Product Documentation

Pivotal™ HD

Version 2.1

Stack and Tools Reference

Rev: A03

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Chapter 1

Overview of Apache Stack and Pivotal Components

Pivotal HD Enterprise is an enterprise-capable, commercially supported distribution of Apache Hadoop packages targeted to traditional Hadoop deployments.

Deployment/Installation Options

Pivotal HD Enterprise supports two options for deployment/installation:

- Deployment through Pivotal Command Center
- Manual installation of RPMs

Pivotal Command Center Deployment

Pivotal Command Center (PCC) is a Web-based interface that supports performing the following actions for Pivotal HD Enterprise:

- Monitoring and management of a Pivotal HD (PHD) environment.
- Deployment and configuration of PHD clusters.

PCC also provides a CLI (Command-Line Interface) which can be used to deploy and configure PHD clusters. You can deploy **most** of the components through the PCC GUI or CLI. However, note that some components (specifically Flume, Sqoop, Oozie, Hamster and GraphLab) can **only** be installed manually.

- For more information about using the GUI, see *Pivotal Command Center User Guide*.
- For more information about using the CLI, see *Pivotal HD Enterprise Installation and Administrator Guide*.

Manual Installation

All the Hadoop and Pivotal components **can** be installed manually without using the PCC GUI or CLI. For manual installs, Pivotal HD Enterprise provides RPM files.

This document provides detailed manual instructions for installing all the Apache components, as well as some of the additional components.

The following sections provide more details about each component, including the various supported deployment options for each component.

Core Apache Stack Components

Component	Description	CLI/GUI Install	Manual Install (RPM)
Hadoop	HDFS: A Hadoop distributed file system (HDFS). YARN: Next-generation Hadoop data-processing framework.	✓	✓
Pig	Procedural language that abstracts lower level MapReduce.	✓	✓
Hive	Data warehouse infrastructure built on top of Hadoop.	✓	✓
HBase	Database for random real time read/write access.	✓	✓
Hcatalog	HCatalog is a table and storage management layer for Hadoop that enables users with different data processing tools — e.g. Pig, MapReduce — to more easily read and write data on the grid.	✓	✓
Mahout	Scalable machine learning and data mining library.	✓	✓
Zookeeper	Hadoop centralized service for maintaining configuration information, naming, providing distributed synchronization, and providing group services.	✓	✓
Flume	A tool used for collecting and aggregating data from multiple sources to a centralized data store.		✓
Sqoop	A tool for transferring bulk data between		✓

Component	Description	CLI/GUI Install	Manual Install (RPM)
	Apache Hadoop and structured datastores.		
Oozie	A workflow scheduler system to manage Apache Hadoop jobs. Oozie Workflow jobs are Directed Acyclical Graphs (DAGs) of actions. Oozie Coordinator jobs are recurrent Oozie Workflow jobs triggered by time (frequency) and data availability.		✓

Pivotal Other Components

Component	Description	CLI/GUI Install	Manual Install (RPM)
Pivotal Command Center (installs the CLI)	A command line and web-based tool for installing, managing and monitoring your Pivotal HD cluster.		✓
Pivotal ADS - HAWQ	HAWQ is a parallel SQL query engine that combines the merits of the Greenplum Database Massively Parallel Processing (MPP) relational database engine and the Hadoop parallel processing framework.	✓	✓
Pivotal ADS - PXF	Extensibility layer to provide support for external data formats such as HBase and Hive.	✓	✓
Hamster	Developed by Pivotal, Hamster is a framework which enable users running MPI programs on Apache Hadoop YARN platform. (OpenMPI is a A High Performance Message Passing Library)		✓

Component	Description	CLI/GUI Install	Manual Install (RPM)
GraphLab	GraphLab is a powerful new system for designing and implementing parallel algorithms in machine learning. It is a graph-based, high performance, distributed computation framework written in C++ that makes use of MPI and has its own programming model.		✓

Location of Installation Instructions

You can find installation instructions for the above components in these documents:

Component	GUI Install	CLI Install	Manual Install
Pivotal Command Center	NOT SUPPORTED	*Pivotal HD Enterprise Installation and Administrator Guide*	NOT SUPPORTED
Pivotal Hadoop Stack	*Pivotal Command Center User Guide*	*Pivotal HD Enterprise Installation and Administrator Guide*	This guide.
Pivotal ADS (HAWQ and PXF)	*Pivotal Command Center User Guide*	*Pivotal HD Enterprise Installation and Administrator Guide*	*Pivotal Extension Framework Installation and User Guide*

Hadoop Versions

PHD 2.1 is based upon Hadoop 2.2.0.

How to Use this Document

Manual Installation Instructions:

- Manually installing a YARN-based cluster using the RPM distribution. See *Manually Installing and Using Pivotal HD 2.1 Stack* on page 12.

Upgrade Instructions:

- Manually upgrading a YARN-based cluster using the RPM distribution. See *Manually Upgrading Pivotal HD Stack to 2.1.0* on page 70.

Security:

- Manually securing your cluster via Kerberos. See *Security* on page 90.

Chapter 2

Manually Installing and Using Pivotal HD 2.1 Stack

This section describes how to manually install and use all the components included with Pivotal HD 2.1.

Distribution Contents

Pivotal HD is a full Apache Hadoop distribution with Pivotal add-ons and a native integration with Pivotal HAWQ.

The RPM distribution of PHD contains the following:

- **Hadoop 2.2.0**
- **Pig 0.12.0**
- **Zookeeper 3.4.5**
- **HBase 0.96.0**
- **Hive 0.12.0**
- **Hcatalog 0.12.0**
- **Mahout 0.7**
- **Flume 1.4.0**
- **Sqoop 1.4.2**
- **Oozie 4.0.0**
- **Hamster 1.1**
- **GraphLab 2.2**

Apache Configuration Reference

The following table provides links to configuration resources for Apache Hadoop and its components:

Component	**Configuration Reference**
Hadoop (HDFS, Yarn)	*http://hadoop.apache.org/docs/r2.2.0/*
Zookeeper	*http://zookeeper.apache.org/doc/r3.4.5/zookeeperStarted.html*
Hbase	*http://hbase.apache.org/book.html*
Hive/Hcatalog	*https://cwiki.apache.org/confluence/display/Hive/Home* *https://cwiki.apache.org/confluence/display/Hive/HBaseIntegration*
Pig	*http://pig.apache.org/docs/r0.12.0/start.html*

Component	Configuration Reference
Mahout	*http://mahout.apache.org/*
Flume	*https://flume.apache.org/releases/1.4.0.html*
Sqoop	*http://sqoop.apache.org/docs/1.4.2/*
Oozie	*http://oozie.apache.org/docs/4.0.0/*

Accessing PHD 2.1

Download and extract the PHD package to your working directory:

```
$>  tar zxvf PHD-2.1.0.0-<nn>.tar.gz
$>  ls -p PHD-2.1.0.0-<nn>
flume/     hadoop/   hbase/     hive/    oozie/                       pig/
   utility/
graphlab/  hamster/  hcatalog/  mahout/  open_source_licenses_PHD.txt
 sqoop/  zookeeper/
```

We define the replaced string, which we use in the following sections for each component, as follows:

Component	PHD Version	Replaced String
Hadoop	`2.2.0_gphd_3_1_0_0`	`<PHD_HADOOP_VERSION>`
HBase	`0.96.0_gphd_3_1_0_0`	`<PHD_HBASE_VERSION>`
Hive	`0.12.0_gphd_3_1_0_0`	`<PHD_HIVE_VERSION>`
Pig	`0.12.0_gphd_3_1_0_0`	`<PHD_PIG_VERSION>`
Mahout	`0.7_gphd_3_1_0_0`	`<PHD_MAHOUT_VERSION>`
HCatalog	`0.12.0_gphd_3_1_0_0`	`<PHD_HCATALOG_VERSION>`
Sqoop	`1.4.2_gphd_3_1_0_0`	`<PHD_SQOOP_VERSION>`
Flume	`1.4.0_gphd_3_1_0_0`	`<PHD_FLUME_VERSION>`
Zookeeper	`3.4.5_gphd_3_1_0_0`	`<PHD_ZOOKEEPER_VERSION>`
Oozie	`4.0.0_gphd_3_1_0_0`	`<PHD_OOZIE_VERSION>`
bigtop-jsvc	`1.0.15_gphd_3_1_0_0`	`<PHD_BIGTOP_JSVC_VERSION>`
bigtop-utils	`0.4.0_gphd_3_1_0_0`	`<PHD_BIGTOP_UTILS_VERSION>`
bigtop-tomcat	`6.0.36_gphd_3_1_0_0`	`PHD_BIGTOP_TOMCAT_VERSION>`

The following sections describe how to manually install Pivotal HD 2.1.

