[version number].csv`

- The Oracle NoSQL Database administrative service collects and aggregates status information, alerts, and performance statistics components that are generated in the store. This provides a detailed, server side view of behavior and performance of the Oracle NoSQL Database server.

- Each Oracle NoSQL Database Storage Node maintains detailed logs of trace information from the services that are housed on that node. The administrative service presents an aggregated, store-wide view of these component logs, but the logs are nevertheless available on each Storage Node in the event that the administrative service is somehow not available, or if it is more convenient to examine the individual logs.

- Oracle NoSQL Database allows Java Management Extensions (JMX) or Simple Network Management Protocol (SNMP) agents to be optionally available for monitoring. The SNMP and JMX interfaces allow you to poll the Storage Nodes for information about the storage node and about any replication nodes that are hosted on the Storage Node. See Standardized Monitoring Interfaces (page 85) for more information.

In addition to the logging mechanisms noted above, you can also view the current health of the store using the Admin Console. This information is viewable on the Topology pane. It shows you what services are currently unavailable. Problematic services are highlighted in red. Two lines at the top of the pane summarize the number of available and unavailable services.

Finally, you can monitor the status of the store by verifying it from within the CLI. See Verifying the Store (page 70) for more information. You can also use the CLI to examine events.

## Events

Events are special messages that inform you of the state of your system. As events are generated, they are routed through the monitoring system so that you can see them. There are four types of events that the store reports:

1. State Change events are issued when a service starts up or shuts down.

2. Performance events report statistics about the performance of various services.

3. Log events are records produced by the various system components to provide trace information about debugging. These records are produced by the standard `java.util.logging` package.

4. Plan Change events record the progress of plans as they execute, are interrupted, fail or are canceled.

Note that some events are considered critical. These events are recorded in the administration service's database, and can be retrieved and viewed using the CLI or the Admin Console.

### Other Events

Plan Change events cannot be directly viewed through Oracle NoSQL Database's administrative interfaces. However, State Change events, Performance events, and Log events are recorded using the EventRecorder facility internal to the Admin. Only events that are considered "critical" are recorded, and the criteria for being designated as such vary with the type of the event. All state change events are considered critical, but only SEVERE log events are. Performance events are considered critical if the reported performance is below a certain threshold.

All such events can be viewed in the CLI using the `show events` and `show event` commands.

Use the CLI `show events` command with no arguments to see all the unexpired events in the database. You can bound the range of events that are displayed using the `-from` and `-to` arguments. You can filter events by type or id as well, using either the `-type` or the `-id` arguments respectively.

For example, this is a fragment of the output from the `show events` command:

```
gt0hgvkiS STAT 2011-09-25 16:30:54.162 UTC rg2-rn3 RUNNING sev1
gt0hgvkjS STAT 2011-09-25 16:30:41.703 UTC rg1-rn1 RUNNING sev1
gt0hgvkkS STAT 2011-09-25 16:30:51.540 UTC rg2-rn2 RUNNING sev1
gt0hicphL LOG  2011-09-25 16:32:03.029 UTC SEVERE[admin1] Task StopAdmin
failed: StopAdmin [INTERRUPTED] start=09-25-11 16:32:03 end=09-25-11
16:32:03 Plan has been interrupted.: null: java.lang.InterruptedException
```

This shows three state change events and one severe log event. The tags at the beginning of each line are individual event record identifiers. If you want to see detailed information for a particular event, you can use the "show event" command, which takes as its argument an event record identifier:

```
kv-> show event -id gt0hicphL
gt0hicphL LOG  2011-09-25 16:32:03.029 UTC SEVERE[admin1] Task StopAdmin
failed: StopAdmin [INTERRUPTED] start=09-25-11 16:32:03 end=09-25-11
16:32:03 Plan has been interrupted.: null: java.lang.InterruptedException
            at java.util.concurrent.locks.AbstractQueuedSynchronizer.
doAcquireSharedNanos(AbstractQueuedSynchronizer.java:1024)
            at java.util.concurrent.locks.AbstractQueuedSynchronizer.
tryAcquireSharedNanos(AbstractQueuedSynchronizer.java:1303)
    ....
```

and so on, for a complete stack trace.

Events expire from the system after a set period, which defaults to thirty days.

## Setting Store Parameters

The three Oracle NoSQL Database service types; Admin, Storage Node and Replication Node; have configuration parameters, some of which can be tweaked after the service is deployed. To see the parameter values that can be changed, you use the following command in the CLI:

```
show parameters -service <id>
```

This command allows you to display service parameters and state for the specified service. The service may be a Replication Node, a Storage Node, or Admin service, as identified by any valid string. You can use the `-policy` optional flag to show global policy parameters.

## Changing Parameters

All of the CLI commands used for creating parameter-changing plans share a similar syntax:

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

All such commands can have multiple `ParameterName=NewValue` assignment arguments on the same command line. If NewValue contains spaces, then the entire assignment argument must be quoted within double quote marks. For example, to change the Admin parameter collectorPollPeriod, you would issue the command:

```
kv-> plan change-parameters -all-admins -params \
    "collectorPollPeriod=20 SECONDS"
```

The following commands are used to change service parameters:

- `plan change-parameters -service <shardId-nodeId> -params [assignments]`

  This command is used to change the parameters of a single Replication Node, which must be identified using the shard and node numbers. The `shardId-nodeId` identifier must be given as a single argument with one embedded hyphen and no spaces. The `shardId` identifier is represented by `rgX`, where `X` refers to the shard number.

- `plan change-parameters -all-rns -params [assignments]`

  This command is used to change the parameters of all Replication Nodes in a store. No Replication Node identifier is needed in this case.

- `plan change-parameters -service <storageNodeId> -params [assignments]`

  This command is used to change the parameters of a single Storage Node instance. The storageNodeId is a simple integer.

- `plan change-parameters -all-admins -params [assignments]`

  This command is used to change Admin parameters. Because each instance of Admin is part of the same replicated service, all instances of the Admin are changed at the same time, so no Admin identifier is needed in this command.

  If an Admin parameter change requires the restarting of the Admin service, KVAdmin loses its connection to the server. Under normal circumstances, KVAdmin automatically reconnects after a brief pause, when the next command is given. At this point the plan is in the `INTERRUPTED` state, and must be completed manually by issuing the `plan execute` command.

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

  This command is used to change security parameters. The parameters are applied implicitly and uniformly across all SNs, RNs and Admins.

In all cases, you can choose to create a plan and execute it; or to create the plan and execute it in separate steps by using the `-noexecute` option of the plan command.

## Setting Store Wide Policy Parameters

Most admin, Storage Node, and replication node parameters are assigned to default values when a store is deployed. It can be inconvenient to adjust them after deployment, so Oracle NoSQL Database provides a way to set the defaults that are used during deployment. These defaults are called store-wide Policy parameters.

You can set policy parameters in the CLI by using this command:

```
change-policy -params [name=value]
```

The parameters to change follow the `-params` flag and are separated by spaces. Parameter values with embedded spaces must be separated by spaces. Parameter values with embedded spaces must be quoted. For example: name = "value with spaces". If the optional `dry-run` flag is specified, the new parameters are returned without changing them.

## Admin Parameters

The following parameters can be set for the Admin service:

- `adminLogFileCount=<Integer>`

  Sets the number of log files that are kept. This value defaults to "20". It is used to control the amount of disk space devoted to logging history.

- `adminLogFileLimit=<Integer>`

  Limits the size of log files. After reaching this limit, the logging subsystem switches to a new log file. This value defaults to "4,000,000" bytes. The limit specifies an approximate maximum amount to write (in bytes) to any one file. If the value is zero, then there is no limit.

- `collectorPollPeriod=<Long TimeUnit>`

  Sets the Monitor subsystem's delay for polling the various services for status updates. This value defaults to "20" seconds. Units are supplied as a string in the `change-parameters` command, for example: -params collectorPollPeriod="2 MINUTES"

- `loggingConfigProps=<String>`

  Property settings for the Logging subsystem in the Admin process. Its format is `property=value;property=value....` Standard java.util.logging properties can be set by this parameter.

- `eventExpiryAge=<Long TimeUnit>`

  You can use this parameter to adjust how long the Admin stores critical event history. The default value is "30 DAYS".

- `configProperties=<String>`

  This is an omnibus string of property settings for the underlying BDB JE subsystem. Its format is `property=value;property=value....`

- `javaMiscParams=<String>`

  This is an omnibus string that is added to the command line when the Admin process is started. It is intended for setting Java VM properties, such as -Xmx and -Xms to control the heap size. If the string is not a valid sequence of tokens for the JVM command line, the Admin process fails to start.

- `adminHttpPort=<Integer>`

  Sets the port on which the Oracle NoSQL Database web-based Admin Console is contacted. Examples in this book use port 5001. If the value is 0, the web interface is disabled.

## Storage Node Parameters

The following parameters can be set for Storage Nodes:

- `serviceLogFileCount=<Integer>`

  Sets the number of log files that are kept, for this Storage Node and for all Replication Nodes hosted on this Storage Node. This value defaults to "20". It is used to control the amount of disk space devoted to logging history.

- `serviceLogFileLimit=<Integer>`

  Limits the size of log files. After reaching this limit, the logging subsystem switches to a new log file. This setting applies to this Storage Node and to all Replication Nodes hosted on this Storage Node. This value defaults to "2,000,000" bytes. The limit specifies an approximate maximum amount to write (in bytes) to any one file. If the value is zero, then there is no limit.

- `haPortRange=<String>`

  Defines the range of port numbers available for assigning to Replication Nodes that are hosted on this Storage Node. A port is allocated automatically from this range when a Replication Node is deployed. The format of the value string is "lowport,highport".

- `haHostname=<String>`

  Sets the name of the network interface used by the HA subsystem. A valid string for a `hostname` can be a DNS name or an IP address.

- `capacity=<Integer>`

  Sets the number of Replication Nodes that can be hosted on this Storage Node. This value is used to inform decisions about where to place new Replication Nodes. Capacity can be set to values greater than 1 when the Storage Node has sufficient disk, CPU, and memory to support multiple Replication Nodes. Default value: "1".

- `memoryMB=<Integer>`

  Sets the amount of memory known to be available on this Storage Node, in megabytes. This number is used to inform the allocation of resources equitably among Replication Nodes when capacity > 1. Defaults to "0", which means "unknown." It allows the deployment plan to configure each Replication Node with an appropriate -Xmx heap size.

- `numCPUs=<Integer>`

  Sets the number of CPUs known to be available on this Storage Node. Default value: 1.

- `rnHeapPercent=<Integer>`

  Sets the percentage of a Storage Node's memory reserved for heap, for all RN processes hosted on this SN. Default value: 85.

- `mgmtClass=<String>`

  The name of the class that provides the Management Agent implementation. See Standardized Monitoring Interfaces (page 85) for more information. The port cannot be a privileged port number (<1024).

- `mgmtPollPort=<Integer>`

  Sets the port on which the SNMP agent listens.

- `mgmtTrapHost=<String>`

  Sets the host to which SNMP notifications are sent.

- `mgmtTrapPort=<Integer>`

  Sets the port to which SNMP notifications are sent.

- `servicePortRange=<String>`

  Sets the range of ports used for communication among administrative services running on a Storage Node and its managed services. This parameter is optional. By default the services use anonymous ports. The format of the value string is "startPort,endPort."

  The range should be large enough to accommodate the Storage Node and all the Replication Nodes (as defined by the capacity parameter) hosted on the machines. The number of ports required depends on whether the system is configured for security. For a non-secure system, each Storage Node consumes three ports (including the Registry Service) and each Replication Node consumes three ports in the range. An Admin, if configured consumes 2 ports. On a secure system, one additional port is required for each Storage Node, Replication Node and Admin. As a general rule, it is good practice to specify a range that is significantly larger than the minimum to allow for increases in Storage Node capacity or network problems that may render ports temporarily unavailable.

  For a non-secure system, as a rough rule of thumb, you can use the following formula to arrive at an estimate for the port range size number:

```
3 (Storage Nodes, adding one for safety) +
3 * capacity (the number of replication nodes) \
+ 2 (added only if the Storage Node is hosting an admin process as well)
```

For example, if a Storage Node has capacity 1 and is hosting an admin process, the range size must be at least 8. You may want to increase the range size beyond this minimum (in increments of 3). Doing so allows for safety and expansion of the Storage Node without requiring future changes to this parameter. If capacity were 2, the the range size must be greater than or equal to 11. It is best to find a range on the machine that is contiguous. If other services on the host use ports in the range, those will be skipped and the range must be larger.

If you are deploying a secure Oracle NoSQL Database then you can use the following formula to arrive at an estimate for the port range size number:

```
4 (Storage Nodes, adding one for safety) +
4 * capacity (the number of replication nodes) \
+ 3 (added only if the Storage Node is hosting an admin process as well)
```

where an additional port was added for each Storage Node, Replication Node or the Admin (if configured).

For more information on configuring Oracle NoSQL Database securely, see the Oracle NoSQL Database Security Guide.

