Oracle® Big Data Appliance

Software User's Guide

Release 2 (2.2.1)

E41241-04

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Provides an introduction to the Oracle Big Data Appliance software and to the administrative tools and procedures.

ORACLE®

Oracle Big Data Appliance Software User's Guide, Release 2 (2.2.1)

E41241-04

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Preface

The *Oracle Big Data Appliance Software User's Guide* describes how to manage and use the installed software.

Audience

This guide is intended for users of Oracle Big Data Appliance including:

- Application developers
- Data analysts
- Data scientists
- Database administrators
- System administrators

The *Oracle Big Data Appliance Software User's Guide* introduces the terminology and concepts necessary to discuss Oracle Big Data Appliance. However, you must acquire the necessary information about administering Hadoop clusters and writing MapReduce programs from other sources.

Documentation Accessibility

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

Access to Oracle Support

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

Related Documents

For more information, see the following documents:

- *Oracle Big Data Appliance Perfect Balance Java API Reference*
- *Oracle Enterprise Manager System Monitoring Plug-in Installation Guide for Oracle Big Data Appliance*
- *Oracle Big Data Appliance Owner's Guide*
- *Oracle Big Data Connectors User's Guide*

Conventions

The following text conventions are used in this document:

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

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Introducing Oracle Big Data Appliance

This chapter presents an overview of Oracle Big Data Appliance and describes the software installed on the system. This chapter contains the following sections:

What Is Big Data?

Using transactional data as the source of business intelligence has been commonplace for many years. As digital technology and the World Wide Web spread into every aspect of modern life, other sources of data can make important contributions to business decision making. Many businesses are looking to these new data sources. They are finding opportunities in analyzing vast amounts of data that until recently was discarded.

Big data is characterized by:

These characteristics pinpoint the challenges in deriving value from big data, and the differences between big data and traditional data sources that primarily provide highly structured, transactional data.

High Variety

Big data is derived from a variety of sources, such as:

- Equipment sensors: Medical, manufacturing, transportation, and other machine sensor transmissions
- Machines: Call detail records, web logs, smart meter readings, Global Positioning System (GPS) transmissions, and trading systems records

- Social media: Data streams from social media sites such as Facebook and blogging sites such as Twitter

Analysts can mine this data repeatedly as they devise new ways of extracting meaningful insights. What seems irrelevant today might prove to be highly pertinent to your business tomorrow.

Challenge: Delivering flexible systems to handle this high variety

High Complexity

As the variety of data types increases, the complexity of the system increases. The complexity of data types also increases in big data because of its low structure.

Challenge: Finding solutions that apply across a broad range of data types.

High Volume

Social media can generate terabytes of daily data. Equipment sensors and other machines can generate that much data in less than an hour.

Even traditional data sources for data warehouses, such as customer profiles from customer relationship management (CRM) systems, transactional enterprise resource planning (ERP) data, store transactions, and general ledger data, have increased tenfold in volume over the past decade.

Challenge: Providing scalability and ease in growing the system

High Velocity

Huge numbers of sensors, web logs, and other machine sources generate data continuously and at a much higher speed than traditional sources, such as individuals entering orders into a transactional database.

Challenge: Handling the data at high speed without stressing the structured systems

The Oracle Big Data Solution

Oracle Big Data Appliance is an engineered system comprising both hardware and software components. The hardware is optimized to run the enhanced big data software components.

Oracle Big Data Appliance delivers:

- A complete and optimized solution for big data
- Single-vendor support for both hardware and software
- An easy-to-deploy solution
- Tight integration with Oracle Database and Oracle Exadata Database Machine

Oracle provides a big data platform that captures, organizes, and supports deep analytics on extremely large, complex data streams flowing into your enterprise from many data sources. You can choose the best storage and processing location for your data depending on its structure, workload characteristics, and end-user requirements.

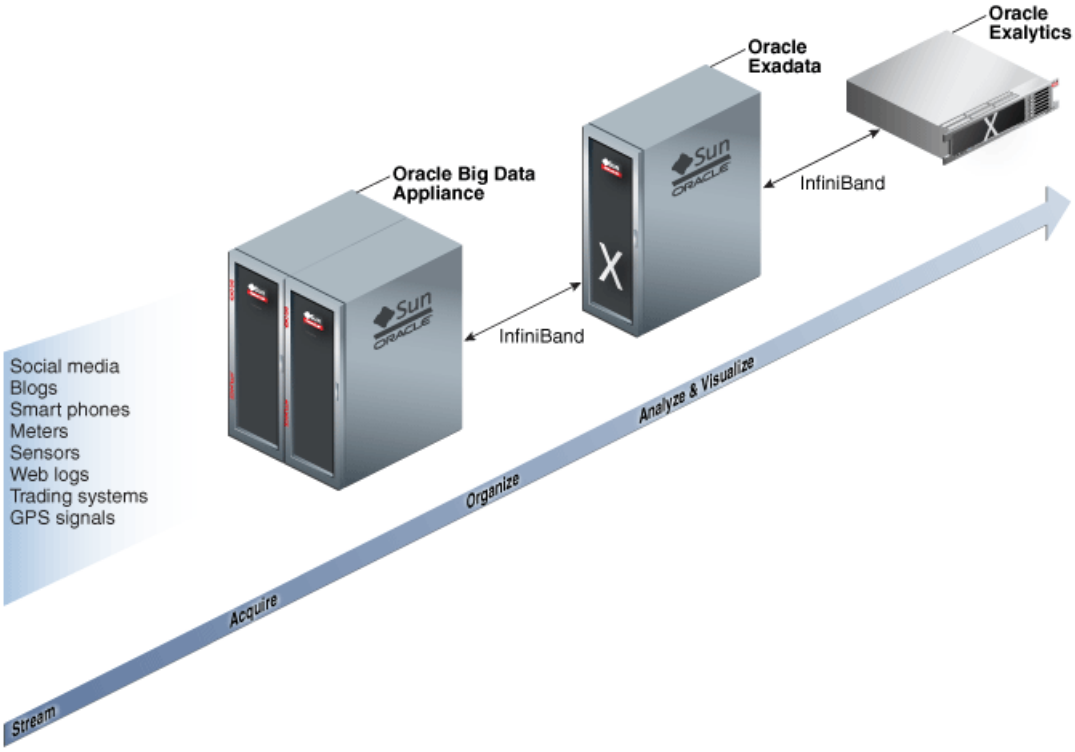
Oracle Database enables all data to be accessed and analyzed by a large user community using identical methods. By adding Oracle Big Data Appliance in front of Oracle Database, you can bring new sources of information to an existing data warehouse. Oracle Big Data Appliance is the platform for acquiring and organizing

big data so that the relevant portions with true business value can be analyzed in Oracle Database.

For maximum speed and efficiency, Oracle Big Data Appliance can be connected to Oracle Exadata Database Machine running Oracle Database. Oracle Exadata Database Machine provides outstanding performance in hosting data warehouses and transaction processing databases. Moreover, Oracle Exadata Database Machine can be connected to Oracle Exalytics In-Memory Machine for the best performance of business intelligence and planning applications. The InfiniBand connections between these engineered systems provide high parallelism, which enables high-speed data transfer for batch or query workloads.

Figure 1–1 shows the relationships among these engineered systems.

Figure 1–1 Oracle Engineered Systems for Big Data



Software for Big Data

The **Oracle Linux** operating system and Cloudera's Distribution including Apache Hadoop (CDH) underlie all other software components installed on Oracle Big Data Appliance. **CDH** is an integrated stack of components that have been tested and packaged to work together.

CDH has a batch processing infrastructure that can store files and distribute work across a set of computers. Data is processed on the same computer where it is stored. In a single Oracle Big Data Appliance rack, CDH distributes the files and workload across 18 servers, which compose a **cluster**. Each server is a node in the cluster.

The software framework consists of these primary components:

- File system: The **Hadoop Distributed File System (HDFS)** is a highly scalable file system that stores large files across multiple servers. It achieves reliability by

replicating data across multiple servers without RAID technology. It runs on top of the Linux file system on Oracle Big Data Appliance.

- MapReduce engine: The MapReduce engine provides a platform for the massively parallel execution of algorithms written in Java.
- Administrative framework: Cloudera Manager is a comprehensive administrative tool for CDH.

CDH is written in Java, and Java is the language for applications development. However, several CDH utilities and other software available on Oracle Big Data Appliance provide graphical, web-based, and other language interfaces for ease of use.

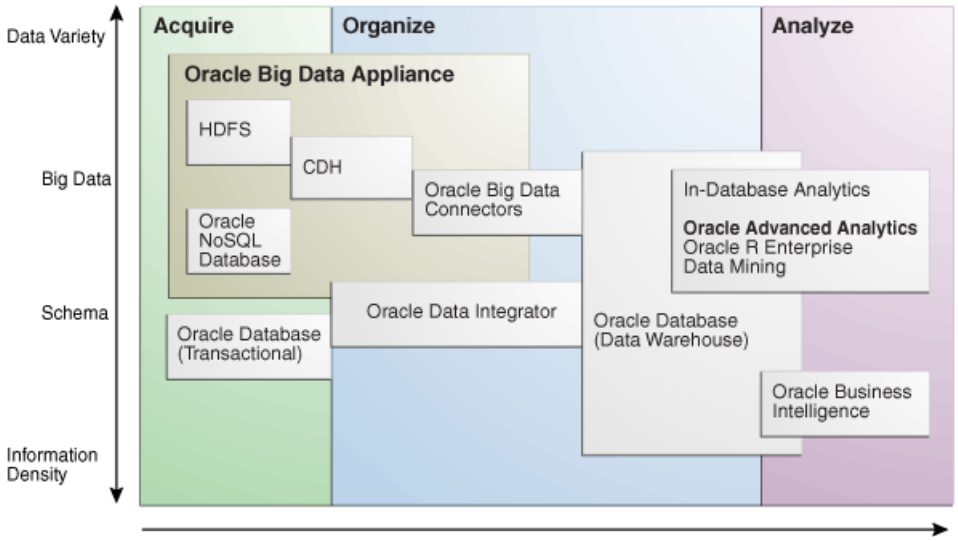
Software Component Overview

The major software components perform three basic tasks:

- Acquire
- Organize
- Analyze and visualize

The best tool for each task depends on the density of the information and the degree of structure. Figure 1–2 shows the relationships among the tools and identifies the tasks that they perform.

Figure 1–2 Oracle Big Data Appliance Software Overview



Acquiring Data for Analysis

Oracle Big Data Appliance provides these facilities for capturing and storing big data:

- Hadoop Distributed File System (HDFS)
- Oracle NoSQL Database
- **Hive**

Databases used for online transaction processing (OLTP) are the traditional data sources for data warehouses. The Oracle solution enables you to analyze traditional data stores with big data in the same Oracle data warehouse. Relational data continues

to be an important source of business intelligence, although it runs on separate hardware from Oracle Big Data Appliance.

Hadoop Distributed File System

Cloudera's Distribution including Apache Hadoop (CDH) on Oracle Big Data Appliance uses the Hadoop Distributed File System (HDFS). HDFS stores extremely large files containing record-oriented data. On Oracle Big Data Appliance, HDFS splits large data files into chunks of 256 megabytes (MB), and replicates each chunk across three different nodes in the cluster. The size of the chunks and the number of replications are configurable.

Chunking enables HDFS to store files that are larger than the physical storage of one server. It also allows the data to be processed in parallel across multiple computers with multiple processors, all working on data that is stored locally. Replication ensures the high availability of the data: if a server fails, the other servers automatically take over its work load.

HDFS is typically used to store all types of big data.

See Also:

- For conceptual information about Hadoop technologies, refer to this third-party publication:

  Hadoop: The Definitive Guide, Third Edition by Tom White (O'Reilly Media Inc., 2012., ISBN: 978-1449311520).

- For documentation about Cloudera's Distribution including Apache Hadoop, see the Cloudera library at

  http://oracle.cloudera.com/

Hive

Hive is an open-source data warehouse that supports data summarization, ad hoc querying, and data analysis of data stored in HDFS. It uses a SQL-like language called **HiveQL**. An interpreter generates MapReduce code from the HiveQL queries. By storing data in Hive, you can avoid writing MapReduce programs in Java.

Hive is a component of CDH and is always installed on Oracle Big Data Appliance. Oracle Big Data Connectors can access Hive tables.

Oracle NoSQL Database

Oracle NoSQL Database is a distributed key-value database built on the proven storage technology of Berkeley DB Java Edition. Whereas HDFS stores unstructured data in very large files, Oracle NoSQL Database indexes the data and supports transactions. But unlike Oracle Database, which stores highly structured data, Oracle NoSQL Database has relaxed consistency rules, no schema structure, and only modest support for joins, particularly across storage nodes.

NoSQL databases, or "Not Only SQL" databases, have developed over the past decade specifically for storing big data. However, they vary widely in implementation. Oracle NoSQL Database has these characteristics:

- Uses a system-defined, consistent hash index for data distribution
- Supports high availability through replication

- Provides single-record, single-operation transactions with relaxed consistency guarantees
- Provides a Java API

Oracle NoSQL Database is designed to provide highly reliable, scalable, predictable, and available data storage. The key-value pairs are stored in shards or partitions (that is, subsets of data) based on a primary key. Data on each shard is replicated across multiple storage nodes to ensure high availability. Oracle NoSQL Database supports fast querying of the data, typically by key lookup.

An intelligent driver links the NoSQL database with client applications and provides access to the requested key-value on the storage node with the lowest latency.

Oracle NoSQL Database includes hashing and balancing algorithms to ensure proper data distribution and optimal load balancing, replication management components to handle storage node failure and recovery, and an easy-to-use administrative interface to monitor the state of the database.

Oracle NoSQL Database is typically used to store customer profiles and similar data for identifying and analyzing big data. For example, you might log in to a website and see advertisements based on your stored customer profile (a record in Oracle NoSQL Database) and your recent activity on the site (web logs currently streaming into HDFS).

Oracle NoSQL Database is an optional component of Oracle Big Data Appliance and runs on a separate cluster from CDH.

See Also:

- *Oracle NoSQL Database Getting Started Guide* at

  `http://docs.oracle.com/cd/NOSQL/html/index.html`
- *Oracle Big Data Appliance Licensing Information*

Organizing Big Data

Oracle Big Data Appliance provides several ways of organizing, transforming, and reducing big data for analysis:

- MapReduce
- Oracle R Support for Big Data
- Oracle Big Data Connectors

MapReduce

The MapReduce engine provides a platform for the massively parallel execution of algorithms written in Java. MapReduce uses a parallel programming model for processing data on a distributed system. It can process vast amounts of data quickly and can scale linearly. It is particularly effective as a mechanism for batch processing of unstructured and semistructured data. MapReduce abstracts lower-level operations into computations over a set of keys and values.

Although big data is often described as unstructured, incoming data always has some structure. However, it does not have a fixed, predefined structure when written to HDFS. Instead, MapReduce creates the desired structure as it reads the data for a particular job. The same data can have many different structures imposed by different MapReduce jobs.

A simplified description of a MapReduce job is the successive alternation of two phases: the Map phase and the Reduce phase. Each Map phase applies a transform function over each record in the input data to produce a set of records expressed as key-value pairs. The output from the Map phase is input to the Reduce phase. In the Reduce phase, the Map output records are sorted into key-value sets, so that all records in a set have the same key value. A reducer function is applied to all the records in a set, and a set of output records is produced as key-value pairs. The Map phase is logically run in parallel over each record, whereas the Reduce phase is run in parallel over all key values.

Note: Oracle Big Data Appliance supports the Yet Another Resource Negotiator (YARN) implementation of MapReduce. However, the Mammoth utility installs and configures only classic MapReduce.

Oracle R Support for Big Data

R is an open-source language and environment for statistical analysis and graphing It provides linear and nonlinear modeling, standard statistical methods, time-series analysis, classification, clustering, and graphical data displays. Thousands of open-source packages are available in the Comprehensive R Archive Network (CRAN) for a spectrum of applications, such as bioinformatics, spatial statistics, and financial and marketing analysis. The popularity of R has increased as its functionality matured to rival that of costly proprietary statistical packages.

Analysts typically use R on a PC, which limits the amount of data and the processing power available for analysis. Oracle eliminates this restriction by extending the R platform to directly leverage Oracle Big Data Appliance. Oracle R Distribution is installed on all nodes of Oracle Big Data Appliance. Analysts continue to work on their PCs using the familiar R user interface while manipulating huge amounts of data stored in HDFS using massively parallel processing.

Oracle R Connector for Hadoop provides R users with high-performance, native access to HDFS and the **MapReduce** programming framework, which enables R programs to run as MapReduce jobs on vast amounts of data. Oracle R Connector for Hadoop is included in the Oracle Big Data Connectors. See "Oracle R Connector for Hadoop" on page 1-8.

Oracle R Enterprise is a separate package that provides real-time access to Oracle Database. It enables you to store the results of your analysis of big data in an Oracle database, where it can be analyzed further.

These two Oracle R packages make Oracle Database and the Hadoop computational infrastructure available to statistical users without requiring them to learn the native programming languages of either one.

See Also:

- For information about R, go to

  `http://www.r-project.org/`

- For information about Oracle R Enterprise, go to

  `http://docs.oracle.com/cd/E36939_01/welcome.html`

Oracle Big Data Connectors

Oracle Big Data Connectors facilitate data access between data stored in CDH and Oracle Database. The connectors are licensed separately from Oracle Big Data Appliance and include:

- Oracle SQL Connector for Hadoop Distributed File System
- Oracle Loader for Hadoop
- Oracle R Connector for Hadoop
- Oracle Data Integrator Application Adapter for Hadoop

See Also: *Oracle Big Data Connectors User's Guide*

Oracle SQL Connector for Hadoop Distributed File System

Oracle SQL Connector for Hadoop Distributed File System (Oracle SQL Connector for HDFS) provides read access to HDFS from an Oracle database using **external tables**.

An external table is an Oracle Database object that identifies the location of data outside of the database. Oracle Database accesses the data by using the metadata provided when the external table was created. By querying the external tables, users can access data stored in HDFS as if that data were stored in tables in the database. External tables are often used to stage data to be transformed during a database load.

You can use Oracle SQL Connector for HDFS to:

- Access data stored in HDFS files
- Access Hive tables.
- Access comma-separated value (CSV) files generated by Oracle Loader for Hadoop
- Load data extracted and transformed by Oracle Data Integrator

Oracle Loader for Hadoop

Oracle Loader for Hadoop is an efficient and high-performance loader for fast movement of data from CDH into a table in an Oracle database. Oracle Loader for Hadoop partitions the data and transforms it into a database-ready format on CDH. It optionally sorts records by primary key before loading the data or creating output files.

You can use Oracle Loader for Hadoop as either a Java program or a command-line utility. The load runs as a MapReduce job on the CDH cluster.

Oracle Loader for Hadoop also reads from and writes to Oracle Data Pump files.