Prerequisities

- Oracle Java Development Kit (JDK) 1.7 must be installed on every machine before installing any of the Hadoop components. Pivotal recommends JDK version 1.7u45.
- You must ensure that time synchronization and DNS are functioning correctly on all client and server machines. For example, run the following command to sync the time with NTP server:

```
$> service ntpd stop; ntpdate <DNS server IP address>; service ntpd start
```

Installation Notes

In this section, we install packages by running the following command:

```
rpm -ivh <package_name>-<version>-<nn>.rpm
```

Where:

<*version*> is the PHD version.

<*nn*> is the build number.

Hadoop HDFS

About Hadoop HDFS

The Hadoop Distributed File System (HDFS) is the primary distributed storage used by Hadoop applications. It is a distributed file system designed to provide reliable, scalable, self-healing, high bandwidth, clustered storage.

Installing Hadoop HDFS

This section provides instructions for installing each of the following core Hadoop RPMs:

- HDFS Namenode Setup
- HDFS Datanode Setup
- HDFS Secondary Namenode Setup
- HDFS NFS Gateway Setup

Hadoop HDFS RPM Packages

Pivotal provides the following RPMs as part of this release. The core packages provide all executables, libraries, configurations, and documentation for Hadoop and are required on every node in the Hadoop cluster as well as on the client workstation that will access the Hadoop service. The daemon packages provide a convenient way to manage Hadoop HDFS daemons as Linux services, which rely on the core package.

hadoop-<PHD_HADOOP_VERSION>-<nn>.x86_64.rpm	
Type	Core
Requires	bigtop-utils, zookeeper-core
Description	Hadoop core packages provides the common core packages for running Hadoop
Install on Nodes	Every node in the Hadoop cluster and the client workstation that will access the Hadoop service.

hadoop-hdfs-<PHD_HADOOP_VERSION>-<nn>.x86_64.rpm	
Type	Core
Requires	Hadoop, bigtop-jsvc
Description	Hadoop HDFS core packages provides the common files for running HFS.
Install on Nodes	Every node in the HDFS cluster and the client workstation that will access the HDFS.

hadoop-hdfs-namenode-<PHD_HADOOP_VERSION>-<nn>.x86_64.rpm	
Type	Daemon
Requires	hadoop-hdfs
Description	Daemon scripts package for Hadoop Namenode, which provides a convenient method to manage Namenode start/stop as a Linux service.
Install on Nodes	HDFS Namenode server only

hadoop-hdfs-datanode-<PHD_HADOOP_VERSION>-<nn>.x86_64.rpm	
Type	Daemon
Requires	hadoop-hdfs
Description	Daemon scripts package for Hadoop Datanode, which provides a convenient method to manage datanode start/stop as a Linux service.
Install on Nodes	All HDFS Datanodes

hadoop-hdfs-secondarynamenode-<PHD_HADOOP_VERSION>-<nn>.x86_64.rpm	
Type	Daemon
Requires	hadoop-hdfs
Description	Daemon scripts package for Hadoop SecondaryNamenode, which provides a convenient method to manage SecondaryNamenode start/stop as a Linux service.
Install on Nodes	One server that will act as the Secondary Namenode

hadoop-hdfs-journalnode-<PHD_HADOOP_VERSION>-<nn>.x86_64.rpm	
Type	Daemon
Requires	hadoop-hdfs
Description	Daemon scripts package for Hadoop JournalNode, which provides a convenient method to manage journalnode start/stop as a Linux service.
Install on Nodes	All HDFS JournalNodes

hadoop-hdfs-nfs3-<PHD_HADOOP_VERSION>-<nn>.x86_64.rpm	
Type	Daemon
Requires	hadoop-hdfs
Description	Daemon scripts package for Hadoop NFS gateway, which provides a convenient method to manage NFS gateway start/stop as a Linux service.
Install on Nodes	Node serving as the NFS server

hadoop-hdfs-portmap-<PHD_HADOOP_VERSION>-<nn>.x86_64.rpm	
Type	Daemon
Requires	hadoop-hdfs
Description	Daemon scripts package for Hadoop portmap, which provides a convenient method to manage portmap start/stop as a Linux service.
Install on Nodes	Node serving as the NFS server

hadoop-hdfs-zkfc-<PHD_HADOOP_VERSION>-<nn>.x86_64.rpm	
Type	Daemon
Requires	hadoop-hdfs
Description	Daemon scripts package for Hadoop zkfc, which provides a convenient method to manage zkfc start/stop as a Linux service.
Install on Nodes	All HDFS zkfc nodes

hadoop-hdfs-fuse-<PHD_HADOOP_VERSION>-<nn>.x86_64.rpm	
Type	Core
Requires	hadoop-libhdfs, hadoop-client
Description	Binaries that can be used to mount hdfs as a local directory.
Install on Nodes	Servers that mount the HDFS

hadoop-libhdfs-<PHD_HADOOP_VERSION>-<nn>.x86_64.rpm	
Type	Core

Requires	hadoop-hdfs
Description	Native implementation of the HDFS.
Install on Nodes	Servers that run native HDFS

hadoop-httpfs-<PHD_HADOOP_VERSION>-<nn>.x86_64.rpm	
Type	Core
Requires	bigtop-tomcat, Hadoop, hadoop-hdfs
Description	HttpFS is a server that provides a REST HTTP gateway supporting all HDFS File System operations (read and write).
Install on Nodes	Servers that will be serving the REST HDFS service

hadoop-doc-<PHD_HADOOP_VERSION>-<nn>.x86_64.rpm	
Type	Doc
Requires	N/A
Description	Hadoop documentation package.

hadoop-client-<PHD_HADOOP_VERSION>-<nn>.x86_64.rpm	
Type	Library
Requires	Hadoop, hadoop-yarn, hadoop-mapreduce, hadoop-hdfs
Description	A set of symbolic links which gathers the libraries for programming Hadoop and submit Hadoop jobs.
Install on Nodes	Clients nodes that will be used to submit Hadoop jobs

Prerequisites: Core Package Setup

Perform the following steps on all the nodes in the Hadoop cluster and its client nodes:

```
$ sudo rpm -ivh working_dir/utility/rpm/bigtop-utils-
<PHD_BIGTOP_UTILS_VERSION>-<nn>.noarch.rpm
$ sudo rpm -ivh working_dir/zookeeper/rpm/zookeeper-<PHD_ZOOKEEPER_VERSION>-
<nn>.noarch.rpm
$ sudo rpm -ivh working_dir/hadoop/rpm/hadoop-<PHD_HADOOP_VERSION>-
<nn>.x86_64.rpm
```

Where `working_dir` is the directory where you want the rpms expanded.