## Replication Node Parameters

The following parameters can be set for Replication Nodes:

- `collectEnvStats=<Boolean>`

  If true, then the underlying BDB JE subsystem dumps statistics into the .stat file. This information is useful for tuning JE performance. Oracle Support may request these statistics to aid in tuning or to investigate a problem.

- `maxTrackedLatency=<Long TimeUnit>`

  The highest latency that is included in the calculation of latency percentiles.

- `configProperties=<String>`

  Contains property settings for the underlying BDB JE subsystem. Its format is `property=value;property=value....`

- `javaMiscParams=<String>`

  A string that is added to the command line when the Replication Node process is started. It is intended for setting Java VM properties, such as -Xmx and -Xms to control the heap size. If the string is not a valid sequence of tokens for the JVM command line, the Admin process fails to start.

- `loggingConfigProps=<String>`

Contains property settings for the Logging subsystem. The format of this string is like that of configProperties, above. Standard java.util.logging properties can be set by this parameter.

- `statsInterval=<Long TimeUnit>`

  Sets the collection period for latency statistics at this Replication Node. This value defaults to "60" seconds. Values like average interval latencies and throughput are averaged over this period of time.

- `cacheSize=<Long>`

  Sets the cache size in the underlying BDB JE subsystem. The units are bytes. The size is limited by the java heap size, which in turn is limited by the amount of memory available on the machine. You should only ever change this low level parameter under explicit directions from Oracle support.

- `latencyCeiling=<Integer>`

  If the Replication Node's average latency exceeds this number of milliseconds, it is considered an "alertable" event. Such an event produces a popup in the Admin Console, and it is stored in the Admin's database as a critical event. If SNMP or JMX monitoring is enabled, the event also causes an appropriate notification to be sent.

- `throughputFloor=<Integer>`

  Similar to latencyCeiling, throughputFloor sets a lower bound on Replication Node throughput. Lower throughput reports are considered alertable. This value is given in operations per second.

- `rnCachePercent=<Integer>`

  The portion of an RN's memory set aside for the JE environment cache.

## Security Parameters

The following parameters can be implicitly and uniformly set across all Storage Nodes, Replication Nodes and Admins:

- 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.

## Admin Restart

Changes to the following Oracle NoSQL Database parameters will result in a Admin restart by the Storage Node Agent:

Admin parameters:

- adminLogFileCount
- adminLogFileLimit
- configProperties
- javaMiscParams
- loggingConfigProps
- adminHttpPort

For example:

```
kv-> plan change-parameters -all-admins -params adminLogFileCount=10
Started plan 14. Use show plan -id 14 to check status.
        To wait for completion, use plan wait -id 14
kv-> show plan -id 14
Plan Change Admin Params (14)
State:                 INTERRUPTED
Attempt number:        1
Started:               2013-08-26 20:12:06 UTC
Ended:                 2013-08-26 20:12:06 UTC
Total tasks:           4
 Successful:           1
 Interrupted:          1
 Not started:          2
Tasks not started
```

```
   Task StartAdmin start admin1
   Task WaitForAdminState waits for Admin admin1 to reach RUNNING state
kv-> plan execute -id 14
Started plan 14. Use show plan -id 14 to check status.
        To wait for completion, use plan wait -id 14
kv-> show plan -id 14
Plan Change Admin Params (14)
State:                 SUCCEEDED
Attempt number:        1
Started:               2013-08-26 20:20:18 UTC
Ended:                 2013-08-26 20:20:18 UTC
Total tasks:           2
 Successful:           2
```

### Note

When you change a parameter that requires an Admin restart using the `plan change-parameters` command, the plan ends in an `INTERRUPTED` state. To transition it to a `SUCCESSFUL` state, re-issue the plan a second time using the `plan execute -id <id>` command.

## Replication Node Restart

Changes to the following Oracle NoSQL Database parameters will result in a Replication Node restart by the Storage Node Agent:

Storage Node parameters:

- serviceLogFileCount
- serviceLogFileLimit
- servicePortRange

Replication Node parameters:

- configProperties
- javaMiscParams
- loggingConfigProps

## Removing an Oracle NoSQL Database Deployment

There are no scripts or tools available to completely remove a Oracle NoSQL Database installation from your hardware. However, the procedure is simple. On each node (machine) comprising your store:

1. Shut down the Storage Node:

   ```
   java -Xmx256m -Xms256m \
   ```

```
-jar KVHOME/lib/kvstore.jar stop -root KVROOT
```

Note that if an Admin process is running on the machine, this command also stops that process.

2. Physically remove the entire contents of KVROOT:

```
> rm -rf KVROOT
```

Once you have performed this procedure on every machine comprising your store, you have completely removed the Oracle NoSQL Database deployment from your hardware.

## Fixing Incorrect Storage Node HA Port Ranges

When you initially configured your installation, you defined a range of ports to be used by the nodes when communication among themselves. (You did this in Installation Configuration (page 12).) This range of ports is called the *HA port range*, where *HA* is short hand for "replication."

If you have specified invalid values for the HA Port Range, you are unable to deploy a Replication Node (RN) or a secondary Administration process (Admin) on any misconfigured Storage Node. You discover the problem when you first attempt to deploy a store or a Admin Replica on a faulty Storage Node. You see these indications that the Replication Node did not come up on this Storage Node:

- The Admin displays an error dialog warning that the Replication Node is in the `ERROR_RESTARTING` state. The Topology tab also shows this state in red, and after a number of retries, it indicates that the Replication Node is in `ERROR_NO_RESTART`.

- The plan goes into `ERROR` state, and its detailed history — available by clicking on the plan in the Admin's `Plan History` tab, or through the CLI's `show plan <planID>` command — shows an error message like this:

```
Attempt 1
        state: ERROR
        start time: 10-03-11 22:06:12
        end time: 10-03-11 22:08:12
        DeployOneRepNode of rg1-rn3 on sn3/farley:5200 [RUNNING]
        failed. ....  Failed to attach to RepNodeService for rg1-rn3,
        see log, /KVRT3/<storename>/log/rg1-rn3*.log, on host
        farley for more information.
```

- The critical events mechanism, accessible through the Admin or CLI shows an alert that contains the same error information from the plan history.

- An examination of the specified .log file or the store-wide log displayed in the Admin's `Log` tab shows a specific error message, such as:

```
[rg1-rn3] Process exiting
java.lang.IllegalArgumentException: Port number 1 is invalid because
the port must be outside the range of "well known" ports
```

The misconfiguration can be addressed with the following steps. Some steps must be executed on the physical node which hosts the Oracle NoSQL Database Storage Node, while others can be done from any node which can access the Admin or CLI.

1. Using the Admin or CLI, cancel the deploy-store or deploy-admin plan which ran afoul of the misconfiguration.

2. On the Storage Node, kill the existing, misconfigured StorageNodeAgentImpl process and all its ManagedProcesses. You can distinguish them from other processes because they have the parameter `-root <KVROOT>`.

3. On the Storage Node, remove all files from the KVROOT directory.

4. On the Storage Node, re-create the Storage Node bootstrap configuration file in the KVROOT directory. For directions on how to do this, see Installation Configuration (page 12).

5. On the Storage Node, restart the Storage Node using the following command:

   ```
   java -Xmx256m -Xms256m -jar KVHOME/lib/kvstore.jar restart
   ```

6. Using the CLI, re-deploy the storage node using the deploy-sn plan.

You can now create and execute a deploy-store or deploy-admin plan, using the same parameters as the initial attempt which uncovered your misconfigured Storage Node.

# Chapter 8. Standardized Monitoring Interfaces

Oracle NoSQL Database allows Java Management Extensions (JMX) or Simple Network Management Protocol (SNMP) agents to be optionally available for monitoring, in addition to the native monitoring provided by the Admin CLI and the Admin Console. These agents provide interfaces on each storage node that allow management clients to poll them for information about the status, performance metrics, and operational parameters of the storage node and its managed services, including replication nodes and admin instances.

Both these management agents can also be configured to push notifications about changes in the status of any of the services, and for violations of preset performance limits.

The JMX interface can be enabled in either the Community Edition or the Enterprise Edition. To use SNMP, however, you must have the Enterprise Edition.

The JMX service exposes MBeans for the three types of components. These MBeans are the java interfaces StorageNodeMBean, RepNodeMBean, and AdminMBean in the package oracle.kv.impl.mgmt.jmx. For more information about the status reported for each component, see the javadoc for these interfaces.

The same information that is reported via JMX can also be reported through SNMP. In this case, the information is organized according to the Management Information Base (MIB) named OracleNosqlMIB, which is included with the Enterprise Edition, in the file lib/nosql.mib.

## Simple Network Management Protocol (SNMP) and Java Management Extensions (JMX)

Both the SNMP and JMX agents in NoSQL Database are read-only interfaces and allow you to poll the storage nodes for information about the storage node and about any replication nodes or admins that are hosted on the storage node. The available information includes service status (such as, RUNNING, STOPPED etc.), operational parameters, and performance metrics.

SNMP and JMX traps/notifications are also delivered for particular events. Notifications are sent for every service status state change; and for violations of performance limits.

### Enabling Monitoring

Monitoring can be enabled on a per-storage node basis in two different ways:

#### In the Bootfile

You can specify that you want to enable JMX or SNMP in the storage node's boot configuration file. Usually, these files are created by using the makebootconfig utility, which has the following options to control these features:

- `[-mgmt {snmp|jmx|none} -pollport <snmp poll port>]`
- `-traphost <snmp trap/notification hostname>]`

- `-trapport <snmp trap/notification port>]`

### Note

When you specify -mgmt snmp, you must also specify -pollport. The SNMP agent listens for connections from SNMP management clients on this port. You may also optionally specify -traphost and -trapport to indicate the destination address for notifications. This would be the hostname and port number of an SNMP management service that is configured to receive notifications at that address.

### Note

When you specify -mgmt jmx, you do not have to specify -pollport. A storage node's JMX agent uses the RMI registry at the same port number as is used for all other RMI services managed by the storage node. (This port number is specified as the -port argument to makebootconfig.)

#### By Changing Storage Node Parameters

You can still enable JMX or SNMP after a store is deployed, by changing the storage node parameters "mgmtClass", "mgmtPollPort", "mgmtTrapHost", and "mgmtTrapPort". Similar to configuring via makebootconfig, the "mgmtPollPort", "mgmtClass", "mgmtTrapHost", and "mgmtTrapPort" are used only for SNMP; and the parameter "mgmtPollPort" must be set when enabling SNMP.

The value of the "mgmtClass" parameter may be one of the following class names:

- To enable JMX:

  ```
  oracle.kv.impl.mgmt.jmx.JmxAgent
  ```

- To enable SNMP:

  ```
  oracle.kv.impl.mgmt.snmp.SnmpAgent
  ```

- To enable neither JMX nor SNMP:

  ```
  oracle.kv.impl.mgmt.NoOpAgent
  ```

For example, you could issue the following command in the Admin CLI to enable SNMP on a storage node:

```
plan change-parameters -service sn1 -wait -params \
mgmtClass=oracle.kv.impl.mgmt.snmp.SnmpAgent \
mgmtPollPort=5002 mgmtTrapHost=192.168.26.42
mgmtTrapPort=32767
```

### Note

Only a single implementation of the management agent may be enabled at a particular time. If you enable SNMP on a storage node where JMX is already enabled; the JMX agent shuts down, and the SNMP agent takes its place.

## Displaying the NoSQL DB MBeans

To view the NoSQL Database JMX Mbeans in a monitoring tool such as JConsole, connect using the hostname and registry port for each Storage Node that you would like to view.

For example, in this case you would specify localhost:5000 to the JConsole Remote Process connection box in the New Connection tab.

# Appendix A. KVStore Command Reference

You can access KVStore commands either through the Command Line Interface(CLI) or through `"java -Xmx256m -Xms256m -jar <kvhome>/lib/kvstore.jar <command>"`. The following sections will describe both the CLI commands and the utility commands accessed through `"java -jar"`.

## CLI Commands and Subcommands

The Command Line Interface (CLI) is run interactively or used to run single commands. The general usage to start the CLI is:

```
java -Xmx256m -Xms256m \
-jar KVHOME/lib/kvstore.jar runadmin
-host <hostname> -port <port> [single command and arguments]
```

If you want to run a script file, you can use the "load" command on the command line:

```
java -Xmx256m -Xms256m \
-jar KVHOME/lib/kvstore.jar runadmin
-host <hostname> -port <port> load -file <path-to-script>
```

If none of the optional arguments are passed, it starts interactively. If additional arguments are passed they are interpreted as a single command to run, then return. The interactive prompt for the CLI is:

```
"kv-> "
```

Upon successful completion of the command, the CLI's process exit code is zero. If there is an error, the exit code will be non-zero.

The CLI comprises a number of commands, some of which have subcommands. Complex commands are grouped by general function, such as "show" for displaying information or "ddl" for manipulating schema. All commands accept the following flags:

- -help

  Displays online help for the command or subcommand.

- ?

  Synonymous with -help. Displays online help for the command or subcommand.

- -verbose

  Enables verbose output for the command.

CLI commands have the following general format:

1. All commands are structured like this:

```
"kv-> command [sub-command] [arguments]
```

2. All arguments are specified using flags which start with "-"
3. Commands and subcommands are case-insensitive and match on partial strings(prefixes) if possible. The arguments, however, are case-sensitive.