Oracle R Connector for Hadoop

Oracle R Connector for Hadoop is a collection of R packages that provide:

- Interfaces to work with Hive tables, Apache Hadoop compute infrastructure, local R environment and database tables
- Predictive analytic techniques written in R or Java as Hadoop MapReduce jobs that can be applied to data in HDFS files

Using simple R functions, you can copy data between R memory, the local file system, HDFS, and Hive. You can schedule R programs to execute as Hadoop MapReduce jobs and return the results to any of those locations. You can transfer existing R scripts and

packages from your PC to Oracle Big Data Appliance, and use Oracle R Connector for Hadoop functions to convert them to the MapReduce paradigm.

Oracle Data Integrator Application Adapter for Hadoop

Oracle Data Integrator (ODI) extracts, transforms, and loads data into Oracle Database from a wide range of sources.

In ODI, a knowledge module (KM) is a code template dedicated to a specific task in the data integration process. You use Oracle Data Integrator Studio to load, select, and configure the KMs for your particular application. More than 150 KMs are available to help you acquire data from a wide range of third-party databases and other data repositories. You only need to load a few KMs for any particular job.

Oracle Data Integrator Application Adapter for Hadoop contains the KMs specifically for use with big data.

Analyzing and Visualizing Big Data

After big data is transformed and loaded in Oracle Database, you can use the full spectrum of Oracle business intelligence solutions and decision support products to further analyze and visualize all your data.

See Also:

- Oracle Business Intelligence website at

  http://www.oracle.com/us/solutions/ent-performance-bi/business-intelligence/index.html

- Data Warehousing and Business Intelligence in the Oracle Database Documentation Library at

  http://www.oracle.com/pls/db112/portal.portal_db?selected=6&frame=

2

Administering Oracle Big Data Appliance

This chapter provides information about the software and services installed on Oracle Big Data Appliance. It contains these sections:

Monitoring a Cluster Using Oracle Enterprise Manager

An Oracle Enterprise Manager plug-in enables you to use the same system monitoring tool for Oracle Big Data Appliance as you use for Oracle Exadata Database Machine or any other Oracle Database installation. With the plug-in, you can view the status of the installed software components in tabular or graphic presentations, and start and stop these software services. You can also monitor the health of the network and the rack components.

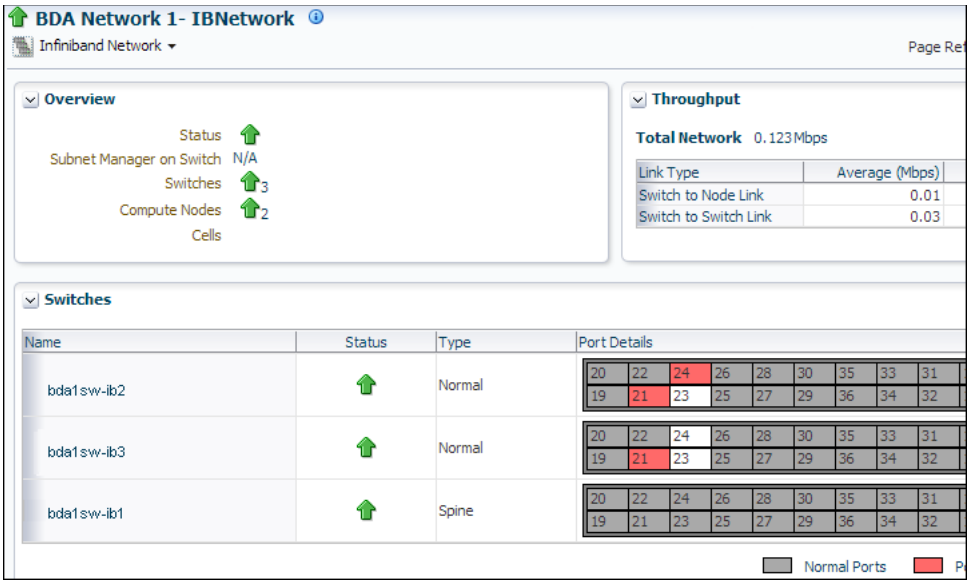
Using the Enterprise Manager Web Interface

After opening Oracle Enterprise Manager web interface, logging in, and selecting a target cluster, you can drill down into these primary areas:

- **InfiniBand network**: Network topology and status for InfiniBand switches and ports. See Figure 2–1.
- **Hadoop cluster**: Software services for HDFS, MapReduce, and ZooKeeper.
- **Oracle Big Data Appliance rack**: Hardware status including server hosts, Oracle Integrated Lights Out Manager (Oracle ILOM) servers, power distribution units (PDUs), and the Ethernet switch.

Figure 2–1 shows some information provided about the InfiniBand switches.

Figure 2–1 InfiniBand Home in Oracle Enterprise Manager



To monitor Oracle Big Data Appliance using Oracle Enterprise Manager:

1. Download and install the plug-in. See *Oracle Enterprise Manager System Monitoring Plug-in Installation Guide for Oracle Big Data Appliance*.
2. Log in to Oracle Enterprise Manager as a privileged user.
3. From the Targets menu, choose **Big Data Appliance** to view the Big Data page. You can see the overall status of the targets already discovered by Oracle Enterprise Manager.
4. Select a target cluster to view its detail pages.
5. Expand the target navigation tree to display the components. Information is available at all levels.
6. Select a component in the tree to display its home page.
7. To change the display, choose an item from the drop-down menu at the top left of the main display area.

> **See Also:** *Oracle Enterprise Manager System Monitoring Plug-in Installation Guide for Oracle Big Data Appliance* for installation instructions and use cases.

Using the Enterprise Manager Command-Line Interface

The Enterprise Manager command-line interface (`emcli`) is installed on Oracle Big Data Appliance along with all the other software. It provides the same functionality as the web interface. You must provide credentials to connect to Oracle Management Server.

To get help, enter `emcli help`.

> **See Also:** *Oracle Enterprise Manager Command Line Interface Guide*

Managing CDH Operations Using Cloudera Manager

Cloudera Manager is installed on Oracle Big Data Appliance to help you with Cloudera's Distribution including Apache Hadoop (CDH) operations. Cloudera Manager provides a single administrative interface to all Oracle Big Data Appliance servers configured as part of the Hadoop cluster.

Cloudera Manager simplifies the performance of these administrative tasks:

- Monitor jobs and services
- Start and stop services
- Manage security and Kerberos credentials
- Monitor user activity
- Monitor the health of the system
- Monitor performance metrics
- Track hardware use (disk, CPU, and RAM)

Cloudera Manager runs on the JobTracker node (node03) and is available on port 7180.

To use Cloudera Manager:

1. Open a browser and enter a URL like the following:

   `http://bda1node03.example.com:7180`

   In this example, `bda1` is the name of the appliance, `node03` is the name of the server, `example.com` is the domain, and `7180` is the default port number for Cloudera Manager.

2. Log in with a user name and password for Cloudera Manager. Only a user with administrative privileges can change the settings. Other Cloudera Manager users can view the status of Oracle Big Data Appliance.

   See Also: *Cloudera Manager Monitoring and Diagnostics Guide* at

   http://www.cloudera.com/content/cloudera-content/cloudera-docs/CM4Ent/latest/Cloudera-Manager-Administration-Guide/Cloudera-Manager-Administration-Guide.html#../Cloudera-Manager-Diagnostics-Guide/Cloudera-Manager-Diagnostics-Guide.html

   or click **Help** on the Cloudera Manager Help menu

Monitoring the Status of Oracle Big Data Appliance

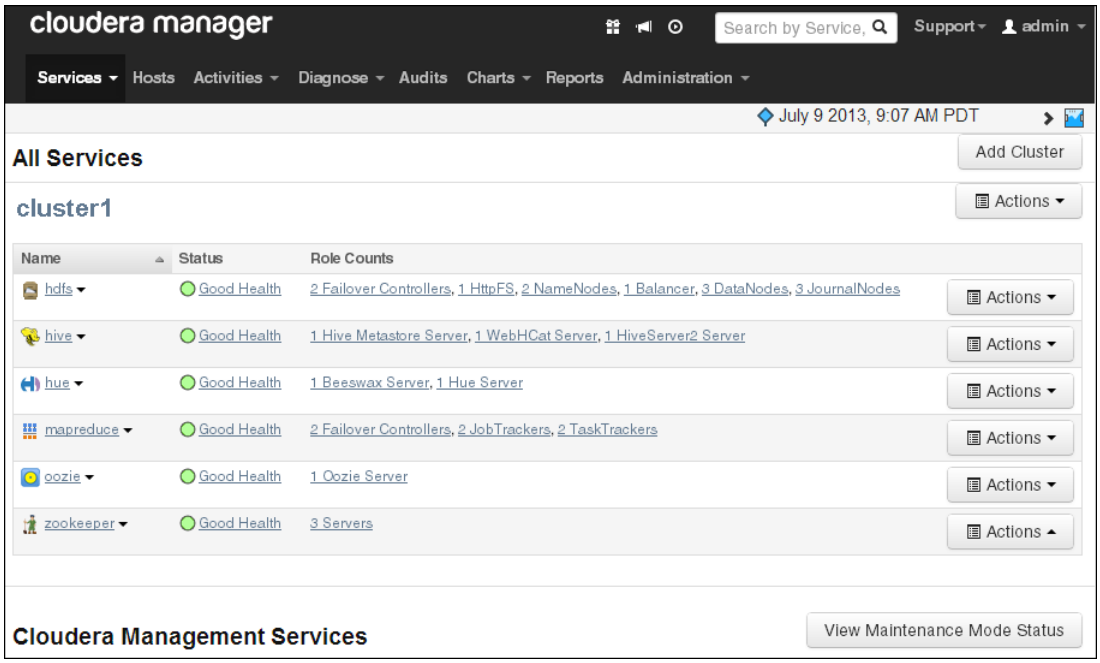
In Cloudera Manager, you can choose any of the following pages from the menu bar across the top of the display:

- **Services**: Monitors the status and health of services running on Oracle Big Data Appliance. Click the name of a service to drill down to additional information.
- **Hosts**: Monitors the health, disk usage, load, physical memory, swap space, and other statistics for all servers.
- **Activities**: Monitors all MapReduce jobs running in the selected time period.
- **Logs**: Collects historical information about the systems and services. You can search for a particular phrase for a selected server, service, and time period. You can also select the minimum severity level of the logged messages included in the search: TRACE, DEBUG, INFO, WARN, ERROR, or FATAL.

- **Events**: Records a change in state and other noteworthy occurrences. You can search for one or more keywords for a selected server, service, and time period. You can also select the event type: Audit Event, Activity Event, Health Check, or Log Message.
- **Charts**: Displays metrics from the Cloudera Manager time-series data store. You can choose from a variety of chart types, such as line and bar.
- **Reports**: Generates reports on demand for disk and MapReduce use.
- **Audits**: Displays the audit history log for a selected time range. You can filter the results by user name, service, or other criteria, and download the log as a CSV file.

Figure 2–2 shows the opening display of Cloudera Manager, which is the Services page.

Figure 2–2 Cloudera Manager Services Page



Performing Administrative Tasks

As a Cloudera Manager administrator, you can change various properties for monitoring the health and use of Oracle Big Data Appliance, add users, and set up Kerberos security.

To access Cloudera Manager Administration:

1. Log in to Cloudera Manager with administrative privileges.
2. Click the Administration (gear) icon at the top right of the page.

Managing Services With Cloudera Manager

Cloudera Manager provides the interface for managing these services:

- HDFS
- Hive
- Hue

- MapReduce
- Oozie
- ZooKeeper

You can use Cloudera Manager to change the configuration of these services, stop, and restart them.

> **Note:** Manual edits to Linux service scripts or Hadoop configuration files do not affect these services. You must manage and configure them using Cloudera Manager.

Using Hadoop Monitoring Utilities

Users can monitor MapReduce jobs without providing a Cloudera Manager user name and password.

Monitoring the JobTracker

Hadoop Map/Reduce Administration monitors the **JobTracker**, which runs on port 50030 of the JobTracker node (node03) on Oracle Big Data Appliance.

To monitor the JobTracker:

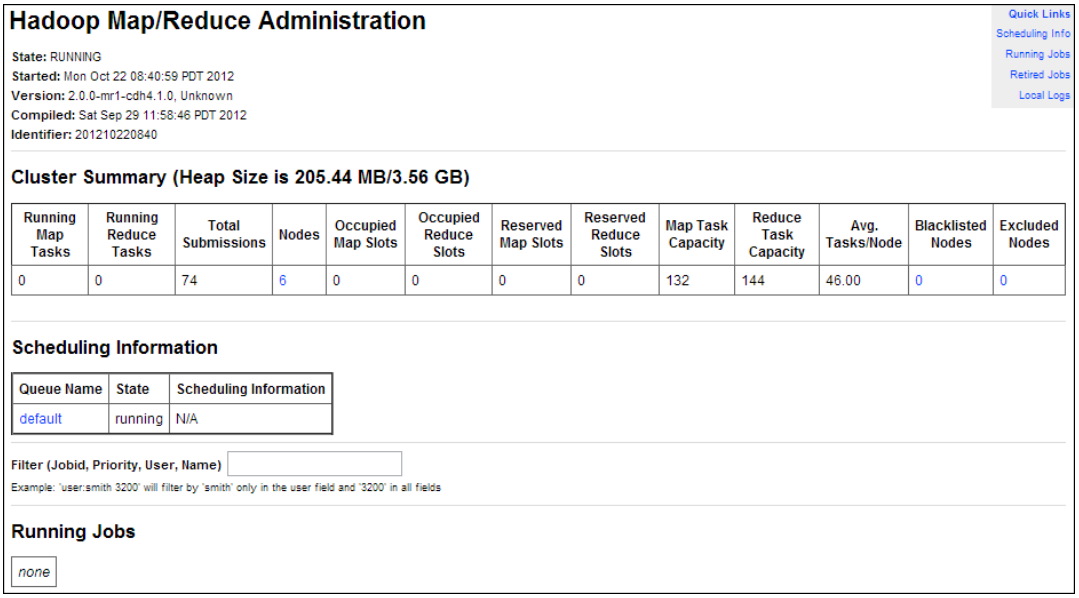
- Open a browser and enter a URL like the following:

  ```
  http://bda1node03.example.com:50030
  ```

  In this example, `bda1` is the name of the appliance, `node03` is the name of the server, and `50030` is the default port number for Hadoop Map/Reduce Administration.

Figure 2–3 shows part of a Hadoop Map/Reduce Administration display.

Figure 2–3 Hadoop Map/Reduce Administration



Monitoring the TaskTracker

The Task Tracker Status interface monitors the **TaskTracker** on a single node. It is available on port 50060 of all noncritical nodes (node04 to node18) in Oracle Big Data Appliance. On six-node clusters, the TaskTracker also runs on node01 and node02.

To monitor a TaskTracker:

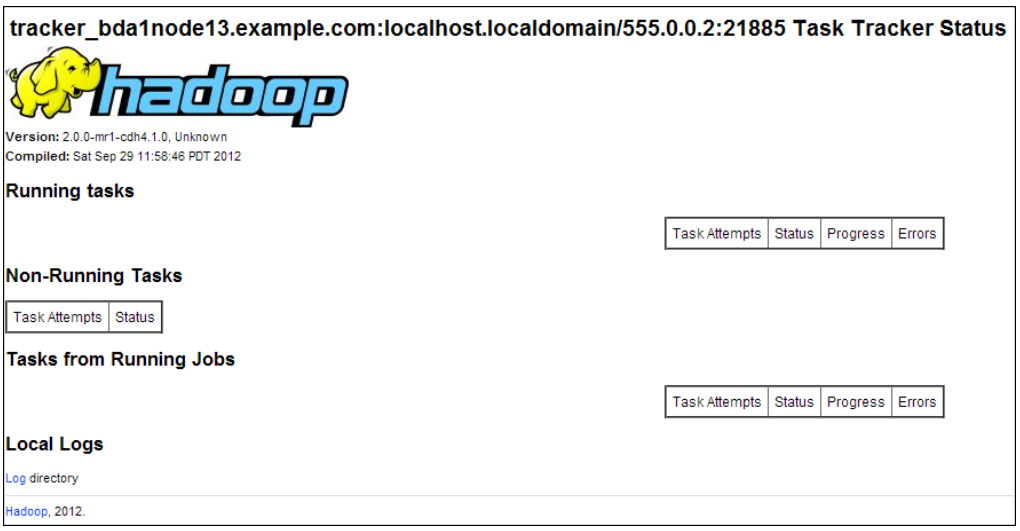
- Open a browser and enter the URL for a particular node like the following:

  ```
  http://bda1node13.example.com:50060
  ```

  In this example, `bda1` is the name of the rack, `node13` is the name of the server, and `50060` is the default port number for the Task Tracker Status interface.

Figure 2–4 shows the Task Tracker Status interface.

Figure 2–4 Task Tracker Status Interface



Using Hue to Interact With Hadoop

Hue runs in a browser and provides an easy-to-use interface to several applications to support interaction with Hadoop and HDFS. You can use Hue to perform any of the following tasks:

- Query Hive data stores
- Create, load, and delete Hive tables
- Work with HDFS files and directories
- Create, submit, and monitor MapReduce jobs
- Monitor MapReduce jobs
- Create, edit, and submit workflows using the Oozie dashboard
- Manage users and groups

Hue runs on port 8888 of the JobTracker node (node03).

To use Hue:

1. Open Hue in a browser using an address like the one in this example:

   ```
   http://bda1node03.example.com:8888
   ```

In this example, `bda1` is the cluster name, `node03` is the server name, and `example.com` is the domain.

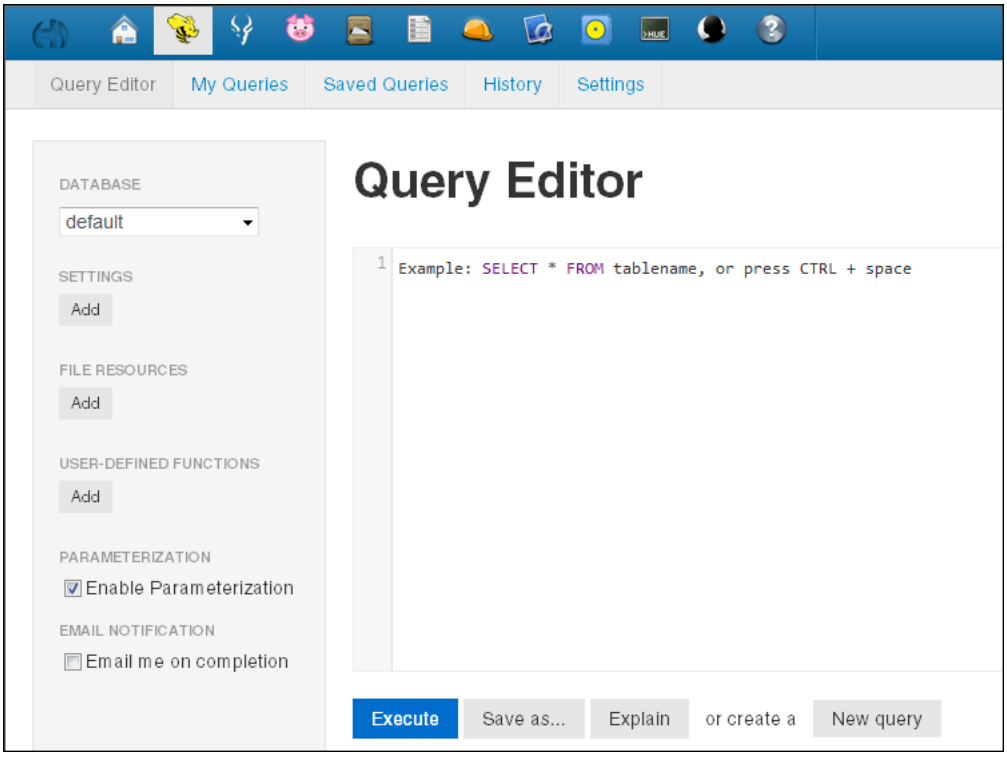
2. Log in with your Hue credentials.