HDFS Namenode Setup

Install the Hadoop Namenode package on the workstation that will serve as HDFS Namenode:

```
$ sudo rpm -ivh working_dir/utility/rpm/bigtop-jsvc-
<PHD_BIGTOP_JSVC_VERSION>-<nn>.x86_64.rpm
$ sudo rpm -ivh working_dir/hadoop/rpm/hadoop-hdfs-<PHD_HADOOP_VERSION>-
<nn>.x86_64.rpm
```

```
$ sudo rpm -ivh working_dir/hadooop/rpm/hadoop-hdfs-namenode-
<PHD_HADOOP_VERSION>-<nn>.x86_64.rpm
```

HDFS Datanode Setup

Install the Hadoop Datanode package on the workstation that will serve as the HDFS Datanode:

```
$ sudo rpm -ivh working_dir/utility/rpm/bigtop-jsvc-
<PHD_BIGTOP_JSVC_VERSION>-<nn>.x86_64.rpm
$ sudo rpm -ivh working_dir/hadoop/rpm/hadoop-hdfs-<PHD_HADOOP_VERSION>-
<nn>.x86_64.rpm
$ sudo rpm -ivh working_dir/hadoop/rpm/hadoop-hdfs-datanode-
<PHD_HADOOP_VERSION>-<nn>.x86_64.rpm
```

HDFS Secondary Namenode Setup

Install the Hadoop Secondary Namenode package on the workstation that will serve as the HDFS Secondary Namenode:

```
$ sudo rpm -ivh working_dir/utility/rpm/bigtop-jsvc-
<PHD_BIGTOP_JSVC_VERSION>-<nn>.x86_64.rpm
$ sudo rpm -ivh working_dir/hadoop/rpm/hadoop-hdfs-<PHD_HADOOP_VERSION>-
<nn>.x86_64.rpm
$ sudo rpm -ivh working_dir/hadoop/rpm/hadoop-hdfs-secondarynamenode-
<PHD_HADOOP_VERSION>-<nn>.x86_64.rpm
```

HDFS NFS Gateway Setup

Install the Hadoop NFS gateway and portmap package on the workstation that will serve as the HDFS NFS gateway and portmap:

```
$ sudo rpm -ivh working_dir/utility/rpm/bigtop-jsvc-
<PHD_BIGTOP_JSVC_VERSION>-<nn>.x86_64.rpm
$ sudo rpm -ivh working_dir/hadoop/rpm/hadoop-hdfs-<PHD_HADOOP_VERSION>-
<nn>.x86_64.rpm
$ sudo rpm -ivh working_dir/hadoop/rpm/hadoop-hdfs-nfs3-
<PHD_HADOOP_VERSION>-<nn>.x86_64.rpm
$ sudo rpm -ivh working_dir/hadoop/rpm/hadoop-hdfs-portmap-
<PHD_HADOOP_VERSION>-<nn>.x86_64.rpm
```

HDFS Configuration

HDFS configuration files are located in the following directory:

`/etc/gphd/hadoop/conf/`

Refer to the Apache Hadoop documentation for how to configure HDFS in distributed mode.

Using Hadoop HDFS

After installing the daemon package for Hadoop, you can start the daemons, as follows:

Starting HDFS

HDFS includes three main components: Namenode, Datanode, Secondary Namenode.

To start the Namenode daemon:

Format the Namenode before starting it, as follows:

```
$ sudo service hadoop-hdfs-namenode init
```

Note: Note: You only have to do this once. However, if you have changed the Hadoop namenode configuration, you may need to run this again.

Then start the Namenode by running the following commands:

```
$ sudo service hadoop-hdfs-namenode start
```

When Namenode is started, you can visit its dashboard at: `http://localhost:50070/`

To start the Datanode daemon:

```
$ sudo service hadoop-hdfs-datanode start
```

To start the Secondary Namenode daemon:

```
$ sudo service hadoop-hdfs-secondarynamenode start
```

Starting NFS gateway

Three daemons are required to provide NFS service: portmap(or rpcbind), mountd and nfsd. The NFS gateway has both mountd and nfsd.

To start the portmap and NFS gateway daemon:

```
$ sudo service rpcbind stop
$ sudo service hadoop-hdfs-portmap start
$ sudo service hadoop-hdfs-nfs3 start
```

To mount the export "/":

Make sure nfs-utils is installed on the client:

```
$ sudo yum install -y nfs-utils
```

Then mount:

```
$ mount -t nfs -o vers=3,proto=tcp,nolock <nfsserver>:/  <mount_point>
```

Using HDFS

When the HDFS components are started, try some HDFS usage commands, for example:

```
$ sudo -u hdfs hdfs dfs -ls /
$ sudo -u hdfs hdfs dfs -mkdir -p /user/hadoop
$ sudo -u hdfs hdfs dfs -chown -R hadoop:hadoop /user/hadoop
$ sudo -u hdfs hdfs dfs -copyFromLocal /etc/passwd /user/hadoop/
```

Note: By default, the root folder is owned by user `hdfs`, so you have to use `sudo -u hdfs ***` to execute the first few commands.

Stopping HDFS

Stop the Namenode Daemon:

```
$ sudo service hadoop-hdfs-namenode stop
```

Stop the Datanode Daemon:

```
$ sudo service hadoop-hdfs-datanode stop
```

Stop the Secondary Namenode Daemon:

```
$ sudo service hadoop-hdfs-secondarynamenode stop
```

Stop the NFS gateway Daemon:

```
$ sudo service hadoop-hdfs-portmap stop
$ sudo service hadoop-hdfs-nfs3 stop
```

Hadoop YARN

About Hadoop YARN

Hadoop MapReduce is a software framework for easily writing applications which process vast amounts of data (multi-terabyte data-sets) in-parallel on large clusters (thousands of nodes) of commodity hardware in a reliable, fault-tolerant manner.

Apache overhauled MapReduce and released MapReduce 2.0 (MRv2) or YARN. YARN now splits the major functionalities of the JobTracker, resource management and job scheduling/monitoring, into separate daemons.

Installing Hadoop YARN

This section provides instructions for installing each of the following core Hadoop YARN RPMs:

- YARN ResourceManager Setup
- YARN NodeManager Setup
- Mapreduce HistoryServer Setup
- YARN ProxyServer Setup

Hadoop YARN RPM Packages

Pivotal provides the following RPMs as part of this release. The core packages provide all executables, libraries, configurations, and documentation for Hadoop and is required on every node in the Hadoop cluster, as well as on the client workstation that will access the Hadoop service. The daemon packages provide a convenient way to manage Hadoop YARN daemons as Linux services, which rely on the core package.

hadoop-<PHD_HADOOP_VERSION>-<nn>.x86_64.rpm	
Type	Core
Requires	bigtop-utils, zookeeper-core
Description	Hadoop core packages provides the common core packages for running Hadoop.
Install on Nodes	Every node in the Hadoop cluster and the client workstation that will access the Hadoop service

hadoop-yarn-<PHD_HADOOP_VERSION>-<nn>.x86_64.rpm	
Type	Core
Requires	hadoop
Description	Hadoop YARN core packages provides common files for running YARN.
Install on Nodes	All YARN nodes

hadoop-yarn-resourcemanager-<PHD_HADOOP_VERSION>-<nn>.x86_64.rpm	
Type	Daemon
Requires	hadoop-yarn
Description	Daemon scripts package for Hadoop YARN ResourceManager, which provides a convenient method to manage ResourceManager start/stop as a Linux service.
Install on Nodes	ResourceManager node

hadoop-yarn-nodemanager-<PHD_HADOOP_VERSION>-<nn>.x86_64.rpm	
Type	Daemon
Requires	hadoop-yarn
Description	Daemon scripts package for Hadoop YARN NodeManager, which provides a convenient method to manage NodeManager start/stop as a Linux service.
Install on Nodes	All NodeManager nodes

hadoop-yarn-proxyserver-<PHD_HADOOP_VERSION>-<nn>.x86_64.rpm	
Type	Daemon
Requires	hadoop-yarn
Description	Daemon scripts package for Hadoop YARN ProxyServer, which provides a convenient method to manage ProxyServer start/stop as a Linux service.
Install on Nodes	Node that will act as a proxy server from the user to applicationmaster

hadoop-mapreduce-<PHD_HADOOP_VERSION>-<nn>.x86_64.rpm	
Type	Core
Requires	hadoop-yarn
Description	Hadoop Mapreduce core libraries.
Install on Nodes	All ResourceManager and NodeManager nodes

hadoop-mapreduce-historyserver-<PHD_HADOOP_VERSION>-<nn>.x86_64.rpm	
Type	Daemon
Requires	hadoop, hadoop-mapreduce
Description	Daemon scripts package for Hadoop MapReduce HistoryServer, which provides a convenient method to manage MapReduce HistoryServer start/stop as a Linux service.
Install on Nodes	Host that will act as the MapReduce HistoryServer

hadoop-doc-<PHD_HADOOP_VERSION>-<nn>.x86_64.rpm	
Type	Doc
Requires	N/A
Description	Hadoop documentation package.

hadoop-client-<PHD_HADOOP_VERSION>-<nn>.x86_64.rpm	
Type	Library
Requires	hadoop, hadoop-hdfs, hadoop-yarn, hadoop-mapreduce
Description	A set of symbolic links which gathers the libraries for programming Hadoop and submit Hadoop jobs.
Install on Nodes	Clients nodes that will be used to submit Hadoop jobs

Prerequisites: Core Package Setup

Perform the following steps on all the nodes in the Hadoop cluster and its client nodes:

```
$ sudo rpm -ivh working_dir/utility/rpm/bigtop-utils-
<PHD_BIGTOP_UTILS_VERSION>-<nn>.noarch.rpm
$ sudo rpm -ivh working_dir/zookeeper/rpm/zookeeper-<PHD_ZOOKEEPER_VERSION>-
<nn>.noarch.rpm
$ sudo rpm -ivh working_dir/hadoop/rpm/hadoop-<PHD_HADOOP_VERSION>-
<nn>.x86_64.rpm
```

Where `working_dir` is the directory where you want the rpms expanded.