This appendix contains the following information on the commands and subcommands:

## aggregate

```
aggregate [-count] [-sum <field[,field,..]>] [-avg <field[,field,..]>]
[-key <key>] [-start <prefixString>] [-end <prefixString>]
```

Performs simple data aggregation operations on numeric fields like count, sum, average, keys, start and end. The aggregate command iterates matching keys in the store so, depending on the specified key, it may take a very long time to complete on a large store.

where:

- `-count`

  Returns the count of matching records.

- `-sum`

  Returns the sum of the values of matching fields. All records with a schema with the named field are matched. Unmatched records are ignored.

- `-avg`

  Returns the average of the values of matching fields. All records with a schema with the named field are matched. Unmatched records are ignored.

- `-key`

  Specifies the key (prefix) to use.

- `-start` and `-end` flags

  Restricts the range used for iteration. This is particularly helpful when getting a range of records based on a key component, such as a well-formatted string. `-start` and `-end` arguments are inclusive.

For example, a simple `count` of all records in the store:

```
kv -> aggregate -count
count: 33508
```

`Sum` and `average` operate on specific field names in matching records which means that only Avro records containing the named fields are used. Sum and average only operate on numeric fields of Avro types INT, LONG, FLOAT, and DOUBLE.

For example, with the following schema:

```
{
  "type" : "record",
  "name" : "Cookie",
  "fields" : [ {
    "name" : "id",
    "type" : "string",
    "default" : ""
  }, {
    "name" : "frequency",
    "type" : "int",
    "default" : 0
  }, {
    "name" : "lastVisit",
    "type" : "string",
    "default" : ""
  }, {
    "name" : "segments",
    "type" : {
      "type" : "array",
      "items" : "string"
    },
    "default" : [ ]
  } ]
}
```

An example of `sum` on a field named `frequency`:

```
kv -> aggregate -sum frequency -key /visits/charitable_donors/date
sum(frequency): 2068
```

An example of `average` on a field named `frequency`:

```
kv -> aggregate -avg frequency -key /visits/charitable_donors/date
avg(frequency): 2.494571773220748
```

## change-policy

```
change-policy [-dry-run] -params [name=value]*
```

Modifies store-wide policy parameters that apply to not yet deployed services. The parameters to change follow the -params flag and are separated by spaces.

Parameter values with embedded spaces must be quoted, for example, name="value with spaces". If -dry-run is specified, the new parameters are returned without changing them.

For more information on setting policy parameters, see Setting Store Wide Policy Parameters (page 76).

## configure

```
configure -name <storename>
```

Configures a new store. This call must be made before any other administration can be performed.

Use the `-name` option to specify the name of the KVStore that you want to configure. The name is used to form a path to records kept in the store. For this reason, you should avoid using characters in the store name that might interfere with its use within a file path. The command line interface does not allow an invalid store name. Valid characters are alphanumeric, '-', '_', and '.'.

## connect

Encapsulates commands that connect to the specified host and registry port to perform administrative functions or connect to the specified store to perform data access functions.

The current store, if any, will be closed before connecting to another store. If there is a failure opening the specified KVStore, the following warning is displayed: "Warning: You are no longer connected to KVStore".

The subcommands are as follows:

- connect admin (page 91)
- connect store (page 91)

### connect admin

```
connect admin -host <hostname> -port <registry port> [-username <user>]
[-security <security-file-path>]
```

Connects to the specified host and registry port to perform administrative functions. An Admin service must be active on the target host. If the instance is secured, you may need to provide login credentials.

### connect store

```
connect store -host <hostname> -port <port> -store <storename> [-username
 <user>] [-security <security-file-path>]
```

Connects to a KVStore to perform data access functions. If the instance is secured, you may need to provide login credentials.

## delete

Encapsulates commands that delete key/value pairs from store or rows from table. The subcommands are as follows:

- delete kv (page 91)
- delete table (page 92)

### delete kv

```
delete kv [-key <key>] [-start prefixString] [-end prefixString] [-all]
```

Deletes one or more keys. If `-all` is specified, delete all keys starting at the specified key. If no key is specified, delete all keys in the store. The `-start` and `-end` flags can be used for restricting the range used for deleting.

For example, to delete all keys in the store starting at root:

```
kv -> delete kv -all
301 Keys deleted starting at root
```

### delete table

```
delete table -name <name>
 [-field <name> -value <value>]*
 [-field <name> [-start <value>] [-end <value>]]
 [-ancestor <name>]* [-child <name>]*
 [-json <string>] [-delete-all]
```

Deletes one or multiple rows from the named table. The table name is a dot-separated name with the format `tableName[.childTableName]*`.

- `-field` and `-value` pairs are used to specify the field values of the primary key, or you can use an empty key to delete all rows from the table.
- `-field`, `-start` and `-end` flags are used for restricting the sub range for deletion associated with the parent key.
- `-ancestor` and `-child` flags are used to delete rows from specific ancestor and/or descendant tables as well as the target table.
- `-json`indicates that the key field values are in JSON format.
- `-delete-all`is used to delete all rows in a table.

## ddl

Encapsulates operations that manipulate schemas in the store. The subcommands are as follows:

- ddl add-schema (page 92)
- ddl enable-schema (page 92)
- ddl disable-schema (page 93)

For details on managing schema in the store, see Managing Avro Schema (page 61).

### ddl add-schema

```
ddl add-schema <-file <file> | -string <schema string>>
[-evolve] [-force]
```

Adds a new schema or changes (evolves) an existing schema with the same name. Use the -evolve flag to indicate that the schema is changing. Use the -force flag to add the schema in spite of evolution warnings.

### ddl enable-schema

```
ddl enable-schema -name <name>.<ID>
```

Enables an existing, previously disabled schema.

### ddl disable-schema

```
ddl disable-schema -name <name>.<ID>
```

Disables an existing schema.

## exit

```
exit | quit
```

Exits the interactive command shell.

## get

Encapsulates commands that get key/value pairs from store or get rows from table. The subcommands are as follows:

- get kv (page 93)
- get table (page 95)

### get kv

```
get kv [-key <keyString>] [-json] [-file <output>] [-all] [-keyonly]
[-valueonly] [-start <prefixString>] [-end <prefixString>]
```

Perform a simple get operation using the specified key. The obtained value is printed out if it contains displayable characters, otherwise the bytes array is encoded using Base64 for display purposes. "[Base64]" is appended to indicate this transformation. The arguments for the get command are:

- `-key <keyString>`

  Indicates the full or the prefix key path to use. If `<keyString>` is a full key path, it returns a single value information. The format of this `get` command is: `get -key <keyString>`. If `<keyString>` is a prefix key path, it returns multiple key/value pairs. The format of this `get` command is: `get -key <keyString> -all`. Key can be composed of both major and minor key paths, or a major key path only. The <keyString> format is: "major-key-path/-/minor-key-path". Additionally, in the case of the prefix key path, a key can be composed of the prefix part of a major key path.

  For example, with some sample keys in the KVStore:

  ```
  /group/TC/-/user/bob
  /group/TC/-/user/john
  /group/TC/-/dep/IT
  /group/SZ/-/user/steve
  /group/SZ/-/user/diana
  ```

  A get command with a key containing only the prefix part of the major key path results in:

  ```
  kv -> get kv -key /group -all -keyonly
  /group/TC/-/user/bob
  /group/TC/-/user/john
  /group/TC/-/dep/IT
  ```

```
/group/SZ/-/user/steve
/group/SZ/-/user/diana
```

A get command with a key containing a major key path results in:

```
kv -> get kv -key /group/TC -all -keyonly
/group/TC/-/user/bob
/group/TC/-/user/john
/group/TC/-/dep/IT
```

Get commands with a key containing major and minor key paths results in:

```
kv -> get kv -key /group/TC/-/user -all -keyonly
/group/TC/-/user/bob
/group/TC/-/user/john
```

```
kv -> get kv -key /group/TC/-/user/bob
{
    "name"  : "bob.smith",
    "age"   : 20,
    "email" : "bob.smith@gmail.com",
    "phone" : "408 555 5555"
}
```

- `-json`

  Should be specified if the record is JSON.

- `-file <output>`

  Specifies an output file, which is truncated, replacing all existing content with new content.

  In the following example, records from the key `/Smith/Bob` are written to the file `"data.out"`.

  ```
  kv -> get kv -key /Smith/Bob -all -file ./data.out
  ```

  In the following example, contents of the file `"data.out"` are replaced with records from the key `/Wong/Bill`.

  ```
  kv -> get kv -key /Wong/Bill -all -file ./data.out
  ```

- `-all`

  Specified for iteration starting at the specified key. If the key argument is not specified, the entire store will be iterated.

- `-keyonly`

  Specified with `-all` to return only keys.

- `-valueonly`

  Specified with `-all` to return only values.

- `-start <prefixString>` and `-end <prefixString>`

  Restricts the range used for iteration. This is particularly helpful when getting a range of records based on a key component, such as a well-formatted string. `-start` and `-end` arguments are inclusive.

  ### Note

  `-start` and `-end` only work on the key component specified by `-key <keyString>`. The value of `<keyString>` should be composed of simple strings and cannot have multiple key components specified.

  For example, a log where its key structure is:

  ```
  /log/<year>/<month>/-/<day>/<time>
  ```

  puts all log entries for the same day in the same partition, but splits the days across shards. The `time` format is: "hour.minute".

  In this way, you can do a `get` of all log entries in February and March, 2013 by specifying:

  ```
  kv -> get kv -all -keyonly -key /log/2013 -start 02 -end 03
  /log/2013/02/-/01/1.45
  /log/2013/02/-/05/3.15
  /log/2013/02/-/15/10.15
  /log/2013/02/-/20/6.30
  /log/2013/02/-/28/8.10
  /log/2013/03/-/01/11.13
  /log/2013/03/-/15/2.28
  /log/2013/03/-/22/4.52
  /log/2013/03/-/31/11.55
  ```

  You can be more specific to the `get` command by specifying a more complete key path. For example, to display all log entries from April 1st to April 4th:

  ```
  kv -> get kv -all -keyonly -key /log/2013/04 -start 01 -end 04
  /log/2013/04/-/01/1.03
  /log/2013/04/-/01/4.05
  /log/2013/04/-/02/7.22
  /log/2013/04/-/02/9.40
  /log/2013/04/-/03/4.15
  /log/2013/04/-/03/6.30
  /log/2013/04/-/03/10.25
  /log/2013/04/-/04/4.10
  /log/2013/04/-/04/8.35
  ```

See the subcommand get table (page 95)

## get table

```
get table -name <name> [-index <name>]
[-field <name> -value <value>]*
```

```
[-field <name> [-start <value>] [-end <value>]]
[-ancestor <name>]* [-child <name>]*
[-json <string>] [-file <output>] [-pretty]
```

Performs a get operation to retrieve row(s) from a named table. The table name is a dot-separated name with the format `tableName[.childTableName]*` .

- `-field` and `-value` pairs are used to specify the field values of the primary key or index key if using index specified by `-index`, or with an empty key to iterate the entire table.
- `-field`, `-start` and `-end` flags are used for restricting the sub range for retrieving associated with parent key.
- `-ancestor` and `-child` flags are used to return results from specific ancestor and/or descendant tables as well as the target table.
- `-file` is used to specify an output file, which is truncated.
- `-pretty` is used for a nicely formatted JSON string with indentation and carriage returns.

## help

```
help [command [sub-command]]
```

Prints help messages. With no arguments the top-level shell commands are listed. With additional commands and sub-commands, additional detail is provided.

```
kv -> help load load -file <path to file>
  Loads the named file and interpret its contents as a script of
  commands to be executed. If any of the commands in the script
  fail, execution will stop at that point.
```

## hidden

Toggles visibility and setting of parameters that are normally hidden. Use these parameters only if advised to do so by Oracle Support.

## history

```
history [-last <n>] [-from <n>] [-to <n>]
```

Displays command history. By default all history is displayed. Optional flags are used to choose ranges for display.

## load

```
load -file <path to file>
```

Loads the named file and interpret its contents as a script of commands to be executed. If any of the commands in the script fail, execution will stop at that point.