   Oracle Big Data Appliance is not configured initially with any Hue user accounts. The first user who connects to Hue can log in with any user name and password, and automatically becomes an administrator. This user can create other user and administrator accounts.

3. Use the icons across the top to open a utility.

Figure 2–5 shows the Beeswax Query Editor for entering Hive queries.

Figure 2–5 Beeswax Query Editor



See Also: *Hue Installation Guide* for information about using Hue, which is already installed and configured on Oracle Big Data Appliance, at

`http://www.cloudera.com/content/cloudera-content/cloudera-docs/CDH4/latest/Hue-2-User-Guide/Hue-2-User-Guide.html`

About the Oracle Big Data Appliance Software

The following sections identify the software installed on Oracle Big Data Appliance and where it runs in the rack. Some components operate with Oracle Database 11.2.0.2 and later releases.

Software Components

These software components are installed on all 18 servers in Oracle Big Data Appliance Rack. Oracle Linux, required drivers, firmware, and hardware verification

utilities are factory installed. All other software is installed on site using the Mammoth Utility. The optional software components may not be configured in your installation.

> **Note:** You do not need to install additional software on Oracle Big Data Appliance. Doing so may result in a loss of warranty and support. See the *Oracle Big Data Appliance Owner's Guide*.

Base image software:

- Oracle Linux 5.8
- Java **HotSpot** Virtual Machine 6 Update 51
- **Oracle R Distribution** 2.15.1
- **MySQL Server** 5.5.17 Advanced Edition
- Puppet, firmware, utilities

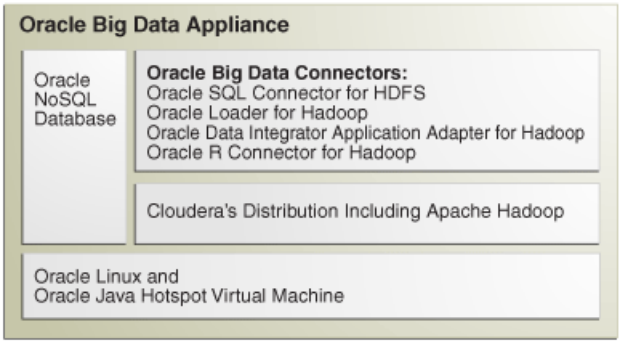
Mammoth installation:

- Cloudera's Distribution including Apache Hadoop Release 4 Update 3 (4.3)
- Cloudera Manager Enterprise 4.6.3
- **Oracle Database Instant Client** 11.2.0.3
- Oracle NoSQL Database Community Edition or Enterprise Edition 11*g* Release 2.0 (optional)
- Oracle Big Data Connectors 2.2 (optional):
  - Oracle SQL Connector for Hadoop Distributed File System (HDFS)
  - Oracle Loader for Hadoop
  - Oracle Data Integrator Agent 11.1.1.6.0
  - Oracle R Connector for Hadoop

See Also: *Oracle Big Data Appliance Owner's Guide* for information about the Mammoth Utility

Figure 2–6 shows the relationships among the major components.

Figure 2–6 Major Software Components of Oracle Big Data Appliance



Logical Disk Layout

Each server has 12 disks. The critical operating system is stored on disks 1 and 2.

Table 2–1 describes how the disks are partitioned.

Table 2–1 Logical Disk Layout

Disk	Description
1 to 2	150 gigabytes (GB) physical and logical partition, mirrored to create two copies, with the Linux operating system, all installed software, NameNode data, and MySQL Database data. The NameNode and MySQL Database data are replicated on two servers for a total of four copies. 2.8 terabytes (TB) HDFS data partition
3 to 12	Single HDFS or Oracle NoSQL Database data partition

About the CDH Software Services

This section contains the following topics:

- Monitoring the CDH Services
- Where Do the CDH Services Run?
- Automatic Failover of the NameNode
- Unconfigured Software

Monitoring the CDH Services

You can use Cloudera Manager to monitor the CDH services on Oracle Big Data Appliance.

To monitor the services:

1. In Cloudera Manager, click the **Services** tab at the top of the page to display the Services page.
2. Click the name of a service to see its detail pages. The service opens on the Status page.
3. Click the link to the page that you want to view: Status, Instances, Commands, Configuration, or Audits.

Where Do the CDH Services Run?

All services are installed on all nodes in a CDH cluster, but individual services run only on designated nodes. There are slight variations in the location of the services depending on the configuration of the cluster.

Service Locations on a Single Rack

Table 2–2 identifies the services in CDH clusters configured within a single rack, including starter racks and clusters with six nodes. Node01 is the first server in the cluster (server 1, 7, or 10), and node*xx* is the last server in the cluster (server 6, 9, 12, or 18).

Table 2–2 Service Locations for One or More CDH Clusters in a Single Rack

Node01	Node02	Node03	Node04	Node05 to *nn*
Balancer				
			Hive, Hue, Oozie	
Cloudera Manager Agent	Cloudera Manager Agent	Cloudera Manager Agent	Cloudera Manager Agent	Cloudera Manager Agent
		Cloudera Manager Server		
DataNode	DataNode	DataNode	DataNode	DataNode
Failover Controller	Failover Controller	Failover Controller	Failover Controller	
JournalNode	JournalNode	JournalNode		
	MySQL Backup	MySQL Primary		
NameNode 1	NameNode 2			
			Oracle Data Integrator Agent	
Puppet	Puppet	Puppet	Puppet	Puppet
Puppet Master				
		JobTracker 1	JobTracker 2	
Task Tracker[1]	Task Tracker[1]	TaskTracker	TaskTracker	TaskTracker
ZooKeeper Server	ZooKeeper Server	ZooKeeper Server		

[1] Starter racks and six-node clusters only

Service Locations in Multirack Clusters

When multiple racks are configured as a single CDH cluster, some critical services are moved to the first server of the second rack.

Critical services on the first server of the second rack:

- Balancer
- Failover Controller
- Journal Node
- NameNode 1
- ZooKeeper Server

The DataNode, Cloudera Manager agent, and Puppet services also run on this server.

Table 2–3 identify the location of services on the first rack of a multirack cluster.

Table 2–3 Service Locations in the First Rack of a Multirack CDH Cluster

Node01	Node02	Node03	Node04	Node05 to *nn*[1]
Cloudera Manager Agent	Cloudera Manager Agent	Cloudera Manager Agent	Cloudera Manager Agent	Cloudera Manager Agent
		Cloudera Manager Server		
DataNode	DataNode	DataNode	DataNode	DataNode
	Failover Controller	Failover Controller	Failover Controller	

Table 2–3 (Cont.) Service Locations in the First Rack of a Multirack CDH Cluster

Node01	Node02	Node03	Node04	Node05 to *nn*[1]
			Hive, Hue, Oozie	
	JournalNode	JournalNode		
	MySQL Backup	MySQL Primary		
	NameNode 2			
			Oracle Data Integrator agent	
Puppet	Puppet	Puppet	Puppet	Puppet
Puppet Master				
		JobTracker 1	JobTracker 2	
TaskTracker		TaskTracker	TaskTracker	TaskTracker
	ZooKeeper Server	ZooKeeper Server		

[1] *nn* includes the servers in additional racks.

Automatic Failover of the NameNode

The NameNode is the most critical process because it keeps track of the location of all data. Without a healthy NameNode, the entire cluster fails. Apache Hadoop v0.20.2 and earlier are vulnerable to failure because they have a single name node.

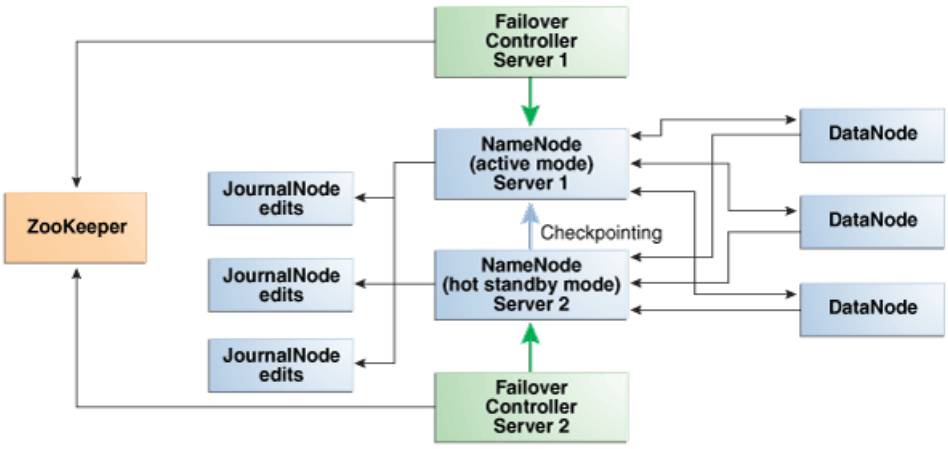
Cloudera's Distribution including Apache Hadoop Version 4 (CDH4) reduces this vulnerability by maintaining redundant NameNodes. The data is replicated during normal operation as follows:

- CDH maintains redundant NameNodes on the first two nodes. One of the NameNodes is in active mode, and the other NameNode is in hot standby mode. If the active NameNode fails, then the role of active NameNode automatically fails over to the standby NameNode.
- The NameNode data is written to a mirrored partition so that the loss of a single disk can be tolerated. This mirroring is done at the factory as part of the operating system installation.
- The active NameNode records all changes to the file system metadata in at least two JournalNode processes, which the standby NameNode reads. There are three JournalNodes, which run on the first three nodes of each cluster.
- The changes recorded in the journals are periodically consolidated into a single fsimage file in a process called checkpointing.

> **Note:** Oracle Big Data Appliance 2.0 and later releases do not support the use of an external NFS filer for backups and do not use NameNode federation.

Figure 2–7 shows the relationships among the processes that support automatic failover of the NameNode.

Figure 2–7 Automatic Failover of the NameNode on Oracle Big Data Appliance



Automatic Failover of the JobTracker

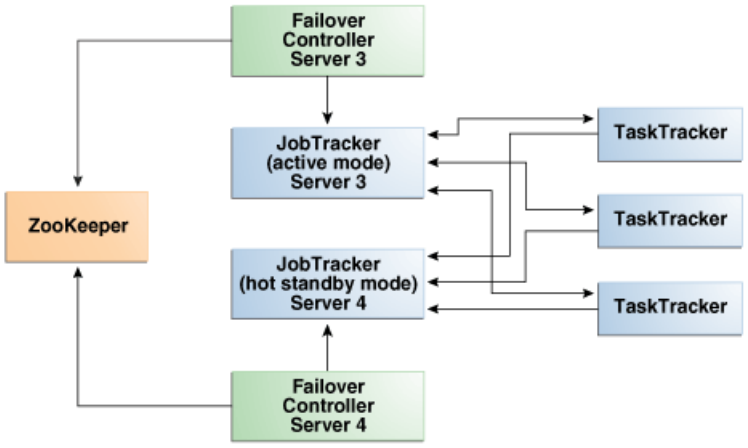
The JobTracker distributes MapReduce tasks across the cluster. Like the NameNode, the JobTracker is a critical point of failure for the node. If the JobTracker fails, then all jobs stop running.

Oracle Big Data Appliance 2.2 and later releases support JobTracker High Available in CDH4 to reduce this vulnerability.

CDH maintains redundant JobTracker services on node03 and -04. One of the services is in active mode, and the other service is in hot standby mode. Failover controllers on the two nodes monitor the health of the services. If the active service fails, then the role of active JobTracker automatically fails over to the standby service.

Figure 2–7 shows the relationships among the processes that support automatic failover of the NameNode.

Figure 2–8 Automatic Failover of the JobTracker on Oracle Big Data Appliance



Unconfigured Software

The RPM installation files for the following tools are available on Oracle Big Data Appliance. Do not download them from the Cloudera website. However, you must install and configure them.

- Flume
- HBase
- Mahout
- Sqoop
- Whirr

You can find the RPM files on the first server of each cluster in /opt/oracle/BDAMammoth/bdarepo/RPMS/noarch.

> **See Also:** *CDH4 Installation and Configuration Guide* for configuration procedures at
>
> http://www.cloudera.com/content/cloudera-content/cloudera-docs/CDH4/latest/CDH4-Installation-Guide/CDH4-Installation-Guide.html

Map and Reduce Resource Configuration

Each node in a cluster has a maximum number of map and reduce tasks that are allowed to run simultaneously. Table 2–4 shows the default configuration of resources for the MapReduce service on Oracle Big Data Appliance X3-2.

Table 2–4 Maximum Map and Reduce Tasks on Oracle Big Data Appliance X3-2

Node	6-Node Cluster	Larger Clusters[1]
Node01 and Node02	14 map 8 reduce	None
Node03 and Node04	10 map 6 reduce	10 map 6 reduce
Node05 to Node*nn*	20 map 13 reduce	20 map 13 reduce

[1] 9 or more nodes

Table 2–5 shows the default configuration of resources for the MapReduce service on Oracle Big Data Appliance Sun Fire X4270 M2-based racks.

Table 2–5 Maximum Map and Reduce Tasks on Sun Fire X4270 M2-Based Racks

Node	6-Node Cluster	Larger Clusters[1]
Node01 and Node02	10 map 6 reduce	None
Node03 and Node04	7 map 4 reduce	7 map 4 reduce
Node05 to Node*nn*	15 map 10 reduce	15 map 10 reduce

[1] 9 or more nodes

Configuring HBase

HBase is an open-source, column-oriented database provided with CDH. HBase is not configured automatically on Oracle Big Data Appliance. You must set up and configure HBase before you can access it from an HBase client on another system.

To create an HBase service:

1. Open Cloudera Manager in a browser, using a URL like the following:

   ```
   http://bda1node03.example.com:7180
   ```

   In this example, `bda1` is the name of the appliance, `node03` is the name of the server, `example.com` is the domain, and `7180` is the default port number for Cloudera Manager.
2. On the All Services page, click **Add a Service**.
3. Select HBase from the list of services, and then click **Continue**.
4. Select zookeeper, and then click **Continue**.
5. Click **Continue** on the host assignments page.
6. Click **Accept** on the review page.

HBase is now ready for you to configure.

To configure HBase on Oracle Big Data Appliance:

1. On the All Services page of Cloudera Manager, click **hbase1**.
2. On the hbase1 page, click **Configuration**.
3. In the Category pane on the left, select **Advanced** under Service-Wide.
4. In the right pane, locate the HBase Service Configuration Safety Valve for hbase-site.xml property and click the Value cell.
5. Enter the following XML property descriptions:

   ```
   <property>
      <name>hbase.master.ipc.address</name>
      <value>0.0.0.0</value>
   </property>
   <property>
      <name>hbase.regionserver.ipc.address</name>
      <value>0.0.0.0</value>
   </property>
   ```

6. Click the **Save Changes** button.
7. From the Actions menu, select either **Start** or **Restart**, depending on the current status of the HBase server.
8. Log out of Cloudera Manager.

Effects of Hardware on Software Availability

The effects of a server failure vary depending on the server's function within the CDH cluster. Oracle Big Data Appliance servers are more robust than commodity hardware, so you should experience fewer hardware failures. This section highlights the most important services that run on the various servers of the primary rack. For a full list, see "Where Do the CDH Services Run?" on page 2-9.

Note: In a multirack cluster, some critical services run on the first server of the second rack. See "Service Locations in Multirack Clusters" on page 2-10.

Critical and Noncritical Nodes

Critical nodes are required for the cluster to operate normally and provide all services to users. In contrast, the cluster continues to operate with no loss of service when a noncritical node fails.

On single-rack clusters, the critical services are installed initially on the first four nodes of the cluster. The remaining nodes (node05 up to node18) only run noncritical services. If a hardware failure occurs on one of the critical nodes, then the services can be moved to another, noncritical server. For example, if node02 fails, then you might move its critical services node05. Table 2–2 identifies the initial location of services for clusters that are configured on a single rack.

In a multirack cluster, some critical services run on the first server of the second rack. See "Where Do the CDH Services Run?" on page 2-9.

Moving a critical node requires that all clients be reconfigured with the address of the new node. The other alternative is to wait for the failed server to be repaired. You must weigh the loss of services against the inconvenience of reconfiguring the clients.

Table 2–6 Critical Service Locations

Node Name	Initial Node Position	Critical Functions
First NameNode	Node01	ZooKeeper[1], first NameNode[1], failover controller[1], balancer[1], puppet master
Second NameNode	Node02	ZooKeeper, second NameNode, failover controller, MySQL backup server
First JobTracker Node	Node03	ZooKeeper, first JobTracker, failover controller, Cloudera Manager server, MySQL primary server
Second JobTracker Node	Node04	Second JobTracker, failover controller, Oracle Data Integrator agent, Hue, Hive, Oozie

[1] In multirack clusters, this service is initially installed on the first server of the second rack.

First Namenode

One instance of the NameNode initially runs on node01. If this node fails or goes offline (such as a reboot), then the second NameNode (node02) automatically takes over to maintain the normal activities of the cluster.

Alternatively, if the second NameNode is already active, it continues without a backup. With only one NameNode, the cluster is vulnerable to failure. The cluster has lost the redundancy needed for automatic failover.

The puppet master also runs on this node. The Mammoth utilities use Puppet, and so you cannot install or reinstall the software if, for example, you must replace a disk drive elsewhere in the rack.

Note: In multirack clusters, the NameNode service is installed on the first server of the *second* rack.

Second NameNode

One instance of the NameNode initially runs on node02. If this node fails, then the function of the NameNode either fails over to the first NameNode (node01) or continues there without a backup. However, the cluster has lost the redundancy needed for automatic failover if the first NameNode also fails.