YARN ResourceManager Setup

Install the YARN ResourceManager package on the workstation that will serve as YARN ResourceManager:

```
$ sudo rpm -ivh working_dir/hadoop/rpm/hadoop-yarn-<PHD_HADOOP_VERSION>-
<nn>.x86_64.rpm
$ sudo rpm -ivh working_dir/hadoop/rpm/hadoop-yarn-resourcemanager-
<PHD_HADOOP_VERSION>-<nn>.x86_64.rpm
```

YARN NodeManager Setup

Install the YARN NodeManager package on the workstation that will serve as YARN nodes:

```
$ sudo rpm -ivh working_dir/hadoop/rpm/hadoop-yarn-<PHD_HADOOP_VERSION>-
<nn>.x86_64.rpm
$ sudo rpm -ivh working_dir/hadoop/rpm/hadoop-yarn-nodemanager-
<PHD_HADOOP_VERSION>-<nn>.x86_64.rpm
```

Mapreduce HistoryServer Setup

Install the YARN Mapreduce History Manager package and its dependency packages on the workstation that will serve as the MapReduce History Server:

```
$ sudo rpm -ivh working_dir/hadoop/rpm/hadoop-yarn-<PHD_HADOOP_VERSION>-
<nn>.x86_64.rpm
$ sudo rpm -ivh working_dir/hadoop/rpm/hadoop-mapreduce-
<PHD_HADOOP_VERSION>-<nn>.x86_64.rpm
$ sudo rpm -ivh working_dir/hadoop/rpm/hadoop-mapreduce-historyserver-
<PHD_HADOOP_VERSION>-<nn>.x86_64.rpm
```

YARN ProxyServer Setup

Install the YARN Proxy Server package and its dependency packages on the workstation that will serve as the YARN Proxy Server.

```
$ sudo rpm -ivh working_dir/hadoop/rpm/hadoop-yarn-<PHD_HADOOP_VERSION>-
<nn>.x86_64.rpm
$ sudo rpm -ivh working_dir/hadoop/rpm/hadoop-yarn-proxyserver-
<PHD_HADOOP_VERSION>-<nn>.x86_64.rpm
```

YARN Configuration

Yarn configuration files are located in the following directory:

`/etc/gphd/hadoop/conf/`

Refer to the Apache Hadoop documentation for how to configure YARN in distributed mode.

Using Hadoop YARN

Starting YARN

YARN includes three services:

- ResourceManager (RM)
- NodeManager (NM)
- MapReduce HistoryManager (MRHM)

RM and NM are required, MRHM is optional.

Before you start these services, create some working directories on HDFS, as follows:

Create working directories on HDFS:

The examples we show here are only examples; the exact steps depend upon your own environment and directory setup.

```
$ sudo -u hdfs hdfs dfs -mkdir /tmp
$ sudo -u hdfs hdfs dfs -chmod 777 /tmp
$ sudo -u hdfs hdfs dfs -mkdir -p /var/log/gphd/hadoop-yarn
$ sudo -u hdfs hdfs dfs -chown yarn:hadoop /var/log/gphd/hadoop-yarn
$ sudo -u hdfs hdfs dfs -mkdir -p /user/history
$ sudo -u hdfs hdfs dfs -chown mapred:hadoop /user/history
$ sudo -u hdfs hdfs dfs -chmod -R 777 /user/history
$ sudo -u hdfs hdfs dfs -mkdir -p /user/hadoop
$ sudo -u hdfs hdfs dfs -chown hadoop:hadoop /user/hadoop
```

Starting ResourceManager

The RM daemon only needs to be started on the master node.

```
$ sudo service hadoop-yarn-resourcemanager start
```

Once RM is started, you can visit its dashboard at: `http://localhost:8088/`

Starting NodeManager

The NodeManager daemon needs to be started on all hosts that will be used as working nodes.

To start NodeManager, run:

```
$ sudo service hadoop-yarn-nodemanager start
```

Start MapReduce HistoryServer

MapReduce HistoryServer only needs to be run on the server that is meant to be the history server. It is an optional service and should only be enabled if you want to keep track of the MapReduce jobs that have been run.

To start the MapReduce History Server, run:

```
$ sudo service hadoop-mapreduce-historyserver start
```

When the MR HistoryServer is started, you can visit its dashboard at: `http://localhost:19888/`

Using YARN

After RM and NM are started, you can now submit YARN applications.

For simplicity, we assume you are running Hadoop in pseudo-distributed mode using the default pseudo configuration.

Note: Before you start using YARN, make sure the HDFS daemons are running.

Here is an example MapReduce job:

```
$ hadoop jar /usr/lib/gphd/hadoop-mapreduce/hadoop-mapreduce-examples-*.jar
 pi 2 200
```

This runs the PI generation example. You can track the progress of this job at the RM dashboard: `http://localhost:8088/`

You can also run other MapReduce examples, for example the following command will print a list of available examples:

```
$ hadoop jar /usr/lib/gphd/hadoop-mapreduce/hadoop-mapreduce-examples-*.jar
```

Stopping YARN

Stop the YARN daemons manually by running the following commands.

To stop the MapReduce HistoryServer Daemon:

```
$ sudo service hadoop-mapreduce-historyserver stop
```

To stop the NodeManager Daemon:

```
$ sudo service hadoop-yarn-nodemanager stop
```

To stop the ResourceManager Daemon:

```
$ sudo service hadoop-yarn-resourcemanager stop
```

Hadoop Pseudo-distributed Configuration

About Pseudo Distribution

Hadoop can be run on a single-node in a pseudo-distributed mode where each Hadoop daemon runs in a separate Java process.

Installing a Hadoop Pseudo-distributed Configuration

This section provides instructions for installing Hadoop Pseudo-distributed Configuration.

hadoop-conf-pseudo-<PHD_HADOOP_VERSION>-<nn>.x86_64.rpm	
Type	Configuration
Requires	hadoop-hdfs-datanode, hadoop-hdfs-secondarynamenode, hadoop-yarn-resourcemanager, hadoop-hdfs-namenode, hadoop-yarn-nodemanager, hadoop-mapreduce-historyserver, hadoop-yarn-proxyserver
Description	A set of configuration files for running Hadoop in pseudo-distributed mode on one single server.
Install on Nodes	Pseudo-distributed host

Hadoop Pseudo-distributed Configuration Setup

Hadoop pseudo-distributed configuration files are created in the following directory:

`/etc/gphd/hadoop/conf/`

```
$ sudo rpm -ivh working_dir/hadoop/rpm/hadoop-conf-pseudo-
<PHD_HADOOP_VERSION>-<nn>.x86_64.rpm
```

Zookeeper

About Zookeeper

ZooKeeper is a high-performance coordination service for distributed applications.

For more info, refer to the Apache Zookeeper page: *http://zookeeper.apache.org/*

Installing Zookeeper

This section describes how to install Zookeeper.

Zookeeper RPM Packages

Pivotal HD provides the following RPMs as part of this release. The core package provides all executable, libraries, configurations, and documentation for Zookeeper and is required on every node in the Zookeeper cluster as well as the client workstation that will access the Zookeeper service. The daemon packages provide a convenient way to manage Zookeeper daemons as Linux services, which rely on the core package.