For example, suppose the following commands are collected in the script file `load-contacts-5.txt`:

```
### Begin Script ###
```

```
put -key /contact/Bob/Walker -value "{\"phone\":\"857-431-9361\", \
\"email\":\"Nunc@Quisque.com\",\"city\":\"Turriff\"}" \
-json example.ContactInfo
put -key /contact/Craig/Cohen -value "{\"phone\":\"657-486-0535\", \
\"email\":\"sagittis@metalcorp.net\",\"city\":\"Hamoir\"}" \
-json example.ContactInfo
put -key /contact/Lacey/Benjamin -value "{\"phone\":\"556-975-3364\", \
\"email\":\"Duis@laceyassociates.ca\",\"city\":\"Wasseiges\"}" \
-json example.ContactInfo
put -key /contact/Preston/Church -value "{\"phone\":\"436-396-9213\", \
\"email\":\"preston@mauris.ca\",\"city\":\"Helmsdale\"}" \
-json example.ContactInfo
put -key /contact/Evan/Houston -value "{\"phone\":\"028-781-1457\", \
\"email\":\"evan@texfoundation.org\",\"city\":\"Geest-G\"}" \
-json example.ContactInfo
exit
### End Script ###
```

Then, the script can be run by using the `load` command in the data command line interface:

### Note

A schema must be loaded to the store before this script can successfully run. For more information on adding schema, see "Adding Schema" section in Oracle NoSQL Database Getting Started.

```
> java -Xmx256m -Xms256m \
-jar KVHOME/lib/kvstore.jar runadmin -host node01 -port 5000 \
-store mystore
kv-> load -file ./load-contacts-5.txt
Operation successful, record inserted.
Operation successful, record inserted.
Operation successful, record inserted.
Operation successful, record inserted.
Operation successful, record inserted.
```

The following schema was previously added to the store:

```
{
     "type": "record",
     "name": "ContactInfo",
     "namespace": "example",
     "fields": [
         {"name": "phone", "type": "string", "default": ""},
         {"name": "email", "type": "string", "default": ""},
         {"name": "city", "type": "string", "default": ""}
     ]
}
```

For more information on using the load command, see Using a Script to Configure the Store (page 32).

## logtail

Monitors the store-wide log file until interrupted by an "enter" key press.

## ping

Pings the runtime components of a store. Only those components available from the Topology are contacted. This leaves out Admin services.

## plan

Encapsulates operations, or jobs that modify store state. All subcommands with the exception of interrupt and wait change persistent state. Plans are asynchronous jobs so they return immediately unless `-wait` is used. Plan status can be checked using `show plans`. The optional arguments for all plans include:

- `-wait`

  Wait for the plan to complete before returning.

- `-plan-name`

  The name for a plan. These are not unique.

- `-noexecute`

  Do not execute the plan. If specified, the plan can be run later using `plan execute`.

- `-force`

  Used to force plan execution and plan retry.

The subcommands are as follows:

- plan add-index (page 99)
- plan add-table (page 99)
- plan cancel (page 101)
- plan change-parameters (page 102)
- plan change-storagedir (page 102)
- plan change-user (page 102)
- plan create-user (page 103)
- plan deploy-admin (page 103)
- plan deploy-datacenter (page 103)
- plan deploy-sn (page 103)

### plan add-index

```
plan add-index -name <name> -table <name> [-field <name>]*
[-desc <description>]
[-plan-name <name>] [-wait] [-noexecute] [-force]
```

Adds an index to a table in the store. The table name is a dot-separated name with the format `tableName[.childTableName]*`.

### plan add-table

```
plan add-table -name <name>
[-plan-name <name>] [-wait] [-noexecute] [-force]
```

Adds a new table to the store. The table name is a dot-separated name with the format `tableName[.childTableName]*`.

Before adding a table, first use the `table create` command to create the named table. The following example defines a table (creates a table by name, adds fields and other table metadata).

```
## Enter into table creation mode
table create -name user -desc "A sample user table"
user->
user-> help
Usage: add-array-field |
add-field |
add-map-field |
add-record-field |
add-schema |
cancel |
exit |
primary-key |
remove-field |
set-description |
shard-key |
show
```

```
## Now add the fields
user-> help add-field
Usage: add-field -type <type> [-name <field-name> ] [-not-required]
[-nullable] [-default <value>] [-max <value>] [-min <value>]
[-max-exclusive] [-min-exclusive] [-desc <description>]
[-size <size>] [-enum-values <value[,value[,...]]
<type>: INTEGER, LONG, DOUBLE, FLOAT, STRING, BOOLEAN, DATE, BINARY, FIX
ED_BINARY, ENUM
```

```
## Adds a field. Ranges are inclusive with the exception of String,
## which will be set to exclusive.
user-> add-field -type Integer -name id
user-> add-field -type String -name firstName
user-> add-field -type String -name lastName
user-> help primary-key
Usage: primary-key -field <field-name> [-field <field-name>]*
## Sets primary key.
user-> primary-key -field id
## Exit table creation mode
user-> exit
## Table User built.
```

Use `table list -create` to see the list of tables that can be added. The following example lists and displays tables that are ready for deployment.

```
kv-> table list
## Tables to be added:
## User -- A sample user table
kv-> table list -name user
## Add table User:
{
  "type" : "table",
  "name" : "User",
  "id" : "User",
  "description" : "A sample user table",
  "shardKey" : [ "id" ],
  "primaryKey" : [ "id" ],
  "fields" : [ {
    "name" : "id",
    "type" : "INTEGER"
  }, {
    "name" : "firstName",
    "type" : "STRING"
  }, {
    "name" : "lastName",
    "type" : "STRING"
  } ]
}
```

The following example adds the table to the store.

```
## Add the table to the store.
kv-> help plan add-table
kv-> plan add-table -name user -wait
Executed plan 5, waiting for completion...
Plan 5 ended successfully
kv-> show tables -name user
{
  "type" : "table",
  "name" : "User",
  "id" : "r",
  "description" : "A sample user table",
  "shardKey" : [ "id" ],
  "primaryKey" : [ "id" ],
  "fields" : [ {
    "name" : "id",
    "type" : "INTEGER"
  }, {
    "name" : "firstName",
    "type" : "STRING"
  }, {
    "name" : "lastName",
    "type" : "STRING"
  } ]
}
```

For more information and examples on table design, see the Introducing Oracle NoSQL Database Tables and Indexes.

## plan cancel

```
plan cancel -id <plan id> | -last
```

Cancels a plan that is not running. A running plan must be interrupted before it can be canceled.

Use the `-last` option to reference the most recently created plan.

## plan change-parameters

```
plan change-parameters -security | -service <id> | -all-rns [-zn <id> | -
znname <name>] | -all-admins [-zn <id> | -znname <name>] [-dry-run]
[-plan-name <name>] [-wait] [-noexecute] [-force] -params [name=value]*
```

Changes parameters for either the specified service, or for all service instances of the same type that are deployed to the specified zone or all zones.

The `-security` flag allows changing store-wide global security parameters, and should never be used with other flags.

The `-service` flag allows a single instance to be affected; and should never be used with either the `-zn` or `-znname` flag.

The `-all-*` flags can be used to change all instances of the service type. The parameters to change follow the `-params` flag and are separated by spaces. The parameter values with embedded spaces must be quoted; for example, name="value with spaces".

One of the -all-* flags can be combined with the -zn or -znname flag to change all instances of the service type deployed to the specified zone; leaving unchanged, any instances of the specified type deployed to other zones. If one of the -all-* flags is used without also specifying the zone, then the desired parameter change will be applied to all instances of the specified type within the store, regardless of zone.

If `-dry-run` is specified, the new parameters are returned without changing them. Use the command `show parameters` to see what parameters can be modified. For more information, see show parameters (page 112).

For more information on changing parameters in the store, see Setting Store Parameters (page 74).

## plan change-storagedir

```
plan change-storagedir -sn <id> -storagedir <path> -add | -remove
[-plan-name <name>] [-wait] [-noexecute]
[-force]
```

Adds or removes a storage directory on a Storage Node, for storing a Replication Node.

## plan change-user

```
plan change-user -name <user name>
[-disable | -enable] [-set-password [-password <new password>]
[-retain-current-password]] [-clear-retained-password]
[-plan-name <name>] [-wait] [-noexecute] [-force]
```

Change a user with the specified name in the store. The -retain-current-password argument option causes the current password to be remembered during the -set-password operation as a valid alternate password for configured retention time or until cleared using -clear-retained-password. If a retained password has already been set for the user, setting password again will cause an error to be reported.

### plan create-user

```
plan create-user -name <user name>
[-admin] [-disable] [-password <new password>]
[-plan-name <name>] [-wait] [-noexecute] [-force]
```

Create a user with the specified name in the store. The -admin argument indicates that the created user has full administrative privileges.

### plan deploy-admin

```
plan deploy-admin -sn <id> -port <http port> [-plan-name <name>]
[-wait] [-noexecute] [-force]
```

Deploys an Admin to the specified Storage Node. Its graphical interface listens on the specified port.

For more information on deploying an admin, see Create an Administration Process on a Specific Host (page 22).

### plan deploy-datacenter

Deprecated. See plan deploy-zone (page 103) instead.

### plan deploy-sn

```
plan deploy-sn -zn <id> | -znname <name> -host <host> -port <port>
[-plan-name <name>] [-wait] [-noexecute] [-force]
```

Deploys the Storage Node at the specified host and port into the specified zone.

For more information on deploying your Storage Nodes, see Create the Remainder of your Storage Nodes (page 24).

### plan deploy-topology

```
plan deploy-topology -name <topology name> [-plan-name <name>]
[-wait] [-noexecute] [-force]
```

Deploys the specified topology to the store. This operation can take a while, depending on the size and state of the store.

For more information on deploying a satisfactory topology candidate, see Deploy the Topology Candidate (page 44).

### plan deploy-zone

```
plan deploy-zone -name <zone name>
-rf <replication factor>
[-type [primary | secondary]]
[-plan-name <name>] [-wait] [-noexecute] [-force]
```

Deploys the specified zone to the store and creates a primary zone if -type is not specified.

For more information on creating a zone, see Create a Zone (page 22).

## plan drop-user

```
plan drop-user -name <user name>
[-plan-name <name>] [-wait] [-noexecute] [-force]
```

Drop a user with the specified name in the store. A logged-in user may not drop itself.

## plan evolve-table

```
plan evolve-table -name <name>
[-plan-name <name>] [-wait] [-noexecute] [-force]
```

Evolves a table in the store. The table name is a dot-separate with the format `tableName[.childTableName]*`.

Use the `table evolve` command to evolve the named table. The following example evolves a table.

```
## Enter into table evolution mode
kv-> table evolve -name User
kv-> show
{
  "type" : "table",
  "name" : "User",
  "id" : "r",
  "description" : "A sample user table",
  "shardKey" : [ "id" ],
  "primaryKey" : [ "id" ],
  "fields" : [ {
    "name" : "id",
    "type" : "INTEGER"
  }, {
    "name" : "firstName",
    "type" : "STRING"
  }, {
    "name" : "lastName",
    "type" : "STRING"
  } ]
}
## Add a field
kv-> add-field -type String -name address
## Exit table creation mode
kv-> exit
## Table User built.
```

```
kv-> plan evolve-table -name User -wait
## Executed plan 6, waiting for completion...
## Plan 6 ended successfully
```

```
kv-> show tables -name User
{
  "type" : "table",
  "name" : "User",
  "id" : "r",
  "description" : "A sample user table",
  "shardKey" : [ "id" ],
  "primaryKey" : [ "id" ],
  "fields" : [ {
    "name" : "id",
    "type" : "INTEGER"
  }, {
    "name" : "firstName",
    "type" : "STRING"
  }, {
    "name" : "lastName",
    "type" : "STRING"
  }, {
    "name" : "address",
    "type" : "STRING"
  } ]
}
```

Use `table list -evolve` to see the list of tables that can be evolved. For more information, see plan add-table (page 99) and table list (page 117).

## plan execute

```
plan execute -id <id> | -last [-wait] [-force]
```

Executes a created but not yet executed plan. The plan must have been previously created using the `-noexecute` flag .

Use the `-last` option to reference the most recently created plan.

## plan interrupt

```
plan interrupt -id <plan id> | -last
```

Interrupts a running plan. An interrupted plan can only be re-executed or canceled. Use -last to reference the most recently created plan.

## plan migrate-sn

```
plan migrate-sn -from <id> -to <id> [-admin-port <admin port>]
[-plan-name <name>] [-wait] [-noexecute] [-force]
```

Migrates the services from one Storage Node to another. The old node must not be running.

The `-admin-port` option is required if the old node hosted an admin service.

Before executing the `plan migrate-sn` command, you can stop any running old Storage Node by using `-java -Xmx256m -Xms256m -jar KVHOME/lib/kvstore.jar stop -root KVROOT`.

### plan remove-admin

```
 plan remove-admin -admin <id> | -zn <id> | -znname <name> [-force]
[-plan-name <name>] [-wait] [-noexecute] [-force]
```

Removes the desired Admin instances; either the single specified instance, or all instances deployed to the specified zone.

If you use the `-admin` flag and there are 3 or fewer Admins running in the store, or if you use the `-zn` or `-znname` flag and the removal of all Admins from the specified zone would result in only one or two Admins in the store, then the desired Admins will be removed only if you specify the `-force` flag.

Also, if you use the `-admin` flag and there is only one Admin in the store, or if you use the `-zn` or `-znname` flag and the removal of all Admins from the specified zone would result in the removal of all Admins from the store, then the desired Admins will not be removed.

### plan remove-index

```
plan remove-index -name <name> -table <name>
[-plan-name <name>] [-wait] [-noexecute] [-force]
```

Removes an index from a table. The table name is a dot-separated name with the format tableName[.childTableName]*.

### plan remove-sn

```
plan remove-sn -sn <id> [-plan-name <name>]
[-wait] [-noexecute] [-force]
```

Removes the specified Storage Node from the topology.