The MySQL backup database also runs on this node. MySQL Server continues to run, although there is no backup of the master database.

First JobTracker

One instance of the JobTracker initially runs on node03. If this node fails or goes offline (such as a reboot), then the second JobTracker (node04) automatically takes over to distribute MapReduce tasks to specific nodes across the cluster.

Alternatively, if the second JobTracker is already active, it continues without a backup. With only one JobTracker, the cluster is vulnerable to failure. The cluster has lost the redundancy needed for automatic failover.

These services are also disrupted:

- **Cloudera Manager**: This tool provides central management for the entire CDH cluster. Without this tool, you can still monitor activities using the utilities described in "Using Hadoop Monitoring Utilities" on page 2-5.
- **MySQL Master Database**: Cloudera Manager, Oracle Data Integrator, Hive, and Oozie use MySQL Database. The data is replicated automatically, but you cannot access it when the master database server is down.

Second JobTracker

One instance of the JobTracker initially runs on node04. If this node fails, then the function of the JobTracker either fails over to the first JobTracker (node03) or continues there without a backup. However, the cluster has lost the redundancy needed for automatic failover if the first JobTracker also fails.

These services are also disrupted:

- **Oracle Data Integrator**: This service supports Oracle Data Integrator Application Adapter for Hadoop. You cannot use this connector when the JobTracker node is down.
- **Hive**: Hive provides a SQL-like interface to data that is stored in HDFS. Most of the Oracle Big Data Connectors can access Hive tables, which are not available if this node fails.
- **Hue**: This administrative tool is not available when the JobTracker node is down.
- **Oozie**: This workflow and coordination service runs on the JobTracker node, and is unavailable when the node is down.

Noncritical Nodes

The noncritical nodes (node05 to node18) are optional in that Oracle Big Data Appliance continues to operate with no loss of service if a failure occurs. The NameNode automatically replicates the lost data to maintain three copies at all times. MapReduce jobs execute on copies of the data stored elsewhere in the cluster. The only loss is in computational power, because there are fewer servers on which to distribute the work.

Collecting Diagnostic Information for Oracle Customer Support

If you need help from Oracle Support to troubleshoot CDH issues, then you should first collect diagnostic information using the `bdadiag` utility with the `cm` option.

To collect diagnostic information:

1. Log in to an Oracle Big Data Appliance server as `root`.
2. Run `bdadiag` with at least the `cm` option. You can include additional options on the command line as appropriate. See the *Oracle Big Data Appliance Owner's Guide* for a complete description of the `bdadiag` syntax.

   ```
   # bdadiag cm
   ```

   The command output identifies the name and the location of the diagnostic file.
3. Go to My Oracle Support at `http://support.oracle.com`.
4. Open a Service Request (SR) if you have not already done so.
5. Upload the bz2 file into the SR. If the file is too large, then upload it to `sftp.oracle.com`, as described in the next procedure.

To upload the diagnostics to ftp.oracle.com:

1. Open an SFTP client and connect to `sftp.oracle.com`. Specify port 2021 and remote directory /support/incoming/*target*, where *target* is the folder name given to you by Oracle Support.

   See Example 2–1 if you are using a command-line SFTP client.
2. Log in with your Oracle Single Sign-on account and password.
3. Upload the diagnostic file to the new directory.
4. Update the SR with the full path and the file name.

Example 2–1 shows the commands to upload the diagnostics using the SFTP command interface.

Example 2–1 Uploading Diagnostics Using FTP

```
$ sftp -o port=2021 my.user.name@oracle.com@sftp.oracle.com
Connecting to sftp.oracle.com...
     .
     .
     .
Enter password for my.user.name@oracle.com
Password: password
sftp> cd support/incoming/SR123456
sftp> put /tmp/bdadiag_bda1node01_1216FM5497_2013_07_18_07_33.tar.bz2
Uploading bdadiag_bda1node01_1216FM5497_2013_07_18_07_33.tar.bz2 to
//support/incoming/create_table.sql
bdadiag_bda1node01_1216FM5497_2013_07_18_07_33.tar.bz2 to support/incoming/create_
table.sql                  100%  311     0.3KB/s   00:00
sftp> exit
$
```

See Also: My Oracle Support Note 549180.1 at

`http://support.oracle.com`

Security on Oracle Big Data Appliance

You can take precautions to prevent unauthorized use of the software and data on Oracle Big Data Appliance.

This section contains these topics:

- About Predefined Users and Groups
- Port Numbers Used on Oracle Big Data Appliance
- About CDH Security Using Kerberos
- About Puppet Security

About Predefined Users and Groups

Every open-source package installed on Oracle Big Data Appliance creates one or more users and groups. Most of these users do not have login privileges, shells, or home directories. They are used by daemons and are not intended as an interface for individual users. For example, Hadoop operates as the `hdfs` user, MapReduce operates as `mapred`, and Hive operates as `hive`.

You can use the `oracle` identity to run Hadoop and Hive jobs immediately after the Oracle Big Data Appliance software is installed. This user account has login privileges, a shell, and a home directory.

Oracle NoSQL Database and Oracle Data Integrator run as the `oracle` user. Its primary group is `oinstall`.

Note: Do not delete or modify the users created during installation, because they are required for the software to operate.

Table 2–7 identifies the operating system users and groups that are created automatically during installation of Oracle Big Data Appliance software for use by CDH components and other software packages.

Table 2–7 Operating System Users and Groups

User Name	Group	Used By	Login Rights
`flume`	`flume`	**Flume** parent and nodes	No
`hbase`	`hbase`	**HBase** processes	No
`hdfs`	`hadoop`	**NameNode**, **DataNode**	No
`hive`	`hive`	Hive metastore and server processes	No
`hue`	`hue`	**Hue** processes	No
`mapred`	`hadoop`	JobTracker, TaskTracker, **Hive Thrift** daemon	Yes
`mysql`	`mysql`	MySQL server	Yes
`oozie`	`oozie`	**Oozie** server	No
`oracle`	`dba`, `oinstall`	Oracle NoSQL Database, Oracle Loader for Hadoop, Oracle Data Integrator, and the Oracle DBA	Yes
`puppet`	`puppet`	Puppet parent (puppet nodes run as `root`)	No
`sqoop`	`sqoop`	**Sqoop** metastore	No

Table 2–7 (Cont.) Operating System Users and Groups

User Name	Group	Used By	Login Rights
svctag		Auto Service Request	No
zookeeper	zookeeper	**ZooKeeper** processes	No

Port Numbers Used on Oracle Big Data Appliance

Table 2–8 identifies the port numbers that might be used in addition to those used by CDH.

To view the ports used on a particular server:

1. In Cloudera Manager, click the **Hosts** tab at the top of the page to display the Hosts page.
2. In the Name column, click a server link to see its detail page.
3. Scroll down to the Ports section.

See Also: For the full list of CDH port numbers, go to the Cloudera website at

http://www.cloudera.com/content/cloudera-content/cloudera-docs/CDH4/4.2.0/CDH4-Installation-Guide/cdh4ig_topic_10.html#../CDH4-Installation-Guide/cdh4ig_topic_9.html

Table 2–8 Oracle Big Data Appliance Port Numbers

Service	Port
Automated Service Monitor (ASM)	30920
HBase master service (node01)	60010
MySQL Database	3306
Oracle Data Integrator Agent	20910
Oracle NoSQL Database administration	5001
Oracle NoSQL Database processes	5010 to 5020
Oracle NoSQL Database registration	5000
Port map	111
Puppet master service	8140
Puppet node service	8139
rpc.statd	668
ssh	22
xinetd (service tag)	6481

About CDH Security Using Kerberos

Apache Hadoop is not an inherently secure system. It is protected only by network security. After a connection is established, a client has full access to the system.

Cloudera's Distribution including Apache Hadoop (CDH) supports Kerberos network authentication protocol to prevent malicious impersonation. You must install and configure Kerberos and set up a Kerberos Key Distribution Center and realm. Then you configure various components of CDH to use Kerberos.

CDH provides these securities when configured to use Kerberos:

- The CDH master nodes, NameNode, and JobTracker resolve the group name so that users cannot manipulate their group memberships.
- Map tasks run under the identity of the user who submitted the job.
- Authorization mechanisms in HDFS and MapReduce help control user access to data.

See Also: `http://oracle.cloudera.com` for these manuals:

- *CDH4 Security Guide*
- *Configuring Hadoop Security with Cloudera Manager*
- *Configuring TLS Security for Cloudera Manager*

About Puppet Security

The puppet node service (`puppetd`) runs continuously as `root` on all servers. It listens on port 8139 for "kick" requests, which trigger it to request updates from the puppet master. It does not receive updates on this port.

The puppet master service (`puppetmasterd`) runs continuously as the puppet user on the first server of the primary Oracle Big Data Appliance rack. It listens on port 8140 for requests to push updates to puppet nodes.

The puppet nodes generate and send certificates to the puppet master to register initially during installation of the software. For updates to the software, the puppet master signals ("kicks") the puppet nodes, which then request all configuration changes from the puppet master node that they are registered with.

The puppet master sends updates only to puppet nodes that have known, valid certificates. Puppet nodes only accept updates from the puppet master host name they initially registered with. Because Oracle Big Data Appliance uses an internal network for communication within the rack, the puppet master host name resolves using `/etc/hosts` to an internal, private IP address.

3

Supporting User Access to Oracle Big Data Appliance

This chapter describes how you can support users who are running MapReduce jobs on Oracle Big Data Appliance or using Oracle Big Data Connectors. It contains these sections:

- Providing Remote Client Access to CDH
- Managing User Accounts
- Recovering Deleted Files

Providing Remote Client Access to CDH

Oracle Big Data Appliance supports full local access to all commands and utilities in Cloudera's Distribution including Apache Hadoop (CDH).

You can use a browser on any computer that has access to the client network of Oracle Big Data Appliance to access Cloudera Manager, Hadoop Map/Reduce Administration, the Hadoop Task Tracker interface, and other browser-based Hadoop tools.

To issue Hadoop commands remotely, however, you must connect from a system configured as a CDH client with access to the Oracle Big Data Appliance client network. This section explains how to set up a computer so that you can access HDFS and submit MapReduce jobs on Oracle Big Data Appliance.

See Also: My Oracle Support ID 1506203.1

Prerequisites

Ensure that you have met the following prerequisites:

- You must have these access privileges:
  - Sudo access to the client system
  - Login access to Cloudera Manager

  If you do not have these privileges, then contact your system administrator for help.
- The client system must run an operating system that Cloudera supports for CDH4. For the list of supported operating systems, see "Before You Install CDH4 on a Cluster" in the *Cloudera CDH4 Installation Guide* at

http://ccp.cloudera.com/display/CDH4DOC/Before+You+Install+CDH4+on+a+Cluster

- The client system must run the same version of Oracle JDK as Oracle Big Data Appliance. CDH4 requires Oracle JDK 1.6.

Installing CDH on Oracle Exadata Database Machine

When you use Oracle Exadata Database Machine as the client, you can use the RPM files on Oracle Big Data Appliance, because both engineered systems use the same operating system (Oracle Linux 5.*x*). Copying the files across the local network is faster than downloading them from the Cloudera website.

Note: In the following steps, replace *version_number* with the missing portion of the file name, such as 2.2.0+189-1.cdh4.2.0.p0.8.el5.

To install a CDH client on Oracle Exadata Database Machine:

1. Log into an Exadata database server.
2. Verify that Hadoop is not installed on your Exadata system:

   ```
   rpm -qa | grep hadoop
   ```

3. If the `rpm` command returns a value, then remove the existing Hadoop software:

   ```
   rpm -e hadoop_rpm
   ```

4. Copy the following Linux RPMs to the database server from the first server of Oracle Big Data Appliance. The RPMs are located in the /opt/oracle/BDAMammoth/bdarepo/RPMS/x86_64 directory.
   - ed-*version_number*.x86_64.rpm
   - m4-*version_number*.x86_64.rpm
   - nc-*version_number*.x86_64.rpm
   - redhat-lsb-*version_number*.x86_64.rpm
5. Install the Oracle Linux RPMs from Step 4 on all database nodes. For example:

   ```
   sudo yum --nogpgcheck localinstall ed-0.2-39.el5_2.x86_64.rpm
   sudo yum --nogpgcheck localinstall m4-1.4.5-3.el5.1.x86_64.rpm
   sudo yum --nogpgcheck localinstall nc-1.84-10.fc6.x86_64.rpm
   sudo yum --nogpgcheck localinstall redhat-lsb-4.0-2.1.4.0.2.el5.x86_64.rpm
   ```

   Be sure to install the Oracle Linux RPMs before installing the CDH RPMs.
6. Copy the following CDH RPMs from the /opt/oracle/BDAMammoth/bdarepo/RPMS/noarch directory.
   - bigtop-utils-*version_number*.noarch.rpm
   - zookeeper-*version_number*.noarch.rpm
7. Copy the following CDH RPMs from the /opt/oracle/BDAMammoth/bdarepo/RPMS/x86_64 directory.
   - hadoop-*version_number*.x86_64.rpm
   - bigtop-jsvc-*version_number*.x86_64.rpm
   - hadoop-hdfs-*version_number*.x86_64.rpm

- hadoop-0.20-mapreduce-*version_number*.x86_64.rpm
- hadoop-yarn-*version_number*.x86_64.rpm
- hadoop-mapreduce-*version_number*.x86_64.rpm
- hadoop-client-*version_number*.x86_64.rpm

8. Install the CDH RPMs in the exact order shown in Steps 6 and 7 on all database servers. For example:

```
rpm -ihv /bigtop-utils-0.4+502-1.cdh4.2.0.p0.12.el5.noarch.rpm
rpm -ihv zookeeper-3.4.5+14-1.cdh4.2.0.p0.12.el5.noarch.rpm
rpm -ihv hadoop-2.0.0+922-1.cdh4.2.0.p0.12.el5.x86_64.rpm
rpm -ihv bigtop-jsvc-1.0.10-1.cdh4.2.0.p0.13.el5.x86_64.rpm
rpm -ihv hadoop-hdfs-2.0.0+922-1.cdh4.2.0.p0.12.el5.x86_64.rpm
rpm -ihv hadoop-0.20-mapreduce-0.20.2+1341-1.cdh4.2.0.p0.21.el5.x86_64.rpm
rpm -ihv hadoop-yarn-2.0.0+922-1.cdh4.2.0.p0.12.el5.x86_64.rpm
rpm -ihv hadoop-mapreduce-2.0.0+922-1.cdh4.2.0.p0.12.el5.x86_64.rpm
rpm -ihv hadoop-client-2.0.0+922-1.cdh4.2.0.p0.12.el5.x86_64.rpm
```

9. Configure the CDH client. See "Configuring CDH" on page 3-3.

Installing a CDH Client on Any Supported Operating System

To install a CDH client on any operating system identified as supported by Cloudera, follow these instructions.

To install the CDH client software:

1. Follow the installation instructions for your operating system provided in the *Cloudera CDH4 Installation Guide* at

   http://ccp.cloudera.com/display/CDH4DOC/CDH4+Installation+Guide

   When you are done installing the Hadoop core and native packages, the system can act as a basic CDH client.

   Note: Be sure to install CDH4 Update 2 (CDH4u2) or a later version.

2. To provide support for other components, such as **Hive**, **Pig**, or **Oozie**, see the component installation instructions.
3. Configure the CDH client. See "Configuring CDH" on page 3-3.

Configuring CDH

After installing CDH, you must configure it for use with Oracle Big Data Appliance.

To configure the Hadoop client:

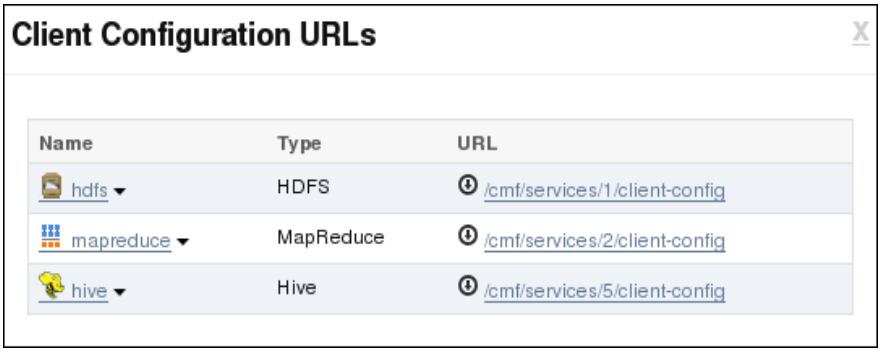
1. Open a browser on your client system and connect to Cloudera Manager. It runs on the JobTracker node (node03) and listens on port 7180, as shown in this example:

   ```
   http://bda1node03.example.com:7180
   ```

2. Log in as `admin`.
3. On the Services tab, open the Actions menu for the cluster, and then select **Client Configuration URLs**.

4. Click the MapReduce URL (/cmf/services/2/client-config) and download mapreduce-clientconfig.zip.

   The following figure shows the download page for the client configuration.



5. Log out of Cloudera Manager and navigate to the download directory.
6. Unzip mapreduce-clientconfig.zip into a permanent location on the client system.

```
$ unzip mapreduce-clientconfig.zip
Archive:  mapreduce-clientconfig.zip
  inflating: hadoop-conf/hadoop-env.sh
  inflating: hadoop-conf/core-site.xml
  inflating: hadoop-conf/hdfs-site.xml
  inflating: hadoop-conf/log4j.properties
  inflating: hadoop-conf/mapred-site.xml
```

   All files are stored in a subdirectory named hadoop-config.

7. Open hadoop-env.sh in a text editor and set `JAVA_HOME` to the correct location on your system:

```
export JAVA_HOME=full_directory_path
```

8. Delete the number sign (#) to uncomment the line, and then save the file.
9. Make a backup copy of the Hadoop configuration files:

```
# cp /full_path/hadoop-conf /full_path/hadoop-conf-bak
```

10. Overwrite the existing configuration files with the downloaded configuration files in Step 6.

```
# cd /full_path/hadoop-conf
# cp * /usr/lib/hadoop/conf
```

11. Verify that you can access HDFS on Oracle Big Data Appliance from the client, by entering a simple Hadoop file system command like the following:

```
$ hadoop fs -ls /user
Found 4 items
drwx------   - hdfs     supergroup          0 2013-01-16 13:50 /user/hdfs
drwxr-xr-x   - hive     supergroup          0 2013-01-16 12:58 /user/hive
drwxr-xr-x   - oozie    hadoop              0 2013-01-16 13:01 /user/oozie
drwxr-xr-x   - oracle   hadoop              0 2013-01-29 12:50 /user/oracle
```

   Check the output for HDFS users defined on Oracle Big Data Appliance, and not on the client system. You should see the same results as you would after entering the command directly on Oracle Big Data Appliance.

12. Validate the installation by submitting a MapReduce job. You must be logged in to the host computer under the same user name as your HDFS user name on Oracle Big Data Appliance.