Note: Zookeeper doesn't require Hadoop Core Packages.

zookeeper-<PHD_ZOOKEEPER_VERSION>-<nn>.noarch.rpm	
Type	Core
Requires	N/A
Description	Zookeeper core package, which provides the executable, libraries, configuration files and documentation.
Install on Nodes	Every node in the ZooKeeper cluster, and the client workstations which will access the ZooKeeper service.

zookeeper-server-<PHD_ZOOKEEPER_VERSION>-<nn>.noarch.rpm	
Type	Deamon
Requires	ZooKeeper Core Package
Description	Daemon scripts package for Zookeeper server, which provides a convenient method to manage Zookeeper server start/stop as a Linux service.
Install on Nodes	N/A

zookeeper-doc-<PHD_ZOOKEEPER_VERSION>-<nn>.noarch.rpm	
Type	Documentation
Requires	N/A
Description	Zookeeper documentation package.

Zookeeper Server Setup

Install the Zookeeper core package and the Zookeeper server daemon package on the workstation that will serve as the Zookeeper server, as follows:

```
$ sudo rpm -ivh working_dir/zookeeper/rpm/zookeeper-<PHD_ZOOKEEPER_VERSION>-
<nn>.noarch.rpm
```

```
$ sudo rpm -ivh working_dir/zookeeper/rpm/zookeeper-server-
<PHD_ZOOKEEPER_VERSION>-<nn>.noarch.rpm
```

Where `working_dir` is the directory where you want the rpms expanded.

Zookeeper Client Setup

Install the Zookeeper core package on the client workstation to access the Zookeeper service, as follows:

```
$ sudo rpm -ivh working_dir/zookeeper/rpm/zookeeper-<PHD_ZOOKEEPER_VERSION>-
<nn>.noarch.rpm
```

Zookeeper Configuration

Zookeeper configuration files are located in the following directory

`/etc/gphd/zookeeper/conf`

This is the default configuration for quick reference and modification.

You can make modifications to these configuration templates or create your own configuration set.

Using Zookeeper

Starting the Zookeeper Daemon

After installing the daemon package for Zookeeper, the Zookeeper server daemon by default starts automatically at system startup.

Start the daemons manually by running the following commands:

Either:

```
$ sudo service zookeeper-server start
```

Or:

```
$ sudo /etc/init.d/zookeeper-server start
```

Accessing the Zookeeper Service

To access the Zookeeper service on a client machine, use the command zookeeper-client directly in the ZK shell:

```
$ zookeeper-client
 In the ZK shell:
 > ls
 > create /zk_test my_data
 > get /zk_test
 > quit
```

You can get a list of available commands by inputting "?" in the Zookeeper shell.

Stopping the Zookeeper Daemon

Stop the Zookeeper server daemon manually by running the following commands:

```
sudo service zookeeper-server stop
```

HBase

About HBase

HBase is a scalable, distributed database that supports structured data storage for large tables.

For more info, refer to the Apache HBase page: *http://hbase.apache.org/*

Installing HBase

This section specifies how to install HBase.

Prerequisites

As HBase is built on top of Hadoop and Zookeeper, the Hadoop and Zookeeper core packages must be installed for HBase to operate correctly.

HBase RPM Packages

Pivotal HD provides the following RPMs as part of this release. The core package provides all executables, libraries, configurations and documentation for HBase and is required on every node in the HBase cluster as well as on the client workstation that wants to access the HBase service. The daemon packages provide a convenient way to manage HBase daemons as Linux services, which rely on the core package.

hbase-<PHD_HBASE_VERSION>-<nn>.noarch.rpm	
Type	Core
Requires	Hadoop HDFS Packages and ZooKeeper Core Package
Description	HBase core package provides all executables, libraries, configuration files and documentations.

hbase-master-<PHD_HBASE_VERSION>-<nn>.noarch.rpm	
Type	Daemon
Requires	HBase Core Package
Description	Daemon scripts package for HMaster, which provides a convenient method to manage HBase HMaster server start/stop as a Linux service.

hbase-regionserver-<PHD_HBASE_VERSION>-<nn>.noarch.rpm	
Type	Daemon
Requires	HBase Core Package
Description	Daemon scripts package for HRegionServer, which provides a convenient method to manage HBase HRegionServer start/stop as a Linux service.

hbase-thrift-<PHD_HBASE_VERSION>-<nn>.noarch.rpm	
Type	Daemon (thrift service)
Requires	HBase Core Package
Description	Daemon scripts package to provide HBase service through thrift.

hbase-rest-<PHD_HBASE_VERSION>-<nn>.noarch.rpm	
Type	Daemon (Restful service)
Requires	HBase Core Package
Description	Daemon scripts package to provide HBase service through REST.

hbase-doc-<PHD_HBASE_VERSION>-<nn>.noarch.rpm	
Type	Documentation
Description	HBase documentation package.

HBase Master Setup

Install the HBase core package and the HBase master daemon package on the workstation that will serve as the HMaster:

```
$ sudo rpm -ivh working_dir/hbase/rpm/hbase-<PHD_HBASE_VERSION>-
<nn>.noarch.rpm
$ sudo rpm -ivh working_dir/hbase/rpm/hbase-master-<PHD_HBASE_VERSION>-
<nn>.noarch.rpm
```

HBase RegionServer Setup

Install the HBase core package and the HBase regionserver daemon package on the workstation that will serve as the HRegionServer:

```
$ sudo rpm -ivh working_dir/hbase/rpm/hbase-<PHD_HBASE_VERSION>-
<nn>.noarch.rpm
$ sudo rpm -ivh working_dir/hbase/rpm/hbase-regionserver-
<PHD_HBASE_VERSION>-<nn>.noarch.rpm
```

HBase Client Setup

Install the HBase core package on the client workstation that will access the HBase service:

```
$ sudo rpm -ivh working_dir/hbase/rpm/hbase-<PHD_HBASE_VERSION>-
<nn>.noarch.rpm
```

HBase Thrift Server Setup

[OPTIONAL]

Install the HBase core package and the HBase thrift daemon package to provide HBase service:

```
$ sudo rpm -ivh working_dir/hbase/rpm/hbase-<PHD_HBASE_VERSION>-
<nn>.noarch.rpm
$ sudo rpm -ivh working_dir/hbase/rpm/hbase-thrift-<PHD_HBASE_VERSION>-
<nn>.noarch.rpm
```

REST Server Setup

[OPTIONAL]

Install the HBase core package and the HBase rest daemon package to provide HBase service through the Restful interface:

```
$ sudo rpm -ivh working_dir/hbase/rpm/hbase-<PHD_HBASE_VERSION>-
<nn>.noarch.rpm
$ sudo rpm -ivh working_dir/hbase/rpm/hbase-rest-<PHD_HBASE_VERSION>-
<nn>.noarch.rpm
```

HBase Configuration

HBase configuration files are located in the following directory:

`/etc/gphd/hbase/conf/`

This is the default configuration for quick reference and modification.

You can make modifications to these configuration templates or create your own configuration set.

HBase Post-Installation Configuration

1. Login to one of the cluster nodes.
2. Create the `hbase.rootdir`:

   ```
   $ sudo -u hdfs hdfs dfs -mkdir -p /hbase
   ```

3. Set the ownership for `hbase.rootdir`:

   ```
   $ sudo -u hdfs hdfs dfs -chown hbase:hadoop /hbase
   ```

4. Add `hbase` user to the `hadoop` group if not already present, by running:

   ```
   $ sudo usermod -G hadoop hbase
   ```

Using HBase

Starting the HBase Daemon

After installing the daemon package for HBase, the HBase server daemons by default start automatically at system startup.

Start the daemons manually by running the following commands:

```
$ sudo service hbase-master start
```

Starting the HRegionServer Daemon

Start the daemons manually by running the following commands:

```
$ sudo service hbase-regionserver start
```

Starting the Hbase Thrift Server Daemon

[OPTIONAL]

Start the daemons manually by running the following commands:

```
$ sudo service hbase-thrift start
```

Starting the Hbase Rest Server Daemon

[OPTIONAL]

Start the daemons manually by running the following commands:

```
$ sudo service hbase-rest start
```

Accessing the HBase Service

To access the HBase service on a client machine, use the command hbase directly in the shell:

```
$ hbase
```

Or you can use this command to enter the hbase console:

```
$ hbase shell
```

In the HBase shell, run some test commands, for example:

```
hbase(main):003:0> create 'test', 'cf'
hbase(main):003:0> list 'test'
hbase(main):004:0> put 'test', 'row1', 'cf:a', 'value1'
hbase(main):005:0> put 'test', 'row2', 'cf:b', 'value2'
hbase(main):006:0> put 'test', 'row3', 'cf:c', 'value3'
hbase(main):007:0> scan 'test'
hbase(main):008:0> get 'test', 'row1'
hbase(main):012:0> disable 'test'
hbase(main):013:0> drop 'test'
hbase(main):014:0> quit
```

Type `help` to get help for the HBase shell.