This command is useful when removing unused, old Storage Nodes from the store. To do this, see Replacing a Failed Storage Node (page 63).

### plan remove-table

```
plan remove-table -name <name> [-keep-data]
[-plan-name <name>] [-wait] [-noexecute] [-force]
```

Removes a table from the store. The named table must exist and must not have any child tables. Indexes on the table are automatically removed. By default data stored in this table is also removed. Table data may be optionally saved by specifying the -keep-data flag. Depending on the indexes and amount of data stored in the table this may be a long-running plan.

The following example removes a table.

```
## Remove a table.
kv-> plan remove-table -name User
## Started plan 7. Use show plan -id 7 to check status.
## To wait for completion, use plan wait -id 7.
kv-> show tables
## No table found.
```

For more information, see Introducing Oracle NoSQL Database Tables and Indexes.

### plan remove-zone

```
plan remove-zone -zn <id> | -znname <name>
[-plan-name <name>] [-wait] [-noexecute]
```

Removes the specified zone from the store.

Before running this command, all Storage Nodes that belong to the specified zone must first be removed using the `plan remove-sn` command.

### plan remove-zone

```
plan remove-zone -zn <id> | -znname <name>
[-plan-name <name>] [-wait] [-noexecute] [-force]
```

Removes the specified zone from the store.

### plan repair-topology

```
plan repair-topology
[-plan-name <name>] [-wait] [-noexecute] [-force]
```

Inspects the store's deployed, current topology for inconsistencies in location metadata that may have arisen from the interruption or cancellation of previous deploy-topology or migrate-sn plans. Where possible, inconsistencies are repaired. This operation can take a while, depending on the size and state of the store.

### plan start-service

```
plan start-service -service <id> | -all-rns [-plan-name <name>]
[-wait] [-noexecute] [-force]
```

Starts the specified service(s).

### plan stop-service

```
plan stop-service -service <id> | -all-rns
[-plan-name <name>] [-wait] [-noexecute] [-force]
```

Stops the specified service(s).

Use this command to stop any affected services so that any attempts by the system to communicate with it are no longer made; resulting in a reduction in the amount of error output related to a failure you are already aware of.

This command is useful during disk replacement process. Use the `plan stop-service` command to stop the affected service prior removing the failed disk. For more information, see Replacing a Failed Disk (page 65).

### plan wait

```
plan wait -id <id> | -last [-seconds <timeout in seconds>]
```

Waits indefinitely for the specified plan to complete, unless the optional timeout is specified.

Use the `-seconds` option to specify the time to wait for the plan to complete.

The `-last` option references the most recently created plan.

## pool

Encapsulates commands that manipulates Storage Node pools, which are used for resource allocations. The subcommands are as follows:

- pool create (page 108)
- pool join (page 108)
- pool remove (page 108)

### pool create

```
pool create -name <name>
```

Creates a new Storage Node pool to be used for resource distribution when creating or modifying a store.

For more information on creating a Storage Node pool, see Create a Storage Node Pool (page 23).

### pool join

```
pool join -name <name> [-service] <snX>*
```

Adds Storage Nodes to an existing Storage Node pool.

### pool remove

```
pool remove -name <name>
```

Removes a Storage Node pool.

## put

Encapsulates commands that put key/value pairs to the store or put rows to a table. The subcommands are as follows:

- put kv (page 108)
- put table (page 110)

### put kv

```
put kv -key <keyString> -value <valueString> [-file]
[-hex | -json <schemaName>] [-if-absent] [-if-present]
```

Put the specified key/value pair into the store. The following arguments apply to the put command:

- `-key<keyString>`

Specifies the name of the key to be put into the store. Key can be composed of both major and minor key paths, or a major key path only. The <keyString> format is: "major-key-path/-/minor-key-path".

For example, a key containing major and minor key paths:

```
kvshell-> put -key /Smith/Bob/-/email -value
"{\"id\": 1,\"email\":\"bob.smith@gmail.com\"}" -json schema.EmailInfo
```

For example, a key containing only a major key path:

```
kvshell-> put -key /Smith/Bob -value"{\"name\":
 \"bob.smith\", \"age\": 20, \"phone\":\"408 555 5555\", \"email\":
 \"bob.smith@gmail.com\"}" -json schema.UserInfo
```

- `-value <valueString>`

  If neither -json or -file is specified, the <valueString> is treated as a raw bytes array.

  For example:

  ```
  kvshell-> put -key /Smith/Bob/-/phonenumber -value "408 555 5555"
  ```

  ### Note

  The mapping of the raw arrays to data structures (serialization and deserialization) is left entirely to the application. This is not the recommended approach. Instead, you should use Avro even for very simple values.

  If used with `-json` to specify a Json string, the `valueString` should be encapsulated in quotation marks, and its internal field name and value with string type should also be encapsulated by string quote characters.

  For example:

  ```
  kvshell-> put -key /Smith/John/-/email -value
  "{\"id\": 1,\"email\":\"john.smith@gmail.com\"}" -json schema.EmailInfo
  ```

- `-file`

  Indicates that the value is obtained from a file. The file to use is identified by the value parameter.

  For example:

  ```
  kvshell-> put -key /Smith/Bob -value ./smith-bob-info.txt
   -file -json schema.UserInfo
  ```

- `-hex`

  Indicates that the value is a BinHex encoded byte value with base64 encoding.

- `-json<schemaName>`

Indicates that the value is a JSON string. Can be specified along with `-file`.

- `-if-absent`

  Indicates that a key/value pair is `put` only if no value for the given key is present.

- `-if-present`

  Indicates that a key/value pair is `put` only if a value for the given key is present.

### put table

```
put table -name <name> [if-absent | -if-present ]
[-json <string>] [-file <file>] [-update]
```

Put a row into the named table. The table name is a dot-separated name with the format table[.childTableName]*.

where:

- `-if-absent`

  Indicates to put a row only if the row does not exist.

- `-if-present`

  Indicates to put a row only if the row already exists.

- `-json`

  Indicates that the value is a JSON string.

- `-file`

  Can be used to load JSON strings from a file.

- `-update`

  Can be used to partially update the existing record.

## show

Encapsulates commands that display the state of the store and its components or schemas. The subcommands are as follows:

- show admins (page 111)
- show events (page 111)
- show faults (page 111)
- show indexes (page 112)

## show admins

```
show admins
```

Displays basic information about Admin services.

## show events

```
show events [-id <id>] | [-from <date>] [-to <date> ]
[-type <stat | log | perf>]
```

Displays event details or list of store events. The status events indicate changes in service status.

Log events are noted if they require attention.

Performance events are not usually critical but may merit investigation. Events marked "SEVERE" should be investigated.

The following date/time formats are accepted. They are interpreted in the local time zone.

*MM-dd-yy HH:mm:ss:SS*
*MM-dd-yy HH:mm:ss*
*MM-dd-yy HH:mm*
*MM-dd-yy*
*HH:mm:ss:SS*
*HH:mm:ss*
*HH:mm*

For more information on events, see Events (page 73).

## show faults

```
show faults [-last] [-command <command index>]
```

Displays faulting commands. By default all available faulting commands are displayed. Individual fault details can be displayed using the -last and -command flags.

### show indexes

```
show indexes [-table <name>] [-name <name>]
```

Displays index metadata. By default the indexes metadata of all tables are listed.

If a specific table is named, its indexes metadata are displayed. If a specific index of the table is named, its metadata is displayed. For more information, see plan add-index (page 99).

### show parameters

```
show parameters -policy | -service <name>
```

Displays service parameters and state for the specified service. The service may be a Replication Node, Storage Node, or Admin service, as identified by any valid string, for example rg1-rn1, sn1, admin2, etc. Use the -policy flag to show global policy parameters.

### show perf

```
show perf
```

Displays recent performance information for each Replication Node.

### show plans

```
show plans [-id <id> | -last]
```

Shows details of the specified plan or list all plans that have been created along with their corresponding plan IDs and status.

Use the `-id` option to specify the plan that you want to show additional detail and status.

The `-last` option shows details of the most recent created plan.

For more information on plan review, see Reviewing Plans (page 19).

### show pools

```
show pools
```

Lists the Storage Node pools.

### show schemas

```
show schemas [-disabled] | [-name <name>]
```

Displays schema details of the named schema or a list of schemas registered with the store.

Use the `-name` option to specify the name of the schema you want to check if it is currently enabled in the store.

Use the `-disabled` option to see all schemas, including those which are currently disabled.

## show snapshots

```
show snapshots [-sn <id>]
```

Lists snapshots on the specified Storage Node. If no Storage Node is specified, one is chosen from the store. You can use this command to view the existing snapshots.

## show tables

```
show tables -name <name>
```

Displays the table information. Use `-original` flag to show the original table information if you are building a table for evolution. The flag is ignored for building table for addition. For more information, see plan add-table (page 99) and plan evolve-table (page 104)

## show topology

```
show topology [-zn] [-rn] [-sn] [-store] [-status] [-perf]
```

Displays the current, deployed topology. By default it shows the entire topology. The optional flags restrict the display to one or more of Zones, Replication Nodes, Storage Nodes and store name, or specify service status or performance.

With this command you can obtain the ID of the zone to which Storage Nodes can be deployed to.

## show upgrade-order

```
show upgrade-order
```

Lists the Storage Nodes which need to be upgraded in an order that prevents disruption to the store's operation.

This command displays one or more Storage Nodes on a line. Multiple Storage Nodes on a line are separated by a space. If multiple Storage Nodes appear on a single line, then those nodes can be safely upgraded at the same time. When multiple nodes are upgraded at the same time, the upgrade must be completed on all nodes before the nodes next on the list can be upgraded.

If at some point you lose track of which group of nodes should be upgraded next, you can always run the show upgrade-order command again.

## show users

```
show users [-name <name>
```

Lists the names of all users, or displays information about a specific user. If no user is specified, lists the names of all users. If a user is specified using the `-name` option, then lists detailed information about the user.

## show zones

```
show zones [-zn <id>] | -znname <name>
```

Lists the names of all zones, or display information about a specific zone.

Use the `-zn` or the `-znname` flag to specify the zone that you want to show additional information; including the names of all of the Storage Nodes in the specified zone, and whether that zone is a primary of secondary zone.

## snapshot

Encapsulates commands that create and delete snapshots, which are used for backup and restore. The subcommands are as follows:

- snapshot create (page 114)
- snapshot remove (page 114)

### snapshot create

```
snapshot create -name <name>
```

Creates a new snapshot using the specified name as the prefix.

Use the `-name` option to specify the name of the snapshot that you want to create.

Snapshots should not be taken while any configuration (topological) changes are being made, because the snapshot might be inconsistent and not usable.

### snapshot remove

```
snapshot remove -name <name> | -all
```

Removes the named snapshot. If -all is specified, remove all snapshots.

Use the `-name` option to specify the name of the snapshot that you want to remove.

If the `-all` option is specified, remove all snapshots.

To create a backup of your store using a snapshot see Taking a Snapshot (page 57).

To recover your store from a previously created snapshot you can use the load utility or restore directly from a snapshot. For more information see Using the Load Program (page 59) or Restoring Directly from a Snapshot (page 60).

## table

Encapsulates commands for building table for addition or evolution. The table name is a dot-separated name with the format `tableName[.childTableName]*`. Tables are created and modified in two steps.

The table command creates new tables or evolves existing tables and saves them in temporary, non-persistent storage in the admin client. These tables are kept by name when exiting the `create` and `evolve` sub-commands.

The second step is to use the `plan` command to deploy the new and changed tables to the store itself. The temporary list of tables can be examined and cleared using the `list` and `clear` sub-commands.

The subcommands are as follows:

## table clear

```
table clear [-name <name> | -all]
```

Clears the tables that are built but not yet created or evolved.

Use `-name <name>` to clear the named table.

Use `-all` to clear all the tables.

## table create

```
table create -name <name> [-desc <description>] [-r2-compat]
```

Builds a new table to add to the store. Use the `plan add-table` command to add new tables. Use the `-r2-compat` flag to create a table on top of the existing R2 key/value pairs.

Usage:

```
exit
```

Exits the building operation, saving the table(or field) for addition (or evolution) to the store.

- add-array-field

  ```
  add-array-field -name <field-name> -desc <description>
  [-not-required] [-nullable]
  ```

  Builds a array field.

- add-field

  Adds a field.

- add-map-field

  ```
  add-map-field -name <field-name> -desc <description>
   [-not-required] [-nullable]
  ```

  Builds a map field.

- add-record-field

  ```
  add-map-field -name <field-name> -desc <description>
   [-not-required] [-nullable]
  ```

  Builds a record field.

- add-schema

  ```
  add-schema -name <schema-name>
  ```

  Builds a table from Avro schema.

- primary-key

  ```
  primary-key -field <field-name> [-field <field-name>]*
  ```

  Sets primary key.

- remove-field

  ```
  remove-field -name <field-name>
  ```

  Removes a field.

- set-description

  ```
  set-description -desc <description>
  ```

  Sets description for the table.

- shard-key

  ```
  shard-key -field <field-name> [-field <field-name>]*
  ```

  Sets shard key.