    The following example calculates the value of *pi*:

```
$ hadoop jar
/usr/lib/hadoop-mapreduce/hadoop-mapreduce-examples-2.0.0-cdh4.2.0.jar pi 10
1000000
Number of Maps  = 10
Samples per Map = 1000000
Wrote input for Map #0
Wrote input for Map #1
     .
     .
     .
13/04/30 08:15:50 INFO mapred.JobClient:     BYTES_READ=240
Job Finished in 12.403 seconds
Estimated value of Pi is 3.14158440000000000000
```

13. Use Cloudera Manager to verify that the job ran on Oracle Big Data Appliance instead of the local system. Select **mapreduce** from the Activities menu for a list of jobs.

Figure 3–1 shows the job created by the previous example.

Figure 3–1 Monitoring a MapReduce Job in Cloudera Manager

Managing User Accounts

This section describes how to create users who can access HDFS, MapReduce, and Hive. It contains the following topics:

- Creating Hadoop Cluster Users
- Providing User Login Privileges (Optional)

Creating Hadoop Cluster Users

When creating additional user accounts, define them as follows:

- To run MapReduce jobs, users must be in the `hadoop` group.
- To create and modify tables in Hive, users must be in the `hive` group.

- To create Hue users, open Hue in a browser and click the User Admin icon. See "Using Hue to Interact With Hadoop" on page 2-6.

To create a Hadoop cluster user:

1. Open an ssh connection as the `root` user to a noncritical node (node04 to node18).
2. Create the user's home directory:

   ```
   # sudo -u hdfs hadoop fs -mkdir /user/user_name
   ```

   You use `sudo` because the HDFS super user is `hdfs` (not `root`).
3. Change the ownership of the directory:

   ```
   # sudo -u hdfs hadoop fs -chown user_name:hadoop /user/user_name
   ```

4. Verify that the directory is set up correctly:

   ```
   # hadoop fs -ls /user
   ```

5. Create the operating system user across all nodes in the cluster:

   ```
   # dcli useradd -G hadoop,hive[,group_name...] -m user_name
   ```

   In this syntax, replace *group_name* with an existing group and *user_name* with the new name.
6. Verify that the operating system user belongs to the correct groups:

   ```
   # dcli id user_name
   ```

7. Verify that the user's home directory was created on all nodes:

   ```
   # dcli ls /home | grep user_name
   ```

Example 3–1 creates a user named `jdoe` with a primary group of `hadoop` and an addition group of `hive`.

Example 3–1 Creating a Hadoop User

```
# sudo -u hdfs hadoop fs -mkdir /user/jdoe
# sudo -u hdfs hadoop fs -chown jdoe:hadoop /user/jdoe
# hadoop fs -ls /user
Found 5 items
drwx------   - hdfs     supergroup          0 2013-01-16 13:50 /user/hdfs
drwxr-xr-x   - hive     supergroup          0 2013-01-16 12:58 /user/hive
drwxr-xr-x   - jdoe     jdoe                0 2013-01-18 14:04 /user/jdoe
drwxr-xr-x   - oozie    hadoop              0 2013-01-16 13:01 /user/oozie
drwxr-xr-x   - oracle   hadoop              0 2013-01-16 13:01 /user/oracle
# dcli useradd -G hadoop,hive -m jdoe
# dcli id jdoe
bda1node01: uid=1001(jdoe) gid=1003(jdoe) groups=1003(jdoe),127(hive),123(hadoop)
bda1node02: uid=1001(jdoe) gid=1003(jdoe) groups=1003(jdoe),123(hadoop),127(hive)
bda1node03: uid=1001(jdoe) gid=1003(jdoe) groups=1003(jdoe),123(hadoop),127(hive)
     .
     .
     .
# dcli ls /home | grep jdoe
bda1node01: jdoe
bda1node02: jdoe
bda1node03: jdoe
```

Providing User Login Privileges (Optional)

Users do not need login privileges on Oracle Big Data Appliance to run MapReduce jobs from a remote client. However, for those who want to log in to Oracle Big Data Appliance, you must set a password. You can set or reset a password the same way.

To set a user password across all Oracle Big Data Appliance servers:

1. Create a Hadoop cluster user as described in "Creating Hadoop Cluster Users" on page 3-5..
2. Confirm that the user does not have a password:

```
# dcli passwd -S user_name
bda1node01.example.com: jdoe NP 2013-01-22 0 99999 7 -1 (Empty password.)
bda1node02.example.com: jdoe NP 2013-01-22 0 99999 7 -1 (Empty password.)
bda1node03.example.com: jdoe NP 2013-01-22 0 99999 7 -1 (Empty password.)
```

   If the output shows either "Empty password" or "Password locked," then you must set a password.

3. Set the password:

```
 hash=$(echo 'password' | openssl passwd -1 -stdin); dcli "usermod
--pass='$hash' user_name"
```

4. Confirm that the password is set across all servers:

```
# dcli passwd -S user_name
bda1node01.example.com: jdoe PS 2013-01-24 0 99999 7 -1 (Password set, MD5
crypt.)
bda1node02.example.com: jdoe PS 2013-01-24 0 99999 7 -1 (Password set, MD5
crypt.)
bda1node03.example.com: jdoe PS 2013-01-24 0 99999 7 -1 (Password set, MD5
crypt.)
```

See Also:

- *Oracle Big Data Appliance Owner's Guide* for information about `dcli`.
- The Linux `man` page for the full syntax of the `useradd` command.

Recovering Deleted Files

CDH provides an optional trash facility, so that a deleted file or directory is moved to a trash directory for a set period of time instead of being deleted immediately from the system. By default, the trash facility is enabled for HDFS and all HDFS clients.

Restoring Files from the Trash

When the trash facility is enabled, you can easily restore files that were previously deleted.

To restore a file from the trash directory:

1. Check that the deleted file is in the trash. The following example checks for files deleted by the `oracle` user:

```
$ hadoop fs -ls .Trash/Current/user/oracle
Found 1 items
-rw-r--r--  3 oracle hadoop  242510990 2012-08-31 11:20
```

```
/user/oracle/.Trash/Current/user/oracle/ontime_s.dat
```

2. Move or copy the file to its previous location. The following example moves ontime_s.dat from the trash to the HDFS /user/oracle directory.

```
$ hadoop fs -mv .Trash/Current/user/oracle/ontime_s.dat /user/oracle/ontime_
s.dat
```

Changing the Trash Interval

The **trash interval** is the minimum number of minutes that a file remains in the trash directory before being deleted permanently from the system. The default value is 1 day (24 hours).

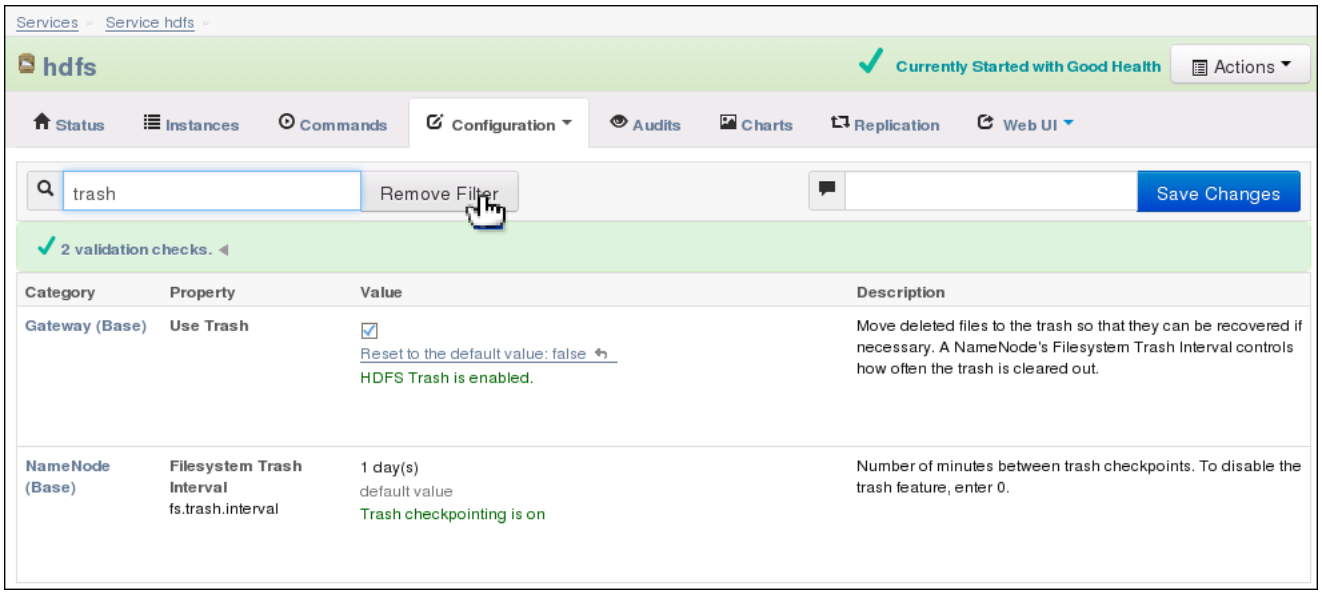
To change the trash interval:

1. Open Cloudera Manager. See "Managing CDH Operations Using Cloudera Manager" on page 2-3.
2. On the All Services page under Name, click **hdfs**.
3. On the hdfs page, click **Configuration**, and then select **View and Edit.**
4. Search for or scroll down to the Filesystem Trash Interval property under NameNode Settings. See Figure 3–2.
5. Click the current value, and enter a new value in the pop-up form.
6. Click **Save Changes**.
7. Expand the Actions menu at the top of the page and choose **Restart**.
8. Open a connection as `root` to a node in the cluster.
9. Deploy the new configuration:

```
dcli -C bdagetclientconfig
```

Figure 3–2 shows the Filesystem Trash Interval property in Cloudera Manager.

Figure 3–2 HDFS Property Settings in Cloudera Manager



Disabling the Trash Facility

The trash facility on Oracle Big Data Appliance is enabled by default. You can change this configuration for a cluster. When the trash facility is disabled, deleted files and directories are not moved to the trash. They are not recoverable.

Completely Disabling the Trash Facility

The following procedure disables the trash facility for HDFS. When the trash facility is completely disabled, the client configuration is irrelevant.

To completely disable the trash facility:

1. Open Cloudera Manager. See "Managing CDH Operations Using Cloudera Manager" on page 2-3.
2. On the All Services page under Name, click **hdfs**.
3. On the hdfs page, click the **Configuration** subtab.
4. Search for or scroll down to the Filesystem Trash Interval property under NameNode Settings. See Figure 3–2.
5. Click the current value, and enter a value of 0 (zero) in the pop-up form.
6. Click **Save Changes**.
7. Expand the Actions menu at the top of the page and choose **Restart**.

Disabling the Trash Facility for Local HDFS Clients

All HDFS clients that are installed on Oracle Big Data Appliance are configured to use the trash facility. An **HDFS client** is any software that connects to HDFS to perform operations such as listing HDFS files, copying files to and from HDFS, and creating directories.

You can use Cloudera Manager to change the local client configuration setting, although the trash facility is still enabled.

Note: If you do not want any clients to use the trash, then you can completely disable the trash facility. See "Completely Disabling the Trash Facility" on page 3-9.

To disable the trash facility for local HDFS clients:

1. Open Cloudera Manager. See "Managing CDH Operations Using Cloudera Manager" on page 2-3.
2. On the All Services page under Name, click **hdfs**.
3. On the hdfs page, click the **Configuration** subtab.
4. Search for or scroll down to the Use Trash property under Client Settings. See Figure 3–2.
5. Deselect the Use Trash check box.
6. Click **Save Changes**. This setting is used to configure all new HDFS clients downloaded to Oracle Big Data Appliance.
7. Open a connection as `root` to a node in the cluster.
8. Deploy the new configuration:

```
dcli -C bdagetclientconfig
```

Disabling the Trash Facility for a Remote HDFS Client

Remote HDFS clients are typically configured by downloading and installing a CDH client, as described in "Providing Remote Client Access to CDH" on page 3-1. Oracle SQL Connector for HDFS and Oracle R Connector for Hadoop are examples of remote clients.

To disable the trash facility for a remote HDFS client:

1. Open a connection to the system where the CDH client is installed.
2. Open /etc/hadoop/conf/hdfs-site.xml in a text editor.
3. Change the trash interval to zero:

```
<property>
     <name>fs.trash.interval</name>
     <value>0</value>
</property>
```

4. Save the file.

4

Optimizing MapReduce Jobs Using Perfect Balance

This chapter describes how you can shorten the run time of some MapReduce jobs by using Perfect Balance. It contains the following sections:

What is Perfect Balance?

The Perfect Balance feature of Oracle Big Data Appliance distributes the reducer load in a MapReduce application so that each reduce task does approximately the same amount of work. While the default Hadoop method of distributing the reduce load is appropriate for many jobs, it does not distribute the load evenly for jobs with significant data skew.

Data skew is an imbalance in the load assigned to different reduce tasks. The **load** is a function of:

- The number of keys assigned to a reducer.
- The number of records and the number of bytes in the values per key.

The total run time for a job is extended, to varying degrees, by the time that the reducer with the greatest load takes to finish. In jobs with a skewed load, some reducers complete the job quickly, while others take much longer. Perfect Balance can significantly shorten the total run time by distributing the load evenly, enabling all reducers to finish at about the same time.

Your MapReduce job can be written using either the `mapred` or `mapreduce` APIs; Perfect Balance supports both of them.

Perfect Balance was tested on MapReduce 1 (MRv1) CDH clusters, which is the default installation on Oracle Big Data Appliance.

About Balancing Jobs Across Map and Reduce Tasks

A typical Hadoop job has map and reduce tasks. Hadoop distributes the *mapper* workload uniformly across Hadoop Distributed File System (HDFS) and across map tasks while preserving the data locality. In this way, it reduces skew in the mappers.

Hadoop also hashes the map-output keys uniformly across all *reducers*. This strategy works well when there are many more keys than reducers, and each key represents a very small portion of the workload. However, it is not effective when the mapper output is concentrated into a small number of keys. Hashing these keys results in skew and does not work in applications like sorting, which require range partitioning.

Perfect Balance distributes the load evenly across reducers by first sampling the data, optionally chopping large keys into two or more smaller keys, and using a load-aware partitioning strategy to assign keys to reduce tasks.

Methods of Running Perfect Balance

You can choose from two methods of running Perfect Balance:

- **Perfect Balance Driver**: You can run a job very easily using the `hadoop` command, without changing your application code.
- **Perfect Balance API**: You can add the code to run Perfect Balance so that it runs after your application setup code.

Both methods are described in "Running a Balanced MapReduce Job" on page 4-9.

Perfect Balance Components

Perfect Balance has these components:

- **Job Analyzer**: Gathers and reports statistics about the MapReduce job so that you can determine whether to use Perfect Balance.
- **Counting Reducer**: Provides additional statistics to help gauge the effectiveness of Perfect Balance.
- **Load Balancer**: Runs before the MapReduce job to generate a static partition plan, and reconfigures the job to use the plan. The balancer includes a user-configurable, progressive sampler that stops sampling the data as soon as it can generate a good partitioning plan.
- **Driver**: Enables you to run Perfect Balance in a `hadoop` command.

Getting Started with Perfect Balance

Take the following basic steps to use Perfect Balance:

1. Ensure that your application meets the following requirements:
   - The job is distributive, so that splitting a group of records associated with a reduce key does not change the results.

     If it is not distributive, then you can still run Perfect Balance after disabling the key splitting feature. The job still benefits from using Perfect Balance, but the load is not as evenly balanced as when key splitting is in effect. See the `oracle.hadoop.balancer.keyLoad.minChopBytes` configuration property.
   - In this release, the mapper tasks cannot use symbolic links in the Hadoop distributed cache.

As a general rule, a job that does not run successfully using a local job runner does not run successfully with Perfect Balance. For example, the local job runner in CDH 4.3 MRv1 clusters (like those configured on Oracle Big Data Appliance 2.2) does not support symbolic links in the mapper.

To run a job with the local job runner, set the following configuration property:

```
mapred.job.tracker=local
```

- This release does not support combiners. The load balancing estimates may not be accurate when combiners are used.

2. Log in to an Oracle Big Data Appliance server. You cannot run Perfect Balance from a remote Hadoop client.
3. Run the examples provided with Perfect Balance to become familiar with the product. All examples shown in this chapter are based on the shipped examples and use the same data set. See "About the Perfect Balance Examples" on page 4-3..
4. Set the following variables using the Bash `export` command:
   - `HADOOP_CLASSPATH`: Add `${BALANCER_HOME}`/jlib/orabalancer.jar and `${BALANCER_HOME}`/jlib/commons-math-2.2.jar to the existing value, if necessary. Also add the JAR files for your application.
   - `HADOOP_USER_CLASSPATH_FIRST`: Set to `true` so that Hadoop uses the Perfect Balance version of commons-math.jar instead of the default version.
   - `BALANCER_HOME`: Set to the Perfect Balance installation directory, which is /opt/oracle/orabalancer-1.0.0-h2 on Oracle Big Data Appliance (optional). The examples in this chapter use this variable, and you can also define it for your convenience. Perfect Balance does not use `BALANCER_HOME`.
5. Run Job Analyzer without the balancer and use the generated report to decide whether the job is a good candidate for using Perfect Balance.

   See "Analyzing a Job for Imbalanced Reducer Loads" on page 4-4.
6. Choose a method of running Perfect Balance.

   See "Methods of Running Perfect Balance" on page 4-2.
7. Decide which configuration properties to set, if any. Create a configuration file or enter the settings individually in the `hadoop` command.

   See "About Configuring Perfect Balance" on page 4-13.
8. Run the job using Perfect Balance.

   See "Running a Balanced MapReduce Job" on page 4-9.
9. Use the Job Analyzer report to evaluate the effectiveness of using Perfect Balance. See "Reading the Job Analyzer Report" on page 4-8.
10. Modify the job configuration properties as desired before rerunning the job with Perfect Balance. See "About Configuring Perfect Balance" on page 4-13.

About the Perfect Balance Examples

The Perfect Balance installation files include a full set of examples that you can run immediately. The InvertedIndex example is a MapReduce application that creates an inverted index on an input set of text files. The inverted index maps words to the location of the words in the text files. The input data is included.

About the Examples in this Chapter

The InvertedIndex example provides the basis for all examples in this chapter. They use the same data set and run the same MapReduce application. The modifications to the InvertedIndex example simply highlight the steps you must perform in running your own applications with Perfect Balance.

If you want to run the examples in this chapter, or use them as the basis for running your own jobs, then make the following changes:

- If you are modifying the examples to run your own application, then add your application JAR files to `HADOOP_CLASSPATH` and `-libjars`.
- Ensure that the value of `mapred.input.dir` identifies the location of your data.