Stopping the HBase Daemon

Stop the daemons manually by running the following commands:

```
$ sudo service hbase-master stop
```

Stopping the HRegionServer Daemon

Stop the daemons manually by running the following commands:

```
$ sudo service hbase-regionserver stop
```

Stopping the Hbase Thrift Server Daemon

[OPTIONAL]

Stop the daemons manually by running the following commands:

```
$ sudo service hbase-thrift stop
```

Stopping the Hbase Rest Server Daemon

[OPTIONAL]

Stop the daemons manually by running the following commands:

```
$ sudo service hbase-rest stop
```

Hive

About Hive

Hive is a data warehouse infrastructure that provides data summarization and ad hoc querying.

For more info, refer to the Apache Hive page: *http://hive.apache.org/*

Installing Hive

This section specifies how to install Hive.

Hive Components

A Hive installation consists of the following components:

- `hive-core`
- `hive-metastore`
- `hive-server`
- `hive-server2`

Prerequisites

As Hive is built on top of Hadoop, HBase and Zookeeper, the Hadoop, HBase and Zookeeper core packages must be installed for Hive to operate correctly. The following prerequisites must be also met before installing Hive:

- DB Server (we recommend using PostgresSQL)

Hive RPM Packages

Hive consists of hive core, hive metastore daemon, hive server and hive server2 packages:

hive-<PHD_HIVE_VERSION>-<nn>.noarch.rpm	
Type	Core
Requires	Hadoop, HBase Core Packages
Description	Hive core package provides the executables, libraries, configuration files and documentations.
Install on Nodes	Hive client, server workstation

hive-server-<PHD_HIVE_VERSION>-<nn>.noarch.rpm

Type	Daemon (hive server)
Requires	Hive Core Package
Description	Daemon scripts package to provide Hive service through thrift.
Install on Nodes	Hive server node

hive-metastore-<PHD_HIVE_VERSION>-<nn>.noarch.rpm	
Type	Deamon (Metastore server)
Requires	Hive Core Package
Description	Daemon scripts package to provide Hive metadata information through metastore server.
Install on Nodes	Hive Metastore server node

hive-server2-<PHD_HIVE_VERSION>-<nn>.noarch.rpm	
Type	Daemon (hive server2)
Requires	Hive Core Package
Description	Daemon scripts package to provide Hive Server2.
Install on Nodes	Hive server2 node

Installing DB for Hive Metastore

Set up DB (Recommend using PostgreSQL) on the hive metastore Node

1. Install postgresql-server on hive metastore node as root:

```
$ sudo yum install postgresql-server
```

2. Initialize the database:

```
$ sudo service postgresql initdb
```

3. Open the `/var/lib/pgsql/data/postgresql.conf` file and set the following values:

```
listen_addresses = '*'
standard_conforming_strings = off
```

4. Open the `/var/lib/pgsql/data/pg_hba.conf` file and comment out all the lines starting with `host` and `local` by adding `#` to start of the line.Then add the following lines:

```
local all all trust
host all all 0.0.0.0 0.0.0.0 trust
```

5. Create the `/etc/sysconfig/pgsql/postgresql` file and add the following parameter/value pair:

```
PGPORT=10432
```

6. Disable SELinux (Security-Enhanced Linux):

Check the state of SELinux:

```
$ getenforce
Enforcing
```

If the result is `Enforcing`, you need to disable it temporarily or permanently.

Either: Disable SELinux temporarily

```
$ sudo setenforce 0
$ getenforce
Permissive
```

Or: Disable SELinux permanently

(You will need to reboot your system to disable SELinux permanently, or disable it temporarily as described above for the same result.)

```
$ sudo sed -i '/^[ ]*SELINUX[ ]*=.*$/d' /etc/selinux/config
$ echo "SELINUX=disabled" | sudo tee -a /etc/selinux/config
SELINUX=disabled
$ # reboot your system
```

7. Start the database:

```
$ sudo service postgresql start
```

8. Create the user, `database`:

```
$ sudo -u postgres createuser -p 10432 -D -S -R -P hive
$ sudo -u postgres createdb -p 10432 -O hive metastore
```

9. Install the Hive Metastore RPM package following the step *Install the Hive Metastore*.
10. Run the postgres sql script to create hive schema in postgres db:

```
$ sudo -u postgres psql -p 10432 -d metastore -U hive -f /usr/
lib/gphd/hive/scripts/metastore/upgrade/postgres/hive-schema-
<HIVE_VERSION>.postgres.sql
```

Hive MetaStore Server Setup

Install the Hive core package and Hive Metastore daemon package to provide Hive metadata information through the centralized Metastore service.

1. Install the Hive metastore:

```
$ sudo yum install postgresql-jdbc
$ sudo rpm -ivh working_dir/hive/rpm/hive-<PHD_HIVE_VERSION>-
<nn>.noarch.rpm
$ sudo rpm -ivh working_dir/hive/rpm/hive-metastore-<PHD_HIVE_VERSION>-
<nn>.noarch.rpm
```

2. Open the `/etc/gphd/hive/conf/hive-site.xml` and change it as follows:

```
<configuration>
 <property>
   <name>javax.jdo.option.ConnectionPassword</name>
   <value>hive</value>
 </property>
 <property>
   <name>hive.metastore.uris</name>
```

```
    <value>thrift://<CHANGE_TO_HIVE_METASTORE_ADDRESS>:9083</value>
  </property>
  <property>
    <name>javax.jdo.option.ConnectionURL</name>
    <value>jdbc:postgresql://<CHANGE_TO_HIVE_METASTORE_ADDRESS>:10432/
metastore</value>
  </property>
  <property>
    <name>hive.hwi.war.file</name>
    <value>/usr/lib/gphd/hive/lib/hive-hwi.war</value>
  </property>
  <property>
    <name>javax.jdo.option.ConnectionDriverName</name>
    <value>org.postgresql.Driver</value>
  </property>
  <property>
    <name>datanucleus.autoCreateSchema</name>
    <value>false</value>
  </property>
  <property>
    <name>javax.jdo.option.ConnectionUserName</name>
    <value>hive</value>
  </property>
  <property>
    <name>hive.metastore.execute.setugi</name>
    <value>true</value>
  </property>
  </configuration>
```

Note: Replace `<CHANGE_TO_HIVE_METASTORE_ADDRESS>` in above file.

3. Link the postgresql jar file:

```
$ sudo ln -s /usr/share/java/postgresql-jdbc.jar /usr/lib/gphd/hive/lib/
postgresql-jdbc.jar
```

4. Start the hive-metastore:

```
$ sudo service hive-metastore start
```

Hive Server Setup

[OPTIONAL]

Install the Hive core package and Hive server package to provide Hive service:

```
$ sudo rpm -ivh working_dir/hive/rpm/hive-<PHD_HIVE_VERSION>-<nn>.noarch.rpm
$ sudo rpm -ivh working_dir/hive/rpm/hive-server-<PHD_HIVE_VERSION>-
<nn>.noarch.rpm
```

Set up PostgreSQL jdbc driver

Copy the `postgresql-jdbc.jar` from the `HIVE_METASTORE` node to `/usr/lib/gphd/hive/lib` on the `HIVE_SERVER` node

Hive Server2 Setup

[OPTIONAL]

Install the Hive core package and Hive server2 package to provide access to the Hive service:

```
$ sudo rpm -ivh working_dir/hive/rpm/hive-<PHD_HIVE_VERSION>-<nn>.noarch.rpm
$ sudo rpm -ivh working_dir/hive/rpm/hive-server2-<PHD_HIVE_VERSION>-
<nn>.noarch.rpm
```

Open the `/etc/gphd/hive/conf/hive-site.xml` and add the following properties:

```
<property>
  <name>hive.server2.thrift.port</name>
  <value><CHANGE_TO_HIVE_SERVER2_PORT></value>
  <description>Port number of HiveServer2 Thrift interface.
  Can be overridden by setting $HIVE_SERVER2_THRIFT_PORT</description>
</property>
<property>
  <name>hive.server2.thrift.bind.host</name>
  <value><CHANGE_TO_HIVE_SERVER2_HOSTNAME></value>
  <description>Bind host on which to run the HiveServer2 Thrift interface.
  Can be overridden by setting $HIVE_SERVER2_THRIFT_BIND_HOST</description>
</property>
```

Note: Replace `<CHANGE_TO_HIVE_SERVER2_PORT> and <CHANGE_TO_HIVE_SERVER2_HOSTNAME>` in above file.