- show

  ```
  {
    "type" : "table",
    "name" : "User",
    "id" : "User",
    "description" : "A sample user table",
    "shardKey" : [ ],
    "primaryKey" : [ ],
    "fields" : [ ]
  }
  ```

  Displays the table information. For more information on `show table`, see show tables (page 113).

- cancel

  ```
  cancel
  ```

  Exits the building operation, canceling the table(or field) under construction.

- exit

For more information and examples on table design, see plan add-table (page 99) and Introducing Oracle NoSQL Database Tables and Indexes.

### table list

```
table list [-name <name>] [-create | -evolve]
```

Lists all the tables built that are not yet created or evolved.

- Use `-name <name>` to show the details of the named table.
- Use `-create` to show the tables for addition.
- Use `-evolve` to show the tables for evolution.

For more information, see plan add-table (page 99) and  Introducing Oracle NoSQL Database Tables and Indexes.

### table evolve

```
table evolve -name <name>
```

Builds a table for evolution.

Use the `plan` command to evolve tables. For more information, see plan evolve-table (page 104) and  Introducing Oracle NoSQL Database Tables and Indexes.

## time

```
time command [sub-command]
```

The time command runs the specified command with the given arguments, and prints the elapsed time of the execution.

For example, to display the time taken to retrieve records and write them to a file:

```
kv -> time get -all -file ./data.out
209 Records returned.
Wrote value to file ./data.out.
Time: 265 ms.
```

For example, to display the time taken to delete all existing keys:

```
kv -> time delete -all
210 Keys deleted starting at root
Time: 265 ms.
```

## topology

Encapsulates commands that manipulate store topologies. Examples are redistribution/rebalancing of nodes or changing replication factor. Topologies are created and modified using this command. They are then deployed by using the `plan deploy-topology` command. For more information, see plan deploy-topology (page 103). The subcommands are as follows:

- topology change-repfactor (page 118)
- topology clone (page 118)
- topology create (page 118)

## topology change-repfactor

```
topology change-repfactor -name <name>  -pool <pool name>
-zn <id> | -znname <name> -rf <replication factor>
```

Modifies the topology to change the replication factor of the specified zone to a new value. The replication factor may not be decreased at this time.

For more information on modifying the replication factor, see Increase Replication Factor (page 41).

## topology clone

```
topology clone -from <from topology> -name <to topology>
```

or

```
topology clone -current -name <to topology>
```

Clones an existing topology so as to create a new candidate topology to be used for topology change operations.

## topology create

```
topology create -name <candidate name> - pool <pool name>
-partitions <num>
```

Creates a new topology with the specified number of partitions using the specified storage pool.

For more information on creating the first topology candidate, see Make the Topology Candidate (page 39).

## topology delete

```
topology delete -name <name>
```

Deletes a topology.

## topology list

```
topology list
```

Lists existing topologies.

### topology preview

```
topology preview -name <name> [-start <from topology>]
```

Describes the actions that would be taken to transition from the starting topology to the named, target topology. If -start is not specified, the current topology is used. This command should be used before deploying a new topology.

### topology rebalance

```
topology rebalance -name <name> -pool <pool name>
[-zn <id> | -znname <name>]
```

Modifies the named topology to create a balanced topology. If the optional `-zn` flag is used, only Storage Nodes from the specified zone are used for the operation.

For more information on balancing a non-compliant topology, see Balance a Non-Compliant Topology (page 42).

### topology redistribute

```
topology redistribute -name <name> -pool <pool name>
```

Modifies the named topology to redistribute resources to more efficiently use those available.

For more information on redistributing resources to enhance write throughput, see Increase Data Distribution (page 40).

### topology validate

```
topology validate [-name <name>]
```

Validates the specified topology. If no topology is specified, the current topology is validated. Validation generates violations and notes.

Violations are issues that can cause problems and should be investigated.

Notes are informational and highlight configuration oddities that can be potential issues or may be expected.

For more information, see Validate the Topology Candidate (page 43).

### topology view

```
topology view -name <name>
```

Displays details of the specified topology.

## verbose

Toggles the global verbosity setting. This property can also be set on a per-command basis using the `-verbose` flag.

## verify

Encapsulates commands that check various parameters of the store. The subcommands are as follows:

- verify configuration (page 120)
- verify prerequisite (page 120)
- verify upgrade (page 120)

### verify configuration

```
verify configuration [-silent]
```

Verifies the store configuration by iterating the components and checking their state against that expected in the Admin database. This call may take a while on a large store.

The `-silent` option suppresses verbose verification messages that are displayed as the verification is proceeding. Instead, only the initial startup messages and the final verification message is displayed.

### verify prerequisite

```
verify prerequisite [-silent] [-sn snX]*
```

Verifies that the storage nodes are at or above the prerequisite software version needed to upgrade to the current version. This call may take a while on a large store.

As part of the verification process, this command displays the components which do not meet the prerequisites or cannot be contacted. It also checks for illegal downgrade situations where the installed software is of a newer minor release than the current version.

When using this command, the current version is the version of the software running the command line interface.

Use the `-sn` option to specify those storage nodes that you want to verify. If no storage nodes are specified, all the nodes in the store are checked.

The `-silent` option suppresses verbose verification messages that are displayed as the verification is proceeding. Instead, only the initial startup messages and the final verification message is displayed.

### verify upgrade

```
verify upgrade [-silent] [-sn snX]*
```

Verifies the storage nodes (and their managed components) are at or above the current version. This call may take a while on a large store.

As part of the verification process, this command displays the components which have not yet been upgraded or cannot be contacted.

When using this command, the current version is the version of the software running the command line interface.

Use the `-sn` option to specify those storage nodes that you want to verify. If no storage nodes are specified, all the nodes in the store are checked.

The `-silent` option suppresses verbose verification messages that are displayed as the verification is proceeding. Instead, only the initial startup messages and the final verification message is displayed.

## Utility commands

You can access utility commands through "`java -jar`".

```
java -Xmx256m -Xms256m \
-jar KVHOME/lib/kvstore.jar <command>
```

This appendix contains the following information on the commands:

### makebootconfig

```
java -Xmx256m -Xms256m \
-jar KVHOME/lib/kvstore.jar makebootconfig [-verbose]
-root <rootDirectory> -host <hostname> -hahostname <hostname>
-harange <startPort,endPort> -port <port> [-admin <adminPort>]
-store-security [none | configure | enable]
[-config <configFile>][-storagedir <path>] [-capacity <n_rep_nodes>]
[-num_cpus <ncpus>][-memory_mb <memory_mb>]
[-servicerange <startPort,endPort>]
[-mgmt {snmp|jmx|none}] [-pollport <snmp poll port>]
[-traphost <snmp trap/notification hostname>]
[-trapport <snmp trap/notification port>]
```

where:

- `-admin <adminPort>` The port on which the web-based Admin Console is contacted. It only needs to be free on the node which runs the admin process. The value defaults to "0", which means that there will be no admin on this node.
- `-capacity <n_rep_nodes>` The total number of Replication Nodes a Storage Node can support. The value defaults to "1".
- `-config <configFile>` Only specified if more than one Storage Node Agent process will share the same root directory. This value defaults to "config.xml".
- `-hahostname <hostname>` Can be used to specify a separate network interface for store replication traffic. This defaults to the hostname specified using the -host flag.
- `-harange <startPort,endPort>` A range of free ports which the Replication Nodes use to communicate among themselves. These ports should be sequential and there must be at least as many as the specified capacity for this node.

- `-store-security [none | configure | enable]` Specifies if security will be used or not. If `-store-security none` is specified, no security will be used. If `-store-security configure` is specified, security will be used and the security configuration utility will be invoked as part of the makebootconfig process. If `-store-security enable` is specified, 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.
- `-host <hostname>` Identifies a host name associated with the node on which the command is run. This hostname identifies the network interface used for communication with this node.
- `-memory_mb <memory_mb>` The total number of megabytes of memory that is available in the machine. If the value is 0, the store will attempt to determine the amount of memory on the machine, but the value is only available when the JVM used is the Oracle Hotspot JVM. The default value is "0".
- `-num_cpus <ncpus>` The total number of processors on the machine available to the Replication Nodes. If the value is 0, the system will attempt to query the Storage Node to determine the number of processors on the machine. This value defaults to "0".
- `-port <port>` The TCP/IP port on which Oracle NoSQL Database should be contacted. Sometimes referred to as the registry port. This port must be free on the node on which this command is run.
- `-root <rootDirectory>` Identifies where the root directory should reside.
- `-servicerange <startPort,endPort>` A range of ports that may be used for communication among administrative services running on a Storage Node and its managed services. This parameter is optional and is useful when services on a Storage Node must use specific ports for firewall or other security reasons. By default the services use anonymous ports. The format of the value string is "startPort,endPort." The value varies with the capacity of the Storage Node.
- `-storagedir <path>` Specify a path to the directory to be used for a Replication Node. This flag may be used more than once in the command to specify multiple storage directories, but the number should not exceed the capacity for the node. If no storage directory is specified, Replication Nodes use a directory under the root directory.

  The use of the -storagedir argument must be coordinated with the use of the capacity argument. For example, if your Storage Node hosts four disks, you would specify a capacity of four and have four -storagedir arguments.

Creates a configuration file used to start a not-yet-deployed Storage Node to be used in an instance of Oracle NoSQL Database. The file must not already exist. You only need to specify the admin option(the Admin Console port) on the node which hosts the initial Oracle NoSQL Database administration processes. To create the initial "boot config" file used to configure the installation see Installation Configuration (page 12).

OracleNoSQL Database allows Java Management Extensions (JMX) or Simple Network Management Protocol (SNMP) agents to be optionally available for monitoring, in addition to the native monitoring provided by the Admin CLI and the Admin Console. In order to enable JMX or SNMP in the storage node's boot configuration file, you can use the -mgmt, -pollport, -traphost and -trapport options. See Standardized Monitoring Interfaces (page 85) for more information.

## start

```
java -Xmx256m -Xms256m \
-jar KVHOME/lib/kvstore.jar start [-verbose]
-root <rootDirectory> [-config <bootstrapFileName>]
```

Starts the Oracle NoSQL Database Storage Node Agent (and if configured, store) in the root directory.

## stop

```
java -Xmx256m -Xms256m \
-jar KVHOME/lib/kvstore.jar stop [-verbose]
-root <rootDirectory> [-config <bootstrapFileName>]
```

Stops the Oracle NoSQL Database Storage Node Agent and services related to the root directory.

## restart

```
java -Xmx256m -Xms256m \
-jar KVHOME/lib/kvstore.jar restart [-verbose]
-root <rootDirectory> [-config <bootstrapFileName>]
```

Stops and then starts the Oracle NoSQL Database Storage Node Agent and services related to the root directory.

## runadmin

```
java -Xmx256m -Xms256m \
-jar KVHOME/lib/kvstore.jar runadmin [-verbose]
-host <hostname> -port <port> [single command and arguments]
```

Runs a utility which provides a command line interface (CLI). It is used to perform store configuration.

## load

```
java -Xmx256m -Xms256m \
-jar KVHOME/lib/kvstore.jar load [-verbose]
-source <backupDir> -host <hostname> -port <port>
-store <storeName> [-status <pathToFile>]
```

where:

- `-host <hostname>` identifies the host name of a node in your store.
- `-port <port>` identifies the registry port in use by the store's node.

- `-source <backupDir>` identifies the on-disk location where the snapshot data is stored.
- `-status <pathToFile>` is an optional parameter that causes the status of the load operation to be saved in the named location on the local machine.
- `-store <storeName>` identifies the name of the store.

Program used to restore a store from a previously created snapshot. By using this tool, you can restore the store to any topology, not just the one that was in use when the snapshot was created. `Load` should be used only to restore to a new, empty store. Do not use this with an existing store because it only writes records if they do not already exist. See Using the Load Program (page 59) for more information.

## ping

```
java -Xmx256m -Xms256m \
-jar KVHOME/lib/kvstore.jar ping [-verbose]
-host <hostname> -port <port>
```

Attempts to contact a store to get status of running services. By using the `ping` command, you can ensure that the Oracle NoSQL Database client library can contact the Oracle NoSQL Database Storage Agent(SNA). You can use the -host option to check an SNA on a remote host.

## version

```
java -Xmx256m -Xms256m \
-jar KVHOME/lib/kvstore.jar version
```

Prints version.

## generateconfig

```
java -Xmx256m -Xms256m \
-jar KVHOME/lib/kvstore.jar generateconfig [-verbose]
-host <hostname> -port <port> -sn <StorageNodeId> -target <zipfile>
```

Generates configuration files for the specified storage node. The generateconfig command creates the target zipfile which contains the required configuration to re-create the storage node. The top-level directory in the zipfile is the store's root directory.

## help

```
java -Xmx256m -Xms256m \
-jar KVHOME/lib/kvstore.jar help <commandName>
```

Prints usage info. With no arguments the top-level shell commands are listed. With a command name, additional detail is provided.

# Appendix B. Initial Capacity Planning

To deploy a store, the user must specify a replication factor, the desired number of partitions, and the Storage Nodes on which to deploy the store. The following sections describe how to calculate these values based upon the application's requirements and the characteristics of the hardware available to host the store.