  The invindx/input directory contains the sample data for the InvertedIndex example. To use this data, you must first set it up. See "Extracting the Example Data Set" on page 4-4.
- Replace `jdoe` with your Hadoop user name.
- Set the `-conf` option to an existing configuration file.

  The jdoe_conf_invindx.xml file is a modification of the configuration file for the InvertedIndex examples. The modified file does not have performance optimizing settings. You can use the example configuration file as is or modify it. See /opt/oracle/orabalancer-1.0.0-h2/examples/invindx/conf_mapreduce.xml (or conf_mapred.xml).
- Review the configuration settings in the file and in the shell script to ensure they are appropriate for your job.
- You can run the browser from your laptop or connect to Oracle Big Data Appliance using a client that supports graphical interfaces, such as VNC.

Extracting the Example Data Set

To run the InvertedIndex examples or any of the examples in this chapter, you must first set up the data files.

To extract the InvertedIndex data files:

1. Log in to an Oracle Big Data Appliance server.
2. Change to the examples/invindx subdirectory:

   ```
   cd /opt/oracle/orabalancer-1.0.0-h2/examples/invindx
   ```

3. Unzip the data and copy it to the HDFS invindx/input directory:

   ```
   ./invindx -setup
   ```

For complete instructions for running the InvertedIndex example, see /opt/oracle/orabalancer-1.0.0-h2/examples/invindx/README.txt.

Analyzing a Job for Imbalanced Reducer Loads

Job Analyzer is a component of Perfect Balance that identifies imbalances in a load, and how effective Perfect Balance is in correcting the imbalance when actually running the job. This section contains the following topics:

- About Job Analyzer
- Running Job Analyzer as a Standalone Utility

About Job Analyzer

Job Analyzer uses the output logs of a MapReduce job to generate a simple report with statistics like the elapsed time and the load for each reduce task. By default, it uses the standard Hadoop counters displayed by the JobTracker user interface, but organizes the data to emphasize the relative performance and load of the reduce tasks, so that you can more easily interpret the results.

If the report shows that the reducers processed very different loads and the run times varied widely, then the application is a good candidate for Perfect Balance.

Methods of Running Job Analyzer

You can choose between two methods of running Job Analyzer:

- **As a standalone utility**: Job Analyzer runs against existing job output logs. This is a good choice if you already ran your application on Oracle Big Data Appliance without using Perfect Balance.
- **Using Perfect Balance**: Job Analyzer runs automatically against the output logs for the current job each time you use Perfect Balance. To see whether the job is a candidate for Perfect Balance, you can set a configuration property so that the job runs without the balancer.

Running Job Analyzer as a Standalone Utility

As a standalone utility, Job Analyzer provides a quick way to analyze the reduce load of a previously run job.

To run Job Analyzer as a standalone utility:

1. Log in to an Oracle Big Data Appliance server. You cannot run Job Analyzer from a remote Hadoop client.
2. Locate the output logs from the job to analyze. Set `mapred.output.dir` to this directory.
3. Run the Job Analyzer utility as described in "Job Analyzer Utility Syntax" on page 4-6.
4. View the Job Analyzer report in a browser.

Job Analyzer Utility Example

Example 4–1 runs a script that sets the required variables, uses the MapReduce job logs stored in jdoe_nobal_outdir, and creates the report in the default location. It then copies the HTML version of the report from HDFS to the /home/jdoe local directory and opens the report in a browser.

If you want to run this example, then replace jdoe_nobal_outdir with the HDFS path to the output logs from a previous job run. You can use the output logs from running the InvertedIndex example. The default HDFS output directory is in invindx/output. See "About the Perfect Balance Examples" on page 4-3.

Example 4–1 Running the Job Analyzer Utility

```
$ cat runja.sh
```

```
BALANCER_HOME=/opt/oracle/orabalancer-1.0.0-h2
export HADOOP_CLASSPATH=${BALANCER_HOME}/jlib/orabalancer.jar:${BALANCER_
HOME}/jlib/commons-math-2.2.jar:$HADOOP_CLASSPATH
export HADOOP_USER_CLASSPATH_FIRST=true

hadoop jar ${BALANCER_HOME}/jlib/orabalancer.jar
oracle.hadoop.balancer.tools.JobAnalyzer \
-D mapred.output.dir=jdoe_nobal_outdir

$ sh ./runja.sh
$
$ hadoop fs -get jdoe_nobal_outdir/_balancer/jobanalyzer-report.html /home/jdoe
$ cd /home/jdoe
$ firefox jobanalyzer-report.html
```

Job Analyzer Utility Syntax

The following is the syntax to run the Job Analyzer utility:

```
bin/hadoop jar ${BALANCER_HOME}/jlib/orabalancer.jar
oracle.hadoop.balancer.tools.JobAnalyzer \
-D mapred.output.dir=job_output_dir \
[ja_report_path]
```

job_output_dir
An HDFS directory where the job files are stored from previously executing the application.

ja_report_path
An HDFS directory where Job Analyzer creates its report (optional). The default directory is *job_output_dir*/_balancer.

Running Job Analyzer With the Perfect Balance Driver

Job Analyzer runs automatically each time you use Perfect Balance. If you are running your application on Oracle Big Data Appliance for the first time, then you may want to set up the job in Perfect Balance to run without the balancer, instead of using the Job Analyzer utility. The job runs using the default Hadoop partitioning strategy, and you can configure Job Analyzer to collect additional statistics. If the analysis shows that the load is skewed, then you can use the same basic setup in Perfect Balance for subsequent runs after turning the balancer on again.

To run Job Analyzer without the balancer:

1. Log in to an Oracle Big Data Appliance server. You cannot run Job Analyzer from a remote Hadoop client.
2. To prevent the balancer from running, set the `oracle.hadoop.balancer.driver.balance` configuration property to `false`.
3. To collect additional statistics and obtain recommendations for configuring future runs, set the `oracle.hadoop.balancer.tools.useCountingReducer` and `oracle.hadoop.balancer.tools.printRecommendation` configuration properties to `true`.

   See "Collecting Additional Metrics" on page 4-8.
4. Decide which additional configuration properties to set, if any.

   See "Job Analyzer Properties" on page 4-13.
5. Run the job using the Perfect Balance driver.

Note: The Perfect Balance API does not use `oracle.hadoop.balancer.driver.balance` or `oracle.hadoop.balancer.tools.useCountingReducer`.

The job uses the default Hadoop distribution of the load to reduce tasks.

Job Analyzer Example

Example 4–2 runs a script that sets the required variables, uses the Perfect Balance driver to run a job without the balancer, and creates the report in the default location. It then copies the HTML version of the report from HDFS to the /home/jdoe local directory and opens the report in a browser.

If you want to run this example, then see "About the Examples in this Chapter" on page 4-4. The output includes warnings, which you can ignore.

Example 4–2 Running Job Analyzer in Perfect Balance

```
$ cat ja_nobalance.sh

BALANCER_HOME=/opt/oracle/orabalancer-1.0.0-h2
export HADOOP_CLASSPATH=${BALANCER_HOME}/jlib/orabalancer.jar:${BALANCER_
HOME}/jlib/commons-math-2.2.jar:$HADOOP_CLASSPATH
export HADOOP_USER_CLASSPATH_FIRST=true

hadoop jar ${BALANCER_HOME}/jlib/orabalancer.jar
oracle.hadoop.balancer.BalancerDriver \
 -D mapred.input.dir=invindx/input \
 -D mapred.output.dir=jdoe_nobal_outdir \
 -D mapred.job.name=nobal \
 -D mapred.reduce.tasks=10 \
 -D oracle.hadoop.balancer.driver.balance=false \
 -D oracle.hadoop.balancer.tools.useCountingReducer=true \
 -D oracle.hadoop.balancer.tools.printRecommendation=true \
 -conf /home/jdoe/jdoe_conf_invindx.xml \
 -libjars ${BALANCER_HOME}/jlib/commons-math-2.2.jar,${BALANCER_
HOME}/jlib/orabalancer.jar

]$ sh ja_nobalance.sh
13/06/26 16:07:12 INFO balancer.BalancerDriver: Submitting job
13/06/26 16:07:13 WARN mapred.JobClient: Use GenericOptionsParser for parsing the
arguments. Applications should implement Tool for the same.
13/06/26 16:07:14 WARN mapred.JobClient: No job jar file set.  User classes may
not be found. See JobConf(Class) or JobConf#setJar(String).
13/06/26 16:07:14 INFO input.FileInputFormat: Total input paths to process : 5
13/06/26 16:07:14 INFO mapred.JobClient: Running job: job_201305031125_0016
13/06/26 16:07:16 INFO mapred.JobClient:  map 0% reduce 0%
13/06/26 16:07:34 INFO mapred.JobClient:  map 5% reduce 0%
     .
     .
     .
13/06/26 16:11:06 INFO mapred.JobClient:     Reduce input records=20000000
13/06/26 16:11:06 INFO mapred.JobClient:     Reduce output records=13871794
13/06/26 16:11:06 INFO mapred.JobClient:     Spilled Records=60000000
13/06/26 16:11:06 INFO mapred.JobClient:     CPU time spent (ms)=184330
13/06/26 16:11:06 INFO mapred.JobClient:     Physical memory (bytes)
snapshot=3421863936
13/06/26 16:11:06 INFO mapred.JobClient:     Virtual memory (bytes)
```

```
snapshot=10147790848
13/06/26 16:11:06 INFO mapred.JobClient:     Total committed heap usage
(bytes)=2158821376


$ hadoop fs -get jdoe_nobal_outdir/_balancer/jobanalyzer-report.html /home/jdoe
$ cd /home/jdoe
$ firefox jobanalyzer-report.html
```

Collecting Additional Metrics

If you set the `oracle.hadoop.balancer.tools.useCountingReducer` configuration property to `true`, then the Job Analyzer report includes the load metrics for each reduce key. This additional information provides a more detailed picture of the load for each reducer, with metrics that are not available in the standard Hadoop counters.

The Job Analyzer report also compares its predicted load with the actual load measured by `CountingReducer`. The difference between these values measures how effective Perfect Balance was in balancing the job.

If you also set oracle.hadoop.balancer.tools.printRecommendation to `true`, then Job Analyzer may recommend key load coefficients for the key load model. Use the recommended values to set the following configuration properties:

- `oracle.hadoop.balancer.linearKeyLoad.byteWeight`
- `oracle.hadoop.balancer.linearKeyLoad.keyWeight`
- `oracle.hadoop.balancer.linearKeyLoad.rowWeight`

When you run the job again, these coefficients result in a more balanced job.

Reading the Job Analyzer Report

Job Analyzer writes its report in two formats: HTML for you, and XML for Perfect Balance. Copy the HTML version from HDFS to the local file system and open it in a browser, as shown in the previous examples.

When inspecting the Job Analyzer report, look for indicators of skew such as:

- The execution time of some reducers is longer than others.
- Some reducers process more records or bytes than others.
- Some map output keys have more records than others.
- Some map output records have more bytes than others.

Figure 4–1 shows a small portion of the analyzer report for the inverted index (invindx) example. It displays the key load coefficient recommendations, because this job ran with the appropriate configuration settings. See "Collecting Additional Metrics" on page 4-8.

The task IDs are links to tables that show the analysis of specific tasks, which enables you to drill down for more details from the first, summary table.

This example uses an extremely small data set, but notice the differences between tasks 7 and 8: The input records range from 3% to 29%, and their corresponding elapsed times range from 9 to 15 seconds. This variation indicates skew. In contrast, tasks 0 and 4 have very different execution times, but process about the same amount of data. This variation is caused by some other factor, and not by skew.

Figure 4–1 Job Analyzer Report for Unbalanced Inverted Index Job

Job Information

Job Name	nobal
Start Time	2013-06-26 16:07:14
Finish Time	2013-06-26 16:11:06
Elapsed Time	00:03:51

Key Load Coefficient Recommendations

The following values are recommended for the coefficients of the key load model:

Coefficient	Value
oracle.hadoop.balancer.linearKeyLoad.keyWeight	107.35396359
oracle.hadoop.balancer.linearKeyLoad.rowWeight	0.00148810
oracle.hadoop.balancer.linearKeyLoad.byteWeight	0.00000000

Reduce Tasks

Task ID	Time					Input							
	Start	Finish	Elapsed	CPU		Shuffle Bytes		Keys		Records		ValueBytes	
				time	%	count	%	count	%	count	%	count	%
0	16:08:56	16:09:24	00:00:28	00:00:09	11	20,987,702	12	13	13	2,300,118	12	43,702,242	12
1	16:09:25	16:09:35	00:00:10	00:00:07	10	15,630,571	9	12	12	1,438,876	7	27,338,644	7
2	16:09:35	16:09:44	00:00:09	00:00:07	9	14,682,583	8	7	7	1,503,328	8	28,563,232	8
3	16:09:44	16:09:55	00:00:10	00:00:07	9	14,977,081	9	10	10	1,450,603	7	27,561,457	7
4	16:09:55	16:10:06	00:00:11	00:00:08	10	21,175,220	12	11	11	2,073,885	10	39,403,815	10
5	16:10:06	16:10:19	00:00:12	00:00:10	13	19,664,004	11	10	10	2,580,271	13	49,025,149	13
6	16:10:19	16:10:27	00:00:08	00:00:06	8	8,867,408	5	9	9	775,690	4	14,738,110	4
7	16:10:27	16:10:37	00:00:09	00:00:05	7	5,912,478	3	6	6	531,247	3	10,093,693	3
8	16:10:37	16:10:52	00:00:15	00:00:12	16	35,890,632	21	11	11	5,824,950	29	110,674,050	29
9	16:10:52	16:11:02	00:00:10	00:00:07	9	16,252,928	9	11	11	1,521,032	8	28,899,608	8
Total	-	-	-	00:01:22	-	174,040,607	-	100	-	20,000,000	-	380,000,000	-

Running a Balanced MapReduce Job

You can use either the Perfect Balance driver or the API to run your application. See "Methods of Running Perfect Balance" on page 4-2.

- Using the Perfect Balance Driver
- Using the Perfect Balance API

Using the Perfect Balance Driver

The following is the syntax to run a job using the Perfect Balance driver:

```
bin/hadoop jar ${BALANCER_HOME}/jlib/orabalancer.jar
oracle.hadoop.balancer.BalancerDriver \
-D application_config_property \
-D perfect_balance_config_property \
-conf application_config_file.xml \
-conf perfect_balance_config_file.xml \
-libjars ${BALANCER_HOME}/jlib/commons-math-2.2.jar,${BALANCER_
HOME}/jlib/orabalancer.jar,application_jar_path.jar...
```

You can include any generic `hadoop` command-line option. The driver implements the `org.apache.hadoop.util.Tool` interface and follows the standard Hadoop methods for building MapReduce applications. You can combine Perfect Balance properties and MapReduce properties in the same configuration file. See "About Configuring Perfect Balance" on page 4-13.

Example 4–3 runs a script named pb_balance.sh, which uses the Perfect Balance driver to run the job. The key load metric properties are set to the values recommended in the Job Analyzer report shown in Figure 4–1.

Example 4–3 Running a Job Using the Perfect Balance Driver

```
$ cat runinvindx.sh

BALANCER_HOME=/opt/oracle/orabalancer-1.0.0-h2
export HADOOP_CLASSPATH=${BALANCER_HOME}/jlib/orabalancer.jar:${BALANCER_
HOME}/jlib/commons-math-2.2.jar:$HADOOP_CLASSPATH
export HADOOP_USER_CLASSPATH_FIRST=true


hadoop jar ${BALANCER_HOME}/jlib/orabalancer.jar
oracle.hadoop.balancer.BalancerDriver \
 -D mapred.input.dir=invindx/input \
 -D mapred.output.dir=jdoe_outdir \
 -D mapred.job.name=jdoe_invindx \
 -D mapred.reduce.tasks=10 \
 -D oracle.hadoop.balancer.tools.useCountingReducer=true \
 -D oracle.hadoop.balancer.tools.printRecommendation=true \
 -D oracle.hadoop.balancer.linearKeyLoad.keyWeight=107.35396359 \
 -D oracle.hadoop.balancer.linearKeyLoad.rowWeight=0.00148810 \
 -D oracle.hadoop.balancer.linearKeyLoad.byteWeight=0.0 \
 -conf /home/jdoe/jdoe_conf_invindx.xml \
 -libjars ${BALANCER_HOME}/jlib/commons-math-2.2.jar,${BALANCER_
HOME}/jlib/orabalancer.jar

$ sh ./runinvindx.sh
13/06/27 09:01:53 INFO balancer.Balancer: Creating balancer
13/06/27 09:01:53 INFO input.FileInputFormat: Total input paths to process : 5
13/06/27 09:01:54 INFO balancer.Balancer: Starting Balancer
13/06/27 09:02:00 INFO balancer.Balancer: Balancer completed
13/06/27 09:02:00 INFO balancer.BalancerDriver: Submitting job
     .
     .
     .
```

Using the Perfect Balance API

The `oracle.hadoop.balancer.Balancer` class contains methods for creating a partitioning plan, saving the plan to a file, and running the MapReduce job using the plan. You only need to add the code to your Java class, not redesign the application. When you run a shell script to run the application, you can include Perfect Balance configuration settings.

Modifying Your Java Code to Use Perfect Balance

The Perfect Balance installation directory contains a complete example, including input data, of a Java MapReduce program that uses the Perfect Balance API.

For a description of the inverted index example and execution instructions, see orabalancer-1.0.0-h2/examples/invindx/README.txt.

To explore the modified Java code, see orabalancer-1.0.0-h2/examples/jsrc/oracle/hadoop/balancer/examples/invindx/InvertedIndexMapred.java or InvertedIndexMapreduce.java.

The modifications to run Perfect Balance include the following:

- The `oracle.hadoop.balancer.useMapreduceApi` configuration property identifies the application's use of either the `mapred` or the `mapreduce` API.
- The `createBalancer` method validates the configuration properties and returns a `Balancer` instance.
- The `waitForCompletion` method samples the data and creates a partitioning plan.
- The `addBalancingPlan` method adds the partitioning plan to the job configuration settings.
- The `configureCountingReducer` method configures the application with a counting reducer that collects data to analyze the reducer load, if the `oracle.hadoop.balancer.tools.useCountingReducer` property is set to `true`.
- The `save` method saves the partition report and generates the Job Analyzer report.

Example 4–4 shows fragments from the inverted index Java code.