Set up PostgreSQL jdbc driver

Copy the `postgresql-jdbc.jar` from the `HIVE_METASTORE` node to `/usr/lib/gphd/hive/lib` on the `HIVE_SERVER2` node.

Hive Configuration

The Hive configuration files are located in the following directory:

`/etc/gphd/hive/conf/`

You can make modifications to this configuration template or create your own.

Hive Post-installation Configuration

1. Login to one of the cluster nodes as root.
2. Create the `hive.warehouse.dir`:

   ```
   $ sudo -u hdfs hadoop fs -mkdir -p /user/hive/warehouse
   ```
3. Set permissions for the `hive.warehouse.dir` :

   ```
   $ sudo -u hdfs hadoop fs -chmod 775 /user/hive/warehouse
   ```
4. Set the ownership for the `hive.warehouse.dir`:

   ```
   $ sudo -u hdfs hadoop fs -chown hive:hadoop /user/hive/warehouse
   ```
5. Add the hive user to the hadoop group, if not already present, by running:

   ```
   $ sudo usermod -G hadoop hive
   ```

Hive Client Setup

Hive is a Hadoop client-side library. Install the Hive core package on the client workstation:

```
 $ sudo rpm -ivh working_dir/hive/rpm/hive-<PHD_HIVE_VERSION>-
<nn>.noarch.rpm
```

Set up PostgreSQL jdbc driver

Copy the `postgresql-jdbc.jar` from the `HIVE_METASTORE` node to `/usr/lib/gphd/hive/lib` on the `HIVE_CLIENT` node.

Using Hive

Start/Stop Hive Metastore Server

Start/stop the Hive Metastore server daemon by running:

```
$ sudo service hive-metastore start
$ sudo service hive-metastore stop
```

Or:

```
$ sudo /etc/init.d/hive-metastore start
$ sudo /etc/init.d/hive-metastore stop
```

Start/Stop Hive Server

[OPTIONAL]

Start/stop the Hive server daemon by running:

```
$ sudo service hive-server start
$ sudo service hive-server stop
```

Start/Stop Hive Server2

[Optional]

Start/stop Hive server2 daemon by running:

```
$ sudo service hive-server2 start
$ sudo service hive-server2 stop
```

Start HiveServer Client

To run Hive on a client machine, use the `hive` command directly in the shell:

```
$ hive
```

For example:

```
$ hive -e "CREATE TABLE test(id string, name string);"
$ hive -e "show tables"
OK
```

```
test
```

Start HiveServer2 Client

HiveServer2 supports a new command shell `Beeline` that works with HiveServer2:

```
$ beeline
```

For example:

```
$ beeline
beeline> !connect jdbc:hive2://<hostname>:<port> <username> <password>
 org.apache.hive.jdbc.HiveDriver
0: jdbc:hive2://localhost> create table test1(id string, name string);
0: jdbc:hive2://localhost> show tables;
+------------+
| tab_name   |
+------------+
| test       |
| test1      |
+------------+
```

HCatalog

About HCatalog

HCatalog is a metadata and table management system layer for Hadoop.

As HCatalog is now released with Hive, refer to the Apache Hive page for more information: *http://hive.apache.org/*

Installing HCatalog

This section specifies how to install HCatalog.

Prerequisites

HCatalog is built on top of Hadoop, HBase , Hive and Zookeeper, so the Hadoop, HBase, Hive and Zookeeper core packages must be installed for HCatalog to operate correctly.

HCatalog RPM Packages

HCatalog consists of four packages:

1. Core package.

hcatalog-<PHD_HCATALOG_VERSION>-<nn>.noarch.rpm	
Type	Core
Requires	Hadoop, HBase and Hive Core Packages.
Description	Hcatalog core package provides the executables, libraries, configuration files and documentation.
Install on Nodes	Hcatalog Client workstation

2. Thrift server daemon package that provides catalog service.

hcatalog-server-<PHD_HCATALOG_VERSION>-<nn>.noarch.rpm	
Type	Daemon (hcatalog server)
Requires	Hcatalog Core Package
Description	Daemon scripts package to provide Hive service through thrift.
Install on Nodes	Hcatalog server node

3. Library package

webhcat-<PHD_HCATALOG_VERSION>-<nn>.noarch.rpm	
Type	Libraries
Requires	Hcatalog Core Package
Description	Daemon scripts package to provide Hive metadata information through metastore server.
Install on Nodes	Webhcat server node

4.Web server daemon package that provides catalog service through http.

webhcat-server-<PHD_HCATALOG_VERSION>-<nn>.noarch.rpm	
Type	Daemon(webhcata server)
Requires	Hcatalog and Webhcat Core Package
Description	Daemon scripts package to provide Webhcat Server.
Install on Nodes	Webhcat server node

HCatalog Client Setup

Hcatalog is a Hadoop client-side library. Install the Hcatalog core package on the client workstation.

```
$ sudo rpm -ivh working_dir/hcatalog/rpm/hcatalog-<PHD_HCATALOG_VERSION>-
<nn>.noarch.rpm
```

HCatalog Server Setup

[OPTIONAL]

Install the Hcatalog core package and Hcatalog thrift daemon package to provide access to the Hcatalog service:

```
$ sudo rpm -ivh working_dir/hcatalog/rpm/hcatalog-<PHD_HCATALOG_VERSION>-
<nn>.noarch.rpm
$ sudo rpm -ivh working_dir/hcatalog/rpm/hcatalog-server-
<PHD_HCATALOG_VERSION>-<nn>.noarch.rpm
```

Webhcat Setup

[OPTIONAL]

Install the Hcatalog core package and Webhcat package to provide Webhcat libraries:

```
$ sudo rpm -ivh working_dir/hcatalog/rpm/hcatalog-<PHD_HCATALOG_VERSION>-
<nn>.noarch.rpm
$ sudo rpm -ivh working_dir/hcatalog/rpm/webhcat-<PHD_HCATALOG_VERSION>-
<nn>.noarch.rpm
```

Webhcat Server Setup

[OPTIONAL]

Install the Hcatalog core package, Webhcat core package and Webhcat daemon package to provide Webhcat service:

```
$ sudo rpm -ivh working_dir/hcatalog/rpm/hcatalog-<PHD_HCATALOG_VERSION>-
<nn>.noarch.rpm
$ sudo rpm -ivh working_dir/hcatalog/rpm/webhcat-<PHD_HCATALOG_VERSION>-
<nn>.noarch.rpm
$ sudo rpm -ivh working_dir/hcatalog/rpm/webhcat-server-
<PHD_HCATALOG_VERSION>-<nn>.noarch.rpm
```

HCatalog Configuration

The Hcatalog configuration files are located in the following directories:

`/etc/gphd/hive/conf/`

`/etc/gphd/hcatalog/conf/`

You can make modifications to these configuration templates or create your own.

Using HCatalog

Start/Stop Hcatalog Server

Start/stop Hcatalog server daemon by running the following commands:

```
$ sudo service hcatalog-server start
$ sudo service hcatalog-server stop
```

Note: hcatalog-server and hive-metastore server can not run on the same node at the same time. These 2 services should be put on different nodes.

Start/Stop Webhcat Server

Start/stop Webhcat server daemon by running the following commands:

```
$ sudo service webhcat-server start
$ sudo service webhcat-server stop
```

Using HCatalog Command-line API

We can use following HCatalog command-line to create a table and access table data:

```
# Create a table
$ hcat -e "CREATE TABLE test(key string, value string) ROW FORMAT DELIMITED
 FIELDS TERMINATED BY ','"
OK

# Get the scheme for a table
$ hcat -e "DESC test"
OK
key   string none
value string none
```

Note: Make sure the user is permitted to read the file (e.g., 'test_data') and write the table (e.g., 'test'), and the YARN service is up.