The resource estimation is a two step process:

1. Determine the storage and I/O throughput capacity of a representative shard, given the characteristics of the application, the disk configuration on each machine, and disk throughput. The amount of physical memory required by each machine and its network throughput capacity is also estimated as part of this step.

2. Use the shard level storage and I/O throughput capacities as a basis for extrapolating throughput from one shard to the required number of shards and machines, given the storewide application requirements.

There is an accompanying spreadsheet that should be used in the planning process. You can find the spreadsheet in your Oracle NoSQL Database distribution here: `<KVHOME>/doc/misc/InitialCapacityPlanning.xls`.

The sections in this appendix correspond to named sections in the spreadsheet. Column A of the spreadsheet lists cell names that are associated with the values in column B. Cell names in red represent values that must be provided as input. Column C describes the value or the computation associated with the value in column B. The sections: Application Characteristics (page 126), Hardware Characteristics (page 127), and Machine Physical Memory (page 128) contain required inputs. Green cell names denote optional inputs; the default values supplied in the spreadsheet should be adequate for most estimates. All other cells are computed by the spreadsheet using the formulas described below.

After filling in the required inputs, the cell *StoreMachines* value will tell you how many Storage Nodes should be available in the storage node pool. The *StorePartitions* value will tell you how many partitions should be specified when creating the store.

Please keep in mind that the computations below yield estimates. The underlying model used as a basis for the estimation makes simplifying assumptions since it's hard to come up with a simple single underlying model that will work well under a wide range of application requirements. So these estimates should only be used as the basis for an initial starting point and refined under simulated or actual load.

## Shard Capacity

To determine the shard capacity first determine the application and hardware characteristics described in this section. Having determined these characteristics, enter them into the accompanying spreadsheet. The spread sheet will then calculate the capacity of a shard on the basis of the supplied application and hardware characteristics.

## Application Characteristics

### Replication Factor

In general, a Replication Factor of 3 is adequate for most applications and is a good starting point. It can be refined if performance testing suggests some other number works better for the specific workload. Do not select a Replication Factor of 2 because doing so means that even a single failure results in too few sites to elect a new master. A Replication Factor of 1 is to be avoided in general since Oracle NoSQL Database has just a single copy of the data; if the storage device hosting the data were to fail the data could be lost.

Larger replication factors provide two benefits:

1. Increased durability to better withstand disk or machine failures.
2. Increased read request throughput, because there are more nodes per shard available to service those requests.

However, the increased durability and read throughput has costs associated with it: more hardware resources to host and serve the additional copies of the data and slower write performance, because each shard has more nodes to which updates must be replicated.

The Replication Factor is defined by the cell *RF*.

### Average Key Size

Use knowledge of the application's key schema and the relative distributions of the various keys to arrive at an average key length. The length of a key on disk is the number of UTF-8 bytes needed to represent the components of the key, plus the number of components, minus one.

This value is defined by the cell *AvgKeySize*.

### Average Value Size

Use knowledge of the application to arrive at an average serialized value size. The value size will vary depending upon the particular serialization format used by the application.

This value is defined by the cell *AvgValueSize*.

### Read and Write Operation Percentages

Compute a rough estimate of the relative frequency of store level read and write operations on the basis of the KVS API operations used by the application.

At the most basic level, each KVS get() call results in a store level read operation and each put() operation results in a store level write operation. Each KVS multi key operation (KVStore.execute(), multiGet(), or multiDelete()) can result in multiple store level read/write operations. Again, use application knowledge about the number of keys accessed in these operations to arrive at an estimate.

Express the estimate as a read percentage, that is, the percentage of the total operations on the store that are reads. The rest of the operations are assumed to be write operations.

This value is defined by the cell *ReadOpsPercent*.

Estimate the percentage of read operations that will likely be satisfied from the file system cache. The percentage depends primarily upon the application's data access pattern and the size of the file system cache. Sizing Advice (page 129) contains a discussion of how this cache is used.

This value is defined by the cell *ReadCacheHitPercent*.

## Hardware Characteristics

Determine the following hardware characteristics based on a rough idea of the type of the machines that will be used to host the store:

- The number of disks per machine that will be used for storing KV pairs. This value is defined by the cell *DisksPerMachine*. The number of disks per machine typically determines the Storage Node Capacity as described in Storage Node Parameters (page 77).
- The usable storage capacity of each disk. This value is defined by the cell *DiskCapacityGB*.
- The IOPs capacity of each disk. This information is typically available in the disk spec sheet as the number of sustained random IO operations/sec that can be delivered by the disk. This value is defined by the cell *DiskIopsPerSec*.

The following discussion assumes that the system will be configured with one RN per disk.

## Shard Storage and Throughput Capacities

There are two types of capacity that are relevant to this discussion: 1) Storage Capacity 2) Throughput Capacity. The following sections describe how these two measures of capacity are calculated. The underlying calculations are done automatically by the attached spreadsheet based upon the application and hardware characteristics supplied earlier.

### Shard Storage Capacity

The storage capacity is the maximum number of KV pairs that can be stored in a shard. It is calculated by dividing the storage actually available for live KV pairs (after accounting for the storage set aside as a safety margin and cleaner utilization) by the storage (including a rough estimation of Btree overheads) required by each KV pair.

The KV Storage Capacity is computed by the cell: *MaxKVPairsPerShard*.

### Shard I/O Throughput capacity

The throughput capacity is a measure of the read and write ops that can be supported by a single shard. In the calculations below, the logical throughput capacity is derived from the disk IOPs capacity based upon the percentage of logical operations that actually translate into disk IOPs after allowing for cache hits. The Machine Physical Memory (page 128) section contains more detail about configuring the caches used by Oracle NoSQL Database.

For logical read operations, the shard-wide IOPs is computed as:

```
(ReadOpsPercent * (1 - ReadCacheHitPercent))
```

Note that all percentages are expressed as fractions.

For logical write operations, the shard-wide IOPs is computed as:

```
(((1 - ReadOpsPercent) / WriteOpsBatchSize) * RF)
```

The writeops calculations are very approximate. Write operations make a much smaller contribution to the IOPs load than do the read ops due to the sequential writes used by the log structured storage system. The use of WriteOpsBatchSize is intended to account for the sequential nature of the writes to the underlying JE log structured storage system. The above formula does not work well when there are no reads in the workload, that is, under pure insert or pure update loads. Under pure insert, the writes are limited primarily by acknowledgement latency which is not modeled by the formula. Under pure update loads, both the acknowledgement latency and cleaner performance play an important role.

The sum of the above two numbers represents the percentage of logical operations that actually result in disk operations (the *DiskIopsPercent* cell). The shard's logical throughput can then be computed as:

```
(DiskIopsPerSec * RF)/DiskIopsPercent
```

and is calculated by the cell *OpsPerShardPerSec*.

## Memory and Network Configuration

Having established the storage and throughput capacities of a shard, the amount of physical memory and network capacity required by each machine can be determined. Correct configuration of physical memory and network resources is essential for the proper operation of the store. If your primary goal is to determine the total size of the store, skip ahead to Estimate total Shards and Machines (page 132) but make sure to return to this section later when it is time to finalize the machine level hardware requirements.

#### Note

You can also set the memory size available for each Storage Node in your store, either through the `memory_mb` parameter of the `makebootconfig` utility or through the `memorymb` Storage Node parameter. For more information, see Installation Configuration (page 12) and Storage Node Parameters (page 77) respectively.

### Machine Physical Memory

The shard storage capacity (computed by the cell *MaxKVPairsPerShard*) and the average key size (defined by the cell*AvgKeySize* cell) can be used to estimate the physical memory requirements of the machine. The physical memory on the machine backs up the caches used by Oracle NoSQL Database.

Sizing the in-memory cache correctly is essential for meeting store's performance goals. Disk I/O is an expensive operation from a performance point of view; the more operations that can be serviced from the cache, the better the store's performance.

Before continuing, it is worth noting that there are two caches that are relevant to this discussion:

1. The JE cache. The underlying storage engine used by Oracle NoSQL Database is Berkeley DB Java Edition (JE). JE provides an in-memory cache. For the most part, this is the cache size that is most important, because it is the one that is simplest to control and configure.

2. The file system (FS) cache. Modern operating systems attempt to improve their I/O subsystem performance by providing a cache, or buffer, that is dedicated to disk I/O. By using the FS cache, read operations can be performed very quickly if the reads can be satisfied by data that is stored there.

## Sizing Advice

JE uses a Btree to organize the data that it stores. Btrees provide a tree-like data organization structure that allows for rapid information lookup. These structures consist of interior nodes (INs) and leaf nodes (LNs). INs are used to navigate to data. LNs are where the data is actually stored in the Btree.

Because of the very large data sets that an Oracle NoSQL Database application is expected to use, it is unlikely that you can place even a small fraction of the data into JE's in-memory cache. Therefore, the best strategy is to size the cache such that it is large enough to hold most, if not all, of the database's INs, and leave the rest of the node's memory available for system overhead (negligible) and the FS cache.

Both INs and LNs can take advantage of the FS cache. Because INs and LNs do not have Java object overhead when present in the FS cache (as they would when using the JE cache), they can make more effective use of the FS cache memory than the JE cache memory.

Of course, in order for the FS cache to be truly effective, the data access patterns should not be completely random. Some subset of your key-value pairs must be favored over others in order to achieve a useful cache hit rate. For applications where the access patterns are not random, the high file system cache hit rates on LNs and INs can increase throughput and decrease average read latency. Also, larger file system caches, when properly tuned, can help reduce the number of stalls during sequential writes to the log files, thus decreasing write latency. Large caches also permit more of the writes to be done asynchronously, thus improving throughput.

## Determine JE Cache Size

To determine an appropriate JE cache size, use the `com.sleepycat.je.util.DbCacheSize` utility. This utility requires as input the number of records and the size of the application keys. You can also optionally provide other information, such as the expected data size. The utility then provides a short table of information. The number you want is provided in the `Cache Size` column, and in the `Minimum, internal nodes only` row.

For example, to determine the JE cache size for an environment consisting of 100 million records, with an average key size of 12 bytes, and an average value size of 1000 bytes, invoke `DbCacheSize` as follows:

```
java -Xmx256m -Xms256m \
-d64 -XX:+UseCompressedOops -jar je.jar DbCacheSize \
-key 12 -data 1000 -records 100000000

          === Environment Cache Overhead ===

          3,156,253 minimum bytes

          To account for JE daemon operation and record locks,
          a significantly larger amount is needed in practice.

          === Database Cache Size ===

          Minimum Bytes    Maximum Bytes   Description
          ---------------  ---------------  -----------
          2,888,145,968    3,469,963,312  Internal nodes only
          107,499,427,952  108,081,245,296  Internal nodes and leaf nodes

          === Internal Node Usage by Btree Level ===

          Minimum Bytes    Maximum Bytes      Nodes    Level
          ---------------  ---------------  ----------  -----
          2,849,439,456    3,424,720,608   1,123,596    1
          38,275,968       44,739,456      12,624    2
          427,512          499,704         141    3
          3,032            3,544           1    4
```

Please make note of the following jvm arguments (they have a special meaning when supplied to DbCacheSize):

1. The -d64 argument is used to ensure a 64 bit jvm environment that is capable of supporting heap size greater than 4GB.

2. The -XX:+UseCompressedOops is used to ensure use of more efficient 32 bit pointers in the 62 bit environment thus permitting better utilization of the JE cache.

These arguments when supplied to `Database Cache Size` serve as an indication that the JE application will also be supplied these arguments and `Database Cache Size` adjusts its calculations appropriately. The arguments are used by Oracle NoSQL Database when starting up the Replication Nodes which uses these caches.

The number you want is in the `Database Cache Size` section of the output, under the "Minimum Bytes" column in the "Internal nodes only" row. The output indicates that a cache size of 2.9 GB is sufficient to hold all the IN nodes representing the Btree in the JE cache. With a JE cache of this size, the IN nodes will be fetched from the JE cache and the LNs will be fetched from the FS cache or the disk.

For more information on using the `DbCacheSize` utility, see this Javadoc page: http://docs.oracle.com/cd/E17277_02/html/java/com/sleepycat/je/util/DbCacheSize.html. Note that in order to use this utility, you must add the `<KVHOME>/lib/je.jar` file to your Java classpath. <KVHOME> represents the directory where you placed the Oracle NoSQL Database package files.

Having used `DbCacheSize` to obtain the JE cache size, the heap size can be calculated from it. To do this, enter the number obtained from `DbCacheSize` into the cell named *DbCacheSizeMB* making sure to convert the units from bytes to MB. The heap size is computed by the cell *RNHeapMB* as below:

```
(DBCacheSizeMB/RNCachePercent)
```

where *RNCachePercent* is the percentage of the heap that is used for the JE cache. The computed heap size should not exceed 32GB, so that the java VM can use its efficient CompressedOops format to represent the java objects in memory. Heap sizes with values exceeding 32GB will appear with a strikethrough in the *RNHeapMB* cell to emphasize this requirement. If the heap size exceeds 32GB, try to reduce the size of the keys to reduce the JE cache size in turn and bring the overall heap size below 32GB.