Example 4–4 Running Perfect Balance in a MapReduce Job

```
      .
      .
      .
import oracle.hadoop.balancer.Balancer;
      .
      .
      .
///// BEGIN: CODE TO INVOKE BALANCER (PART-1, before job submission) //////
    Balancer balancer = null;

    // Specify the old mapred api
    job.setBoolean("oracle.hadoop.balancer.useMapreduceApi", false);

    boolean useBalancer = job.getBoolean(InvertedIndex.PROP_USE_BALANCER,
        InvertedIndex.DEFAULT_USE_BALANCER);
    if(useBalancer)
    {
      balancer = Balancer.createBalancer(job);
      balancer.waitForCompletion();
      balancer.addBalancingPlan(job);
    }

    if(job.getBoolean("oracle.hadoop.balancer.tools.useCountingReducer", true))
    {
      Balancer.configureCountingReducer(job);
    }
    ////////////// END: CODE TO INVOKE BALANCER (PART-1) ///////////////////////

    RunningJob rj = JobClient.runJob(job);

    ////////////////////////////////////////////////////////////////////////////
    // BEGIN: CODE TO INVOKE BALANCER (PART-2, after job completion, optional)
    // If balancer ran, this saves the partition file report into the _balancer
    // subdirectory of the job output directory. It also writes a JobAnalyzer
    // report.
    Balancer.save(rj, job);
    ////////////// END: CODE TO INVOKE BALANCER (PART-2) ///////////////////////
      .
      .
      .
}
```

See Also: *Oracle Big Data Appliance Perfect Balance Java API Reference*

Running Your Modified Java Code with Perfect Balance

When you run your modified Java code, you can set the Perfect Balance properties, using the standard `hadoop` command syntax:

```
bin/hadoop jar application_jarfile.jar ApplicationClass \
-conf application_config.xml \
-conf perfect_balance_config.xml \
-D application_config_property \
-D perfect_balance_config_property \
-libjars
/opt/oracle/orabalancer-1.0.0-h2/jlib/commons-math-2.2.jar,/opt/oracle/orabalancer
-1.0.0-h2/jlib/orabalancer.jar,application_jar_path.jar...
```

Example 4–5 runs a script named pb_balanceapi.sh, which runs the `InvertedIndexMapreduce` class example packaged in the Perfect Balance JAR file. The key load metric properties are set to the values recommended in the Job Analyzer report shown in Figure 4–1.

To run the InvertedIndexMapreduce class example, see "About the Perfect Balance Examples" on page 4-3.

Example 4–5 Running the InvertedIndexMapreduce Class

```
$ cat pb_balanceapi.sh
BALANCER_HOME=/opt/oracle/orabalancer-1.0.0-h2
APP_JAR_FILE=/opt/oracle/orabalancer-1.0.0-h2/jlib/orabalancer.jar
export HADOOP_CLASSPATH=${BALANCER_HOME}/jlib/orabalancer.jar:${BALANCER_
HOME}/jlib/commons-math-2.2.jar:$HADOOP_CLASSPATH
export HADOOP_USER_CLASSPATH_FIRST=true

hadoop jar ${APP_JAR_FILE}
oracle.hadoop.balancer.examples.invindx.InvertedIndexMapreduce \
 -D mapred.input.dir=invindx/input \
 -D mapred.output.dir=jdoe_outdir_api \
 -D mapred.job.name=jdoe_invindx_api \
 -D mapred.reduce.tasks=10 \
 -D oracle.hadoop.balancer.tools.useCountingReducer=true \
 -D oracle.hadoop.balancer.tools.printRecommendation=true \
 -D oracle.hadoop.balancer.linearKeyLoad.keyWeight=107.35396359 \
 -D oracle.hadoop.balancer.linearKeyLoad.rowWeight=0.00148810 \
 -D oracle.hadoop.balancer.linearKeyLoad.byteWeight=0.0 \
-libjars ${BALANCER_HOME}/jlib/commons-math-2.2.jar,${BALANCER_
HOME}/jlib/orabalancer.jar

$ sh ./balanceapi.sh
13/06/24 17:21:47 INFO balancer.Balancer: Creating balancer
13/06/24 17:21:48 INFO input.FileInputFormat: Total input paths to process : 5
13/06/24 17:21:48 INFO balancer.Balancer: Starting Balancer
13/06/24 17:21:54 INFO balancer.Balancer: Balancer completed
     .
     .
     .
```

About Perfect Balance Reports

Perfect Balance generates these reports when it runs a job:

- Job Analyzer report that contains various indicators about the distribution of the load in a job. The report is saved in HTML for you, and XML for Perfect Balance to use. The report is always named jobanalyzer-report.html and -.xml. See "Reading the Job Analyzer Report" on page 4-8.
- Partition report that identifies the keys that are assigned to the various mappers. This report is saved in XML for Perfect Balance to use; it does not contain information of use to you. The report is named ${mapred_output_dir}/_balancer/orabalancer_report.xml.
- Reduce key metric reports that Perfect Balance generates for each file partition, when the appropriate configuration properties are set. The reports are saved in XML for Perfect Balance to use; they do not contain information of use to you. They are named ${mapred_output_dir}/_balancer/ReduceKeyMetricList-attempt_*jobid_taskid_task_attemptid*.xml.

  See "Collecting Additional Metrics" on page 4-8.

The reports are stored by default in the job output directory (${mapred.output.dir}). Following is the structure of that directory:

```
job_output_directory
   /_SUCCESS
   /_balancer
      ReduceKeyMetricList-attempt_201305031125_0016_r_000000_0.xml
      ReduceKeyMetricList-attempt_201305031125_0016_r_000001_0.xml
         .
         .
         .
     jobanalyzer-report.html
     jobanalyzer-report.xml
   /_logs
      /history
         job_201305031125_0016_1372277234720_jdoe_invindx_nobal
         localhost.localdomain_1367594758596_job_201305031125_0016_conf.xml
   /part-r-00000
   /part-r-00001
     .
     .
     .
```

About Configuring Perfect Balance

Perfect Balance uses the standard Hadoop methods of specifying configuration properties in the command line. You can use the `-conf` option to identify a configuration file, or the `-D` option to specify individual properties. All Perfect Balance configuration properties have default values, and so setting them is optional.

"Perfect Balance Configuration Property Reference" on page 4-14 lists the configuration properties in alphabetical order with a full description. The following are functional groups of properties.

BalancerDriver Properties

- `oracle.hadoop.balancer.driver.balance`
- `oracle.hadoop.balancer.submitJob`

Job Analyzer Properties

- `oracle.hadoop.balancer.tools.jobConfPath`

- oracle.hadoop.balancer.tools.jobHistoryPath
- oracle.hadoop.balancer.tools.printRecommendation
- oracle.hadoop.balancer.tools.useCountingReducer
- oracle.hadoop.balancer.tools.writeKeyBytes

Key Chopping Properties

- oracle.hadoop.balancer.enableSorting
- oracle.hadoop.balancer.keyLoad.minChopBytes

Load Balancing Properties

- oracle.hadoop.balancer.confidence
- oracle.hadoop.balancer.maxLoadFactor
- oracle.hadoop.balancer.maxSamplesPct
- oracle.hadoop.balancer.minSplits

Load Model Properties

- oracle.hadoop.balancer.keyLoad.class
- oracle.hadoop.balancer.linearKeyLoad.byteWeight
- oracle.hadoop.balancer.linearKeyLoad.keyWeight
- oracle.hadoop.balancer.linearKeyLoad.rowWeight

MapReduce-Related Properties

- oracle.hadoop.balancer.useMapreduceApi
- oracle.hadoop.balancer.inputFormat.mapred.map.tasks
- oracle.hadoop.balancer.inputFormat.mapred.max.split.size

Partition Report Properties

- oracle.hadoop.balancer.report.overwrite
- oracle.hadoop.balancer.reportPath
- oracle.hadoop.balancer.tmpDir

Sampler Properties

- oracle.hadoop.balancer.numThreads
- oracle.hadoop.balancer.useClusterStats

Perfect Balance Configuration Property Reference

This section describes the Perfect Balance configuration properties and a few generic Hadoop MapReduce properties that Perfect Balance reads from the job configuration

- MapReduce Configuration Properties
- Perfect Balance Configuration Properties

MapReduce Configuration Properties

mapred.input.dir
Type: String

Default Value: Not defined

Description: A comma-separated list of input directories.

mapred.input.format.class
Type: String

Default Value: `org.apache.hadoop.mapred.TextInputFormat`

Description: The full name of the `InputFormat` class.

mapred.mapper.class
Type: String

Default Value: `org.apache.hadoop.mapred.lib.IdentityMapper`

Description: The full name of the mapper class.

mapred.output.dir
Type: String

Default Value: Not defined

Description: The job output directory.

mapred.ouput.format.class
Type: String

Default Value: `org.apache.hadoop.mapred.TextOutputFormat`

Description: The full name of the `OutputFormat` class.

mapred.partitioner.class
Type: String

Default Value: `org.apache.hadoop.mapred.lib.HashPartitioner`

Description: The full name of the partitioner class.

mapred.reducer.class
Type: String

Default Value: `org.apache.hadoop.mapred.lib.IdentityReducer`

Description: The full name of the reducer class.

mapreduce.inputformat.class
Type: String

Default Value: `org.apache.hadoop.mapreduce.lib.input.TextInputFormat`

Description: The full name of the `InputFormat` class.

mapreduce.map.class
Type: String

Default Value: `org.apache.hadoop.mapreduce.Mapper`

Description: The full name of the mapper class.

mapreduce.outputformat.class
Type: String

Default Value: `org.apache.hadoop.mapreduce.lib.output.TextOutputFormat`

Description: The full name of the `OutputFormat` class.

mapreduce.partitioner.class
Type: String

Default Value: `org.apache.hadoop.mapreduce.lib.partition.HashPartitioner`

Description: The full name of the partitioner class.

mapreduce.reduce.class
Type: String

Default Value: `org.apache.hadoop.mapreduce.Reducer`

Description: The full name of the reducer class.

Perfect Balance Configuration Properties

oracle.hadoop.balancer.confidence
Type: Float

Default Value: `0.95`

Description: The statistical confidence indicator for the load factor specified by the `oracle.hadoop.balancer.maxLoadFactor` property.

This property accepts values greater than or equal to 0.5 and less than 1.0 (0.5 <= *value* < 1.0). A value less than 0.5 resets the property to its default value. Oracle recommends a value greater than or equal to 0.9. Typical values are 0.95 and 0.99.

oracle.hadoop.balancer.driver.balance
Type: Boolean

Default Value: `true`

Description: Controls whether the `BalancerDriver` class runs the balancer. Set to `false` to turn off balancing. The Perfect Balance driver uses this property; the API does not.

oracle.hadoop.balancer.enableSorting
Type: Boolean

Default Value: `false`

Description: Controls how the map output keys are **chopped**, that is, split into smaller keys:

- `false`: Uses a hash function.
- `true`: Uses the map output key sorting comparator as a total-order partitioning function. The balancer preserves the total order over the values of the chopped keys.

oracle.hadoop.balancer.inputFormat.mapred.map.tasks
Type: Integer

Default Value: `100`

Description: Sets the Hadoop `mapred.map.tasks` property for the duration of sampling, just before calling the input format `getSplits` method. It does not change `mapred.map.tasks` for the actual job. The optimal number of map tasks is a trade-off between obtaining a good sample (larger number) and having finite memory resources (smaller number).

Set this property to a value greater than or equal to one (1). A value less than 1 disables the property.

Some input formats, such as `DBInputFormat`, use this property as a hint to determine the number of splits returned by `getSplits`. Higher values indicate that more chunks of data are sampled at random, which improves the sample.

You can increase the value for larger data sets, that is, more than a million rows of about 100 bytes per row. However, extremely large values can cause the input format's `getSplits` method to run out of memory by returning too many splits.

oracle.hadoop.balancer.inputFormat.mapred.max.split.size
Type: Long

Default Value: `1048576` (1 MB)

Description: Sets the Hadoop `mapred.max.split.size` property for the duration of sampling, just before calling the input format's `getSplits` method. It does not change `mapred.max.split.size` for the actual job.

Set this property to a value greater than or equal to one (1). A value less than 1 disables the property. The optimal split size is a trade-off between obtaining a good sample (smaller splits) and efficient I/O performance (larger splits).

Some input formats, such as `FileInputFormat`, use the maximum split size as a hint to determine the number of splits returned by `getSplits`. Smaller split sizes indicate that more chunks of data are sampled at random, which improves the sample. Set the value small enough for good sampling performance, but no smaller. Extremely small values can cause inefficient I/O performance, while not improving the sample.

You can increase the value for larger data sets (tens of terabytes) or if the input format's `getSplits` method throws an out of memory error. Large splits are better for I/O performance, but not for sampling.

oracle.hadoop.balancer.keyLoad.class
Type: Class

Default Value: `oracle.hadoop.balancer.KeyLoadLinear`

Description: The name of a class that implements the `oracle.hadoop.balancer.KeyLoad` interface.

oracle.hadoop.balancer.keyLoad.minChopBytes
Type: Long

Default Value: `0`

Description: Controls whether Perfect Balance chops large map output keys into medium keys:

- `-1`: Perfect Balance does not chop large map output keys.
- `0`: Perfect Balance chops large map output keys and determines the optimal size of each medium key.
- *Positive integer*: Perfect Balance chops large map output keys into medium keys with a size greater than or equal to the specified integer.

oracle.hadoop.balancer.linearKeyLoad.byteWeight
Type: Float

Default Value: `0.05`

Description: Weights the number of bytes per key in the linear key load model specified by the `oracle.hadoop.balancer.KeyLoadLinear` class.

oracle.hadoop.balancer.linearKeyLoad.keyWeight
Type: Float

Default Value: 50.0

Description: Weights the number of medium keys per large key in the linear key load model specified by the `oracle.hadoop.balancer.KeyLoadLinear` class.

oracle.hadoop.balancer.linearKeyLoad.rowWeight
Type: Float

Default Value: 0.05

Description: Weights the number of rows per key in the linear key load model specified by the `oracle.hadoop.balancer.KeyLoadLinear` class.

oracle.hadoop.balancer.maxLoadFactor
Type: Float

Default Value: 0.05

Description: The target reducer load factor that you want the balancer's partition plan to achieve.

The load factor is the relative deviation from an estimated value. For example, if `maxLoadFactor=0.05` and `confidence=0.95`, then with a confidence greater than 95%, the job's reducer loads should be, at most, 5% greater than the value in the partition plan.

The values of these two properties determine the sampler's stopping condition. The balancer samples until it can generate a plan that guarantees the specified load factor at the specified confidence level. This guarantee may not hold if the sampler stops early because of other stopping conditions, such as the number of samples exceeds `oracle.hadoop.balancer.maxSamplesPct`. The partition report logs the stopping condition.

See `oracle.hadoop.balancer.confidence`.

oracle.hadoop.balancer.maxSamplesPct
Type: Float

Default Value: `0.01` (1%)

Description: Limits the number of samples that Perfect Balance can collect to a fraction of the total input records. A value less than zero disables the property (no limit).

You may need to increase the value for Hadoop applications with very unbalanced reducer partitions or densely clustered map-output keys. The sampler needs to sample more data to achieve a good partitioning plan in these cases.

See `oracle.hadoop.balancer.useClusterStats`.

oracle.hadoop.balancer.minSplits
Type: Integer

Default Value: `5`

Description: Sets the minimum number of splits that the sampler reads. If the total number of splits is less than this value, then the sampler reads all splits. Set this property to a value greater than or equal to one (`1`). A nonpositive number sets the property to `1`.

oracle.hadoop.balancer.numThreads
Type: Integer

Default Value: `5`

Description: Number of sampler threads. Set this value based on the processor and memory resources available on the node where the job is initiated. A higher number of sampler threads implies higher concurrency in sampling. Set this property to one (`1`) to disable multithreading in the sampler.

oracle.hadoop.balancer.report.overwrite
Type: Boolean

Default Value: `false`

Description: Controls whether Perfect Balance overwrites files in the location specified by the `oracle.hadoop.balancer.reportPath` property. By default, Perfect Balance does not overwrite files; it throws an exception. Set this property to `true` to allow partition reports to be overwritten.

oracle.hadoop.balancer.reportPath
Type: String

Default Value: *directory*/orabalancer_report-*random_unique_string*.xml, where directory for HDFS is the home directory of the user who submits the job. For the local file system, it is the directory where the job is submitted.

Description: The path where Perfect Balance writes the partition report before the Hadoop job output directory is available, that is, before the MapReduce job finishes running. At the end of the job, Perfect Balance moves the file to *job_output_dir*/_balancer/orabalancer_report.xml. In the API, the `save` method does this task.

See `oracle.hadoop.balancer.submitJob`.

oracle.hadoop.balancer.submitJob
Type: Boolean

Default Value: `true`

Description: Controls whether the `BalancerDriver` class submits the Hadoop job for execution. Set to `false` to prevent the job from executing. In this case, the partition report is stored in the path identified by `oracle.hadoop.balancer.reportPath`.

oracle.hadoop.balancer.tmpDir
Type: String

Default Value: /tmp/orabalancer-*user_name*

Description: The path to a staging directory in the file system of the job output directory (HDFS or local). Perfect Balance creates the directory if it does not exist, and copies the partition report to it for loading into the Hadoop distributed cache.

oracle.hadoop.balancer.tools.jobConfPath
Type: String

Default Value: `${mapred.output.dir}`/_logs/history

Description: The path to a Hadoop job configuration file. Job Analyzer uses this setting to locate the file.

oracle.hadoop.balancer.tools.jobHistoryPath
Type: String

Default Value: `${mapred.output.dir}`/_logs/history

Description: The path to a Hadoop job history file. Job Analyzer uses this setting to locate the file.

oracle.hadoop.balancer.tools.printRecommendation
Type: Boolean

Default Value: `false`

Description: Controls whether Job Analyzer recommends values for the key load model properties, based on the elapsed time, input record, and input value byte statistics it gathers for each key. Job Analyzer does not print a recommendation in its report if it cannot make a confident recommendation. You can set the load model properties to the recommended values when running a balanced job. See "Load Model Properties" on page 4-14.

oracle.hadoop.balancer.tools.useCountingReducer
Type: Boolean

Default Value: `false`

Description: Controls whether Job Analyzer can collect load statistics for each reduce task in a job. Set to `true` to allow statistics collection. The Perfect Balance driver uses this property; the API does not.

oracle.hadoop.balancer.tools.writeKeyBytes
Type: Boolean

Default Value: `false`

Description: Controls whether the counting reducer collects the byte representations of the reduce keys for the Job Analyzer. Set this property to `true` to represent the unique key values in base64 in the report. A string representation of the key, created using `key.toString`, is also provided in the report. This string value may not be unique for each key.

oracle.hadoop.balancer.useClusterStats
Type: Boolean

Default Value: `true`

Description: Enables the sampler to use cluster sampling statistics. These statistics improve the accuracy of sampled estimates, such as the number of records in a map-output key, when the map-output keys are distributed in clusters across input splits, instead of being distributed independently across all input splits.

Set this property to `false` only if you are absolutely certain that the map-output keys are not clustered. This setting improves the sampler's estimates only when there is, in fact, no clustering. Oracle recommends leaving this property set to `true`, because the distribution of map-output keys is usually unknown.

oracle.hadoop.balancer.useMapreduceApi
Type: Boolean

Default Value: `true`

Description: Identifies the MapReduce API used in the Hadoop job:

- `true`: The job uses the `mapreduce` API.
- `false`: The job uses the `mapred` API.