The heap size is used as the basis for computing the memory required by the machine as below:

```
(RNHeapMB * DisksPerMachine)/SNRNHeapPercent
```

where *SNRNHeapPercent* is the percentage of the physical memory that is available for use by the RN's hosted on the machine. The result is available in the cell *MachinePhysicalMemoryMB*.

## Machine Network Throughput

We need to ensure that the NIC attached to the machine is capable of delivering the application I/O throughput as calculated earlier in Shard I/O Throughput capacity (page 127), because otherwise it could prove to be a bottleneck.

The number of bytes received by the machine over the network as a result of write operations initiated by the client is calculated as:

```
(OpsPerShardPerSec * (1 - ReadOpsPercent) *
 (AvgKeySize + AvgValueSize)) * DisksPerMachine
```

and is denoted by *ReceiveBytesPerSec* in the spreadsheet. Note that whether a node is a master or a replica does not matter for the purposes of this calculation; the inbound write bytes come from the client for the master and from the masters for the replicas on the machine.

The number of bytes received by the machine as a result of read requests is computed as:

```
((OpsPerShardPerSec * ReadOpsPercent)/RF) *
 (AvgKeySize + ReadRequestOverheadBytes) * DisksPerMachine
```

where *ReadRequestOverheadBytes* is a fixed constant overhead of 100 bytes.

The bytes sent out by the machine over the network as a result of the read operations has two underlying components:

1. The bytes sent out in direct response to application read requests and can be expressed as:

```
((OpsPerShardPerSec *  ReadOpsPercent)/RF) *
 (AvgKeySize + AvgValueSize) * DisksPerMachine
```

2. The bytes sent out as replication traffic by the masters on the machine expressed as:

```
(OpsPerShardPerSec * (1 - ReadOpsPercent) *
 (AvgKeySize + AvgValueSize) * (RF-1)) * MastersOnMachine
```

The sum of the above two values represents the total outbound traffic denoted by SendBytesPerSec in the spreadsheet.

The total inbound and outbound traffic must be comfortably within the NIC's capacity. The spreadsheet calculates the kind of network card, GigE or 10GigE, that is required to support the traffic.

## Estimate total Shards and Machines

Having calculated the per shard capacity in terms of storage and throughput, the total number of shards and partitions can be estimated on the basis of the maximum storage and throughput required by the store as a whole using a simple extrapolation. The following inputs must be supplied for this calculation:

1. The maximum number of KV pairs that will stored in the initial store. This value is defined by the cell *MaxKVPairs*. This initial maximum value can be increased subsequently by using the topology transformation commands described in Transform the Topology Candidate (page 40).

2. The maximum read/write mixed operation throughput expressed as operations/sec for the entire store. The percentage of read operations in this mix must be the same as that supplied earlier in the *ReadOpsPercent* cell. This value is defined by the cell *MaxStorewideOpsPerSec*.

The required number of shards is first computed on the basis of storage requirements as below:

```
MaxKVPairs/MaxKVPairsPerShard
```

This value is calculated by the cell *StorageBasedShards*.

The required number of shards is then computed again based upon IO throughput requirements as below:

```
MaxStorewideOpsPerSec/OpsPerShardPerSec
```

This value is calculated by the cell named *OpsBasedShards*.

The maximum of the shards computed on the basis of storage and throughput above is sufficient to satisfy both the total storage and throughput requirements of the application.

The value is calculated by the cell *StoreShards*. To highlight the basis on which the choice was made, the smaller of the two values in *StorageBasedShards* or *OpsBasedShards* has its value crossed out.

Having determined the number of required shards, the number of required machines is calculated as:

```
MAX(RF, (StoreShards*RF)/DisksPerMachine)
```

## Number of Partitions

Every shard in the store must contain at least one partition, but it is best to configure the store so that each shard always contains more than one partition. The records in the KVStore are spread evenly across the KVStore partitions, and as a consequence they are also spread evenly across shards. The total number of partitions that the store should contain is determined when the store is initially created. This number is static and cannot be changed over the store's lifetime, so it is an important initial configuration parameter.

The number of partitions must be more than the largest number of shards the store will contain. It is possible to add shards to the store, and when you do, the store is re-balanced by moving partitions between shards (and with them, the data that they contain). Therefore, the total number of partitions is actually a permanent limit on the total number of shards your store is able to contain.

Note that there is some overhead in configuring an excessively large number of partitions. That said, it does no harm to select a partition value that provides plenty of room for growing the store. It is not unreasonable to select a partition number that is 10 times the maximum number of shards.

The number of partitions is calculated by the cell *StorePartitions*.

```
StoreShards * 10
```

# Appendix C. Machine Tuning

The default tuning parameters available for the Oracle NoSQL Database software should in general be acceptable for production systems, and so do not require any tuning. However, the underlying operating system will have default values for various kernel parameters which require modification in order to achieve the best possible performance for your store's installation.

This appendix identifies the kernel parameters that you should manage when installing a *production* store. By this, we mean any store whose performance is considered critical. Evaluation systems installed into a lab environment probably do not need this level of tuning unless you are using those systems to measure the store's performance.

### Note

Oracle NoSQL Database is most frequently installed on Linux systems, and so that is what this appendix focuses on.

## Linux Page Cache Tuning

Tune your page cache to permit the OS to write asynchronously to disk whenever possible. This allows background writes, which minimize the latency resulting from serial write operations such as fsync. This also helps with write stalls which occur when the file system cache is full and needs to be flushed to disk to make room for new writes. We have observed significant speedups (15-20%) on insert-intensive benchmarks when these parameters are tuned as described below.

Place the following commands in `/etc/sysctl.conf`. Run

```
sysctl -p
```

to load the new settings so they can take effect without needing to reboot the machine.

```
# Set vm.dirty_background_bytes to 10MB to ensure that
# on a 40MB/sec hard disk a fsync never takes more than 250ms and takes
# just 125ms on average. The value of vm.dirty_background_bytes
# should be increased on faster SSDs or I/O subsytems with higher
# throughput. You should increase this setting by the same proportion
# as the relative increase in throughput. For example, for a typical SSD
# with a throughput of 160MB/sec, vm.dirty_background_bytes should be set
# to 40MB so fsync takes ~250ms. In this case, the value was increased by
# a factor of 4.
vm.dirty_background_bytes=10485760

# IO calls effectively become synchronous(waiting for the underlying
# device to complete them). This setting helps minimize the
# possibility of a write request stalling in JE while holding the
# write log latch.
vm.dirty_ratio=40
```

```
# Ensures that data does not hang around in memory longer than
# necessary. Given JE's append-only style of writing, there is
# typically little benefit from having an intermediate dirty page
# hanging around, because it is never going to be modified. By
# evicting the dirty page earlier, its associated memory is readily
# available for reading or writing new pages, should that become
# necessary.
vm.dirty_expire_centisecs=1000
```

Earlier versions of the Linux kernel may not support `vm.dirty_background_bytes`. On these older kernels you can use `vm.dirty_background_ratio` instead. Pick the ratio that gets you closest to 10MB. On some systems with a lot of memory this may not be possible due to the large granularity associated with this configuration knob. A further impediment is that a ratio of 5 is the effective minimum in some kernels.

```
vm.dirty_background_ratio=5
```

Use `sysctl -a` to verify that the parameters described here are set as expected.

## OS User Limits

When running a large Oracle NoSQL Database store, the default OS limits may be insufficient. The following sections list limits that are worth reviewing.

### File Descriptor Limits

Use `ulimit -n` to determine the maximum number of files that can be opened by a user. The number of open file descriptors may need to be increased if the defaults are too low. It's worth keeping in mind that each open network connection also consumes a file descriptor. Machines running clients as well as machines running RNs may need to increase this limit for large stores with 100s of nodes.

Add entries like the ones below in `/etc/security/limits.conf` to change the file descriptor limits:

```
$username soft nofile 10240
$username hard nofile 10240
```

where `$username` is the username under which the Oracle NoSQL Database software runs.

Note that machines hosting multiple replication nodes; that is, machines configured with a capacity > 1; will need larger limits than what is identified here.

### Process and Thread Limits

Use `ulimit -u` to determine the maximum number of processes (threads are counted as processes under Linux) that the user is allowed to create. Machines running clients as well as machines running RNs may need to increase this limit to accommodate large numbers of concurrent requests.

Add entries like the ones below in `/etc/security/limits.conf` to change the thread limits:

```
$username soft nproc 8192
$username hard nproc 8192
```

where `$username` is the username under which the Oracle NoSQL Database software runs.

Note that machines hosting multiple replication nodes; that is, machines configured with a capacity > 1; will need larger limits than what is identified here.

## Linux Network Configuration Settings

Before continuing, it is worth checking that the network interface card is configured as expected during the initial setup of each SN, because it is harder to debug these problems later when such configuration problems show up under load.

Use the following command to determine which network interface is being used to access a particular subnet on each host. This command is particularly useful for machines with multiple NICs:

```
$ ip addr ls to 192.168/16
2: eth0: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc pfifo_fast
    state UP qlen 1000
    inet 192.168.1.19/24 brd 192.168.1.255 scope global eth0
```

Use the following command to get information about the configuration of the NIC:

```
$ ethtool -i eth2
driver: enic
version: 2.1.1.13
firmware-version: 2.0(2g)
bus-info: 0000:0b:00.0
```

Use the following command to get information about the NIC hardware:

```
$ lspci -v | grep "Ethernet controller"
00:03.0 Ethernet controller: Intel Corporation 82540EM Gigabit
Ethernet Controller (rev 02)
```

Use the following command to get information about the network speed. Note that this command requires sudo:

```
$ sudo ethtool eth0 | grep Speed
    Speed: 1000Mb/s
```

You may want to consider using 10 gigabit Ethernet, or other fast network implementations, to improve performance for large clusters.

### Server Socket Backlog

The typical default maximum server socket backlog, typically set at 128, is too small for server style loads. It should be at least 1K for server applications and even a 10K value is not unreasonable for large stores.

Set the `net.core.somaxconn` property in `sysctl.conf` to modify this value.

## Isolating HA Network Traffic

If the machine has multiple network interfaces, you can configure Oracle NoSQL Database to isolate HA replication traffic on one interface, while client request traffic uses another interface. Use the `-hahost` parameter to the `makebootconfig` command to specify the interface to be used by HA as in the example below:

```
java -Xmx256m -Xms256m \
-jar kvstore.jar makebootconfig -root /disk1/kvroot \
-host sn10.example.com -port 5000 -harange 5010,5020 \
-storagedir /disk2/kv -hahost sn10-ha.example.com
```

In this example, all client requests will use the interface associated with `sn10.example.com`, while HA traffic will use the interface associated with `sn10-ha.example.com`.

## Receive Packet Steering

When multiple RNs are located on a machine with a single queue network device, enabling Receive Packet Steering (RPS) can help performance by distributing the CPU load associated with packet processing (soft interrupt handling) across multiple cores. Multi-queue NICs provide such support directly and do not need to have RPS enabled.

Note that this tuning advice is particularly appropriate for customers using Oracle Big Data Appliance.

You can determine whether a NIC is multi-queue by using the following command:

```
sudo ethtool -S eth0
```

A multi-queue NIC will have entries like this:

```
 rx_queue_0_packets: 271623830
     rx_queue_0_bytes: 186279293607
     rx_queue_0_drops: 0
     rx_queue_0_csum_err: 0
     rx_queue_0_alloc_failed: 0
     rx_queue_1_packets: 273350226
     rx_queue_1_bytes: 188068352235
     rx_queue_1_drops: 0
     rx_queue_1_csum_err: 0
     rx_queue_1_alloc_failed: 0
     rx_queue_2_packets: 411500226
     rx_queue_2_bytes: 206830029846
     rx_queue_2_drops: 0
     rx_queue_2_csum_err: 0
     rx_queue_2_alloc_failed: 0
...
```

For a For a 32 core Big Data Appliance using Infiniband, use the following configuration to distribute receive packet processing across all 32 cores:

```
echo ffffffff > /sys/class/net/eth0/queues/rx-0/rps_cpus
```

where `ffffffff` is a bit mask selecting all 32 cores.

For more information on RPS please consult:

1. http://docs.oracle.com/cd/E37670_01/E37355/html/ol_about_uek.html
2. http://lwn.net/Articles/361440/

# Appendix D. Solid State Drives (SSDs)

If you are planning on using Solid State Drives (SSDs) for your Oracle NoSQL Database deployment, a special consideration should be taken. Because of how SSDs work, I/O latency can become an issue with SSDs over time. Correct configuration and use of `trim` can help minimize these latency issues.

## Trim requirements

In general, for TRIM to be effective, the following requirements must be met:

- The SSD itself must support trim.
- Linux-kernel 2.6.33 or later.
- Filesystem ext4 (ext3 does not support trim).

## Enabling Trim

The `trim` support must be explicitly enabled for the ext4 file system. You should mount the file system with trim enabled.

# Appendix E. Third Party Licenses

All of the third party licenses used by Oracle NoSQL Database are described in the `LICENSE.txt` file, which you can find in your KVHOME directory.