5

Configuring Oracle Exadata Database Machine for Use with Oracle Big Data Appliance

This chapter provides information about optimizing communications between Oracle Exadata Database Machine and Oracle Big Data Appliance. It describes how you can configure Oracle Exadata Database Machine to use InfiniBand alone, or SDP over InfiniBand, to communicate with Oracle Big Data Appliance.

This chapter contains the following sections:

About Optimizing Communications

Oracle Exadata Database Machine and Oracle Big Data Appliance use Ethernet by default, although typically they are also connected by an InfiniBand network. Ethernet communications are much slower than InfiniBand. After you configure Oracle Exadata Database Machine to communicate using InfiniBand, it can obtain data from Oracle Big Data Appliance many times faster than before.

Moreover, client applications that run on Oracle Big Data Appliance and push the data to Oracle Database can use Sockets Direct Protocol (SDP) for an additional performance boost. SDP is a standard communication protocol for clustered server environments, providing an interface between the network interface card and the application. By using SDP, applications place most of the messaging burden upon the network interface card, which frees the CPU for other tasks. As a result, SDP decreases network latency and CPU utilization, and thereby improves performance.

About Applications that Pull Data Into Oracle Exadata Database Machine

Oracle SQL Connector for Hadoop Distributed File System (HDFS) is an example of an application that pulls data into Oracle Exadata Database Machine. The connector enables an Oracle external table to access data stored in either HDFS files or a Hive table.

The external table provide access to the HDFS data. You can use the external table for querying HDFS data or for loading it into an Oracle database table.

Oracle SQL Connector for HDFS functions as a Hadoop client running on the database servers in Oracle Exadata Database Machine.

If you use Oracle SQL Connector for HDFS or another tool that pulls the data into Oracle Exadata Database Machine, then for the best performance, you should configure the system to use InfiniBand. See "Specifying the InfiniBand Connections to Oracle Big Data Appliance" on page 5-2.

> **See Also :** *Oracle Big Data Connectors User's Guide* for information about Oracle SQL Connector for HDFS

About Applications that Push Data Into Oracle Exadata Database Machine

Oracle Loader for Hadoop is an example of an application that pushes data into Oracle Exadata Database Machine. The connector is an efficient and high-performance loader for fast movement of data from a Hadoop cluster into a table in an Oracle database. You can use it to load data from Oracle Big Data Appliance to Oracle Exadata Database Machine.

Oracle Loader for Hadoop functions as a database client running on the Oracle Big Data Appliance. It must make database connections from Oracle Big Data Appliance to Oracle Exadata Database Machine over the InfiniBand network. Use of Sockets Direct Protocol (SDP) for these database connections further improves performance.

If you use Oracle Loader for Hadoop or another tool that pushes the data into Oracle Exadata Database Machine, then for the best performance, you should configure the system to use SDP over InfiniBand as described in this chapter.

> **See Also :** *Oracle Big Data Connectors User's Guide* for information about Oracle Loader for Hadoop

Prerequisites

Oracle Big Data Appliance and Oracle Exadata Database Machine racks must be cabled together using InfiniBand cables. The IP addresses must be unique across all racks and use the same subnet for the InfiniBand network.

> **See Also:**
>
> - *Oracle Big Data Appliance Owner's Guide* about multirack cabling
> - *Oracle Big Data Appliance Configuration Worksheets* about IP addresses and subnets

Specifying the InfiniBand Connections to Oracle Big Data Appliance

You can configure Oracle Exadata Database Machine to use the InfiniBand IP addresses of the Oracle Big Data Appliance servers. Otherwise, the default network is Ethernet. Use of the InfiniBand network improves the performance of all data transfers between Oracle Big Data Appliance and Oracle Exadata Database Machine.

To identify the Oracle Big Data Appliance InfiniBand IP addresses:

1. If you have not done so already, install a CDH client on Oracle Exadata Database Machine. See "Providing Remote Client Access to CDH" on page 3-1.
2. Obtain a list of host names and InfiniBand IP addresses for all Oracle Big Data Appliance servers.

   An Oracle Big Data Appliance rack can have 6, 12, or 18 servers.

3. Log in to Oracle Exadata Database Machine with `root` privileges.
4. Edit /etc/hosts on Oracle Exadata Database Machine and add the Oracle Big Data Appliance host names and InfiniBand IP addresses. The following example shows the sequential IP numbering:

```
192.168.8.1       bda1node01.example.com    bda1node01
192.168.8.2       bda1node02.example.com    bda1node02
192.168.8.3       bda1node03.example.com    bda1node03
192.168.8.4       bda1node04.example.com    bda1node04
192.168.8.5       bda1node05.example.com    bda1node05
192.168.8.6       bda1node06.example.com    bda1node06
```

5. Check /etc/nsswitch.conf for a line like the following:

```
hosts:      files dns
```

   Ensure that the line does not reverse the order (`dns files`); if it does, your additions to /etc/hosts will not be used. Edit the file if necessary.

6. Ping all Oracle Big Data Appliance servers. Ensure that `ping` completes and shows the InfiniBand IP addresses.

```
# ping bda1node01.example.com
PING bda1node01.example.com (192.168.8.1) 56(84) bytes of data.
64 bytes from bda1node01.example.com (192.168.8.1): icmp_seq=1 ttl=50 time=20.2
ms
     .
     .
     .
```

7. Run CDH locally on Oracle Exadata Database Machine and test HDFS functionality by uploading a large file to a Oracle Big Data Appliance server. Check that your network monitoring tools (such as `sar`) show I/O activity on the InfiniBand devices.

   To upload the file, use syntax like the following, which copies localfile.dat to the HDFS testdir directory on node05 of Oracle Big Data Appliance:

```
hadoop fs -put localfile.dat hdfs://bda1node05.example.com/testdir/
```

Enabling SDP on Exadata Database Nodes

The following procedure describes how to enable SDP on database nodes in an Oracle Exadata Database Machine running Oracle Linux. SDP improves the performance of client applications that run on Oracle Big Data Appliance and push data to Oracle Exadata Database Machine.

To enable SDP on Oracle Exadata Database Machine:

1. Open /etc/infiniband/openib.conf file in a text editor, and add the following line:

```
set: SDP_LOAD=yes
```

2. Save these changes and close the file.
3. To enable both SDP and TCP, open /etc/ofed/libsdp.conf in a text editor, and add the `use both` rule:

```
use both server * :
use both client * :
```

4. Save these changes and close the file.

5. Open `/etc/modprobe.conf` file in a text editor, and add this setting:

   ```
   options ib_sdp sdp_zcopy_thresh=0 recv_poll=0
   ```

6. Save these changes and close the file.
7. Replicate these changes across all database nodes in the Oracle Exadata Database Machine rack.
8. Restart all database nodes for the changes to take effect.
9. If you have multiple Oracle Exadata Database Machine racks, then repeat these steps on all of them.

Configuring a JDBC Client for SDP

The following procedure explains how to configure a JDBC client to use SDP.

To enable SDP support for JDBC:

1. Configure the database to support InfiniBand, as described in the *Oracle Database Net Services Administrator's Guide*. Ensure that you set the protocol to SDP.
2. Set the `LD_PRELOAD` environment variable to libsdp.so before starting the Java virtual machine. This example uses the Bash shell:

   ```
   export LD_PRELOAD="libsdp.so"
   ```

Creating an SDP Listener on the InfiniBand Network

To add a listener for the Oracle Big Data Appliance connections coming in on the InfiniBand network, first add a network resource for the InfiniBand network with virtual IP addresses.

> **Note:** This example lists two nodes for an Oracle Exadata Database Machine quarter rack. If you have an Oracle Exadata Database Machine half or full rack, you must repeat node-specific lines for each node in the cluster.

1. Edit `/etc/hosts` on each node in the Exadata rack to add the virtual IP addresses for the InfiniBand network. Make sure that these IP addresses are not in use. For example:

   ```
   # Added for Listener over IB
   192.168.10.21 dm01db01-ibvip.example.com dm01db01-ibvip
   192.168.10.22 dm01db02-ibvip.example.com dm01db02-ibvip
   ```

2. As the `root` user, create a network resource on one database node for the InfiniBand network. For example:

   ```
   # /u01/app/grid/product/11.2.0.2/bin/srvctl add network -k 2 -S
   192.168.10.0/255.255.255.0/bondib0
   ```

3. Verify that the network was added correctly with a command like the following examples:

   ```
   # /u01/app/grid/product/11.2.0.2/bin/crsctl stat res -t | grep net
   ora.net1.network
   ora.net2.network -- Output indicating new Network resource
   ```

or

```
# /u01/app/grid/product/11.2.0.2/bin/srvctl config network -k 2
Network exists: 2/192.168.10.0/255.255.255.0/bondib0, type static -- Output
indicating Network resource on the 192.168.10.0 subnet
```

4. Add the virtual IP addresses on the network created in Step 2, for each node in the cluster. For example:

```
# srvctl add vip -n dm01db01 -A dm01db01-ibvip/255.255.255.0/bondib0 -k 2
#
# srvctl add vip -n dm01db02 -A dm01db02-ibvip/255.255.255.0/bondib0 -k 2
```

5. As the `oracle` user who owns Grid Infrastructure Home, add a listener for the virtual IP addresses created in Step 4.

```
# srvctl add listener -l LISTENER_IB -k 2 -p TCP:1522,/SDP:1522
```

6. For each database that will accept connections from the middle tier, modify the `listener_networks init` parameter to allow load balancing and failover across multiple networks (Ethernet and InfiniBand). You can either enter the full `TNSNAMES` syntax in the initialization parameter or create entries in `tnsnames.ora` in the `$ORACLE_HOME/network/admin` directory. The `TNSNAMES.ORA` entries must exist in `GRID_HOME`. The following example first updates `tnsnames.ora`.

   Complete this step on each node in the cluster with the correct IP addresses for that node. `LISTENER_IBREMOTE` should list all other nodes that are in the cluster. `DBM_IB` should list all nodes in the cluster.

   Note: The `TNSNAMES` entry is only read by the database instance on startup, if you modify the entry that is referred to by any `init.ora` parameter (`LISTENER_NETWORKS`), you must restart the instance or issue an `ALTER SYSTEM SET LISTENER_NETWORKS` command for the modifications to take affect by the instance.

```
DBM =
(DESCRIPTION =
(ADDRESS = (PROTOCOL = TCP)(HOST = dm01-scan)(PORT = 1521))
(CONNECT_DATA =
(SERVER = DEDICATED)
(SERVICE_NAME = dbm)
))

DBM_IB =
(DESCRIPTION =
(LOAD_BALANCE=on)
(ADDRESS = (PROTOCOL = TCP)(HOST = dm01db01-ibvip)(PORT = 1522))
(ADDRESS = (PROTOCOL = TCP)(HOST = dm01db02-ibvip)(PORT = 1522))
(CONNECT_DATA =
(SERVER = DEDICATED)
(SERVICE_NAME = dbm)
))

LISTENER_IBREMOTE =
(DESCRIPTION =
(ADDRESS_LIST =
(ADDRESS = (PROTOCOL = TCP)(HOST = dm01db02-ibvip.mycompany.com)(PORT = 1522))
))
```

```
LISTENER_IBLOCAL =
(DESCRIPTION =
(ADDRESS_LIST =
(ADDRESS = (PROTOCOL = TCP)(HOST = dm01db01-ibvip.mycompany.com)(PORT = 1522))
(ADDRESS = (PROTOCOL = SDP)(HOST = dm01db01-ibvip.mycompany.com)(PORT = 1523))
))

LISTENER_IPLOCAL =
(DESCRIPTION =
(ADDRESS_LIST =
(ADDRESS = (PROTOCOL = TCP)(HOST = dm0101-vip.mycompany.com)(PORT = 1521))
))

LISTENER_IPREMOTE =
(DESCRIPTION =
(ADDRESS_LIST =
(ADDRESS = (PROTOCOL = TCP)(HOST = dm01-scan.mycompany.com)(PORT = 1521))
))
```

7. Connect to the database instance as `sysdba`.
8. Modify the `listener_networks init` parameter by using the SQL `ALTER SYSTEM` command:

```
SQL> alter system set listener_networks=
     '((NAME=network2) (LOCAL_LISTENER=LISTENER_IBLOCAL)
        (REMOTE_LISTENER=LISTENER_IBREMOTE))',
     '((NAME=network1)(LOCAL_LISTENER=LISTENER_IPLOCAL)
        (REMOTE_LISTENER=LISTENER_IPREMOTE))' scope=both;
```

9. On the Linux command line, use the `srvctl` command to restart `LISTENER_IB` to implement the modification in Step 7:

```
# srvctl stop listener -l LISTENER_IB
# srvctl start listener -l LISTENER_IB
```

Glossary

ASR

Oracle Auto Service Request, a software tool that monitors the health of the hardware and automatically generates a service request if it detects a problem.

See also **OASM**.

Balancer

A service that ensures that all nodes in the cluster store about the same amount of data, within a set range. Data is balanced over the nodes in the cluster, not over the disks in a node.

CDH

Cloudera's Distribution including Apache Hadoop, the version of Apache Hadoop and related components installed on Oracle Big Data Appliance.

Cloudera's Distribution including Apache Hadoop (CDH)

See **CDH**.

cluster

A group of servers on a network that are configured to work together. A server is either a master node or a worker node.

All servers in an Oracle Big Data Appliance rack form a cluster. Servers 1, 2, and 3 are master nodes. Servers 4 to 18 are worker nodes.

See **Hadoop**.

DataNode

A server in a CDH cluster that stores data in HDFS. A DataNode performs file system operations assigned by the NameNode.

See also **HDFS**; **NameNode**.

Flume

A distributed service in CDH for collecting and aggregating data from almost any source into a data store such as HDFS or HBase.

See also **HBase**; **HDFS**.

Hadoop

A batch processing infrastructure that stores files and distributes work across a group of servers. Oracle Big Data Appliance uses Cloudera's Distribution including Apache Hadoop (CDH).

Hadoop Distributed File System (HDFS)

See **HDFS**.

Hadoop User Experience (Hue)

See **Hue**.

HBase

An open-source, column-oriented database that provides random, read/write access to large amounts of sparse data stored in a CDH cluster. It provides fast lookup of values by key and can perform thousands of insert, update, and delete operations per second.

HDFS

Hadoop Distributed File System, an open-source file system designed to store extremely large data files (megabytes to petabytes) with streaming data access patterns. HDFS splits these files into data blocks and distributes the blocks across a CDH cluster.

When a data set is larger than the storage capacity of a single computer, then it must be partitioned across several computers. A distributed file system can manage the storage of a data set across a network of computers.

See also **cluster**.

Hive

An open-source data warehouse in CDH that supports data summarization, ad hoc querying, and data analysis of data stored in HDFS. It uses a SQL-like language called HiveQL. An interpreter generates MapReduce code from the HiveQL queries.

By using Hive, you can avoid writing MapReduce programs in Java.

See also **Hive Thrift**; **HiveQL**; **MapReduce**.

Hive Thrift

A remote procedure call (RPC) interface for remote access to CDH for Hive queries.

See also **CDH**; **Hive**.

HiveQL

A SQL-like query language used by Hive.

See also **Hive**.

HotSpot

A Java Virtual Machine (JVM) that is maintained and distributed by Oracle. It automatically optimizes code that executes frequently, leading to high performance. HotSpot is the standard JVM for the other components of the Oracle Big Data Appliance stack.

Hue

Hadoop User Experience, a web user interface in CDH that includes several applications, including a file browser for HDFS, a job browser, an account management tool, a MapReduce job designer, and Hive wizards. Cloudera Manager runs on Hue.

See also **HDFS**; **Hive**.

Java HotSpot Virtual Machine

See **HotSpot**.

JobTracker

A service that assigns MapReduce tasks to specific nodes in the CDH cluster, preferably those nodes storing the data.

See also **Hadoop**; **MapReduce**.

MapReduce

A parallel programming model for processing data on a distributed system.

A MapReduce program contains these functions:

- Mappers: Process the records of the data set.
- Reducers: Merge the output from several mappers.
- Combiners: Optimizes the result sets from the mappers before sending them to the reducers (optional).

MySQL Server

A SQL-based relational database management system. Cloudera Manager, Oracle Data Integrator, Hive, and Oozie use MySQL Server as a metadata repository on Oracle Big Data Appliance.

NameNode

A service that maintains a directory of all files in HDFS and tracks where data is stored in the CDH cluster.

See also **HDFS**.

node

A server in a CDH cluster.

See also **cluster**.

NoSQL Database

See **Oracle NoSQL Database**.

OASM

Oracle Automated Service Manager, a service for monitoring the health of Oracle Sun hardware systems. Formerly named Sun Automatic Service Manager (SASM).

Oozie

An open-source workflow and coordination service for managing data processing jobs in CDH.

Oracle Database Instant Client

A small-footprint client that enables Oracle applications to run without a standard Oracle Database client.

Oracle Linux

An open-source operating system. Oracle Linux 5.6 is the same version used by Exalogic 1.1. It features the Oracle Unbreakable Enterprise Kernel.

Oracle NoSQL Database

A distributed key-value database that supports fast querying of the data, typically by key lookup.

Oracle R Distribution

An Oracle-supported distribution of the R open-source language and environment for statistical analysis and graphing.

Oracle R Enterprise

A component of the Oracle Advanced Analytics Option. It enables R users to run R commands and scripts for statistical and graphical analyses on data stored in an Oracle database.

Pig

An open-source platform for analyzing large data sets that consists of the following:

- Pig Latin scripting language
- Pig interpreter that converts Pig Latin scripts into MapReduce jobs

Pig runs as a client application.

See also **MapReduce**.

Puppet

A configuration management tool for deploying and configuring software components across a cluster. The Oracle Big Data Appliance initial software installation uses Puppet.

The Puppet tool consists of these components: puppet agents, typically just called puppets; the puppet master server; a console; and a cloud provisioner.

See also **puppet agent**; **puppet master**.

puppet agent

A service that primarily pulls configurations from the puppet master and applies them. Puppet agents run on every server in Oracle Big Data Appliance.

See also **Puppet**; **puppet master**

puppet master

A service that primarily serves configurations to the puppet agents.

See also **Puppet**; **puppet agent**.

Sqoop

A command-line tool that imports and exports data between HDFS or Hive and structured databases. The name Sqoop comes from "SQL to Hadoop." Oracle R Connector for Hadoop uses the Sqoop executable to move data between HDFS and Oracle Database.

table

In Hive, all files in a directory stored in HDFS.

See also **HDFS**.

TaskTracker

A service that runs on each node and executes the tasks assigned to it by the JobTracker service.

See also **JobTracker**.

ZooKeeper

A centralized coordination service for CDH distributed processes that maintains configuration information and naming, and provides distributed synchronization and group services.

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