Using HCatalog with REST

```
# Get table by using webhcat, you need to change hostname and username to
 appropriate value
$ curl -s 'http://<hostname>:50111/templeton/v1/ddl/database/default/table/
test?user.name=username'
{"columns":[{"name":"key","type":"string"},
{"name":"value","type":"string"}],"database":"default","table":"test"}
```

Using HCatalog with Pig

```
$ pig -useHCatalog
#use HCatLoader to have table schema retrieved automatically
$grunt> A = LOAD 'test' USING org.apache.hcatalog.pig.HCatLoader();
$grunt> DESCRIBE A;
#output
A: {key: chararray,value: chararray}
```

Pig

About Pig

Pig is a high-level data-flow language and execution framework for parallel computation.

For more info, refer to the Apache Pig page: *http://pig.apache.org/*

Installing Pig

This section specifies how to install Pig.

Prerequisites

As Pig is built on top of Hadoop, the Hadoop package must be installed to run Pig correctly.

Pig RPM Packages

Pig has only one core package.

pig-<PHD_PIG_VERSION>-<nn>.noarch.rpm	
Type	Core
Requires	Hadoop Core Packages
Description	Pig core package provides executable, libraries, configuration files and documentation.
Install on Nodes	Pig client workstation

pig-doc-<PHD_PIG_VERSION>-<nn>.noarch.rpm	
Type	Documentation
Requires	N/A
Description	Pig documentation package.

Pig Client Setup

Pig is a Hadoop client-side library. To install the Pig package on the client workstation, run:

```
$ sudo rpm -ivh working_dir/pig/rpm/pig-<PHD_PIG_VERSION>-<nn>.noarch.rpm
```

Pig Configuration

Pig configuration files are located in the following directory:

`/etc/gphd/pig/conf/`

This directory contains the default configuration templates for quick reference and modification.

You can modify these configuration templates or create your own configuration set.

Using Pig

To run Pig scripts on a client machine, use the command `pig` directly in the shell:

```
$ pig
```

For more information about the `pig` command usage, run:

```
$ pig -help
```

Using Pig with Hbase

Use the following script to register the Hbase library in your Pig script:

```
register /usr/lib/gphd/hbase/lib/htrace-core-*.jar
register /usr/lib/gphd/hbase/lib/hbase-*.jar
register /usr/lib/gphd/zookeeper/zookeeper.jar;
```

Using Pig with Piggybank/Hive

Piggybank is a Java library which includes numerous useful Pig UDFs. Piggybank provides UDFs for different Pig storage functions, math functions, string functions and datetime functions, etc.

After you have installed the Pig RPM package, the Piggybank library is also installed on the host.

The Piggybank jar is in the following location:

`/usr/lib/gphd/pig/piggybank.jar`

The library jars that Piggybank depends on are in the following location:

`/usr/lib/gphd/pig/lib/`

Use the following script to register the Piggybank library in your Pig script:

```
register /usr/lib/gphd/pig/lib/avro-*.jar
register /usr/lib/gphd/pig/lib/commons-*.jar
register /usr/lib/gphd/pig/lib/groovy-all-*.jar
register /usr/lib/gphd/pig/lib/guava-*.jar
register /usr/lib/gphd/pig/lib/jackson-*.jar
register /usr/lib/gphd/pig/lib/joda-time-*.jar
register /usr/lib/gphd/pig/lib/json-simple-*.jar
register /usr/lib/gphd/pig/lib/parquet-pig-bundle-*.jar
register /usr/lib/gphd/pig/lib/protobuf-java-*.jar
register /usr/lib/gphd/pig/lib/snappy-java-*.jar
register /usr/lib/gphd/pig/lib/automaton-*.jar
register /usr/lib/gphd/pig/piggybank.jar
```

Here are some notes for using Hive storage (such as HiveColumnarStorage) in Piggybank.

- PHD Hive must be installed. Please refer to the *Hive* on page 33 for Hive installation.

- You can register Piggybank dependency jars as needed in your Pig script with the above code.
- Additionally, use the following Pig code to register Hive jars in your script:

```
register /usr/lib/gphd/hive/hive-exec-*.jar
register /usr/lib/gphd/hive/hive-common-*.jar
```

Mahout

About Mahout

Mahout is a scalable machine learning and data mining library.

For more information, refer to the Apache Mahout page: *http://mahout.apache.org/*

Installing Mahout

This section specifies how to install Mahout.

Prerequisites

Mahout is built on top of Hadoop, so the Hadoop package must be installed to get Mahout running.

Mahout RPM Packages

Mahout has only one core package.

mahout-<PHD_MAHOUT_VERSION>-<nn>.noarch.rpm	
Type	Core
Requires	Hadoop Core Packages
Description	Mahout core package provides executable, libraries, configuration files and documentation.
Install on Nodes	Mahout client workstation

Mahout Client Setup

Mahout is a Hadoop client-side library. Install the Mahout package on the client workstation:

```
$ sudo rpm -ivh working_dir/mahout/rpm/mahout-<PHD_MAHOUT_VERSION>-
<nn>.noarch.rpm
```

Mahout Configuration

Mahout configuration files are located in the following directory:

`/etc/gphd/mahout/conf/`

This contains the default configuration templates for quick reference and modification.

You can modify these configuration templates or create your own configuration set.

Using Mahout

To run Mahout scripts on a client machine, use the command `mahout` directly in the shell:

```
$ mahout <PROGRAM>
```

Check the full list of mahout programs by running:

```
$ mahout
```

Flume

About Flume

Flume is a distributed, reliable, and available service for efficiently collecting, aggregating, and moving large amounts of log data. It has a simple and flexible architecture based on streaming data flows. It is robust and fault tolerant with tunable reliability mechanisms and many failover and recovery mechanisms. It uses a simple extensible data model that allows for online analytic application.

For more information, see the Apache Flume page: *http://flume.apache.org/*

Installing Flume

This section specifies how to install Flume.

Prerequisites

As Flume is built on top of Hadoop, the Hadoop package must be installed to get Flume running correctly. (Hadoop core and hadoop hdfs should be installed)

Flume RPM Packages

Flume consists of one core package and a flume agent package.

flume-<PHD_FLUME_VERSION>-<nn>.noarch.rpm

Type	Flume
Requires	Hadoop Core Packages
Description	Flume core package provides executable, libraries, configuration files and documentation.
Install on Nodes	Flume workstation

flume-agent-<PHD_FLUME_VERSION>-<nn>.noarch.rpm	
Type	Flume Agent
Requires	Flume Package
Description	Daemon scripts package to provide Flume service for generating, processing, and delivering data.
Install on Nodes	Flume agent node

Flume Setup

Flume is a Hadoop client-side library. Install the Flume package on the client workstation:

```
$ sudo rpm -ivh working_dir/flume/rpm/flume-<PHD_FLUME_VERSION>-
<nn>.noarch.rpm
```

Flume Agent Setup

[OPTIONAL]

Install the Flume package and Flume agent daemon package to provide Flume service for generating, processing, and delivering data:

```
$ sudo rpm -ivh working_dir/flume/rpm/flume-<PHD_FLUME_VERSION>-
<nn>.noarch.rpm
$ sudo rpm -ivh working_dir/flume/rpm/flume-agent-<PHD_FLUME_VERSION>-
<nn>.noarch.rpm
```

Flume Configuration

Flume configuration files are located in the following directory:

`/etc/gphd/flume/conf/`

This contains the default configuration templates for quick reference and modification.

You can modify these configuration templates or create your own configuration set.

Using Flume

Flume Configuration Example

```
$ cat /etc/gphd/flume/conf/flume.conf
agent.sources = r1
agent.sinks = k1
agent.channels = c1

# Describe/configure the source
agent.sources.r1.type = netcat
agent.sources.r1.bind = localhost
agent.sources.r1.port = 44444

# Describe the sink
agent.sinks.k1.type = hdfs
agent.sinks.k1.hdfs.path = hdfs://localhost/user/flume/
agent.sinks.k1.hdfs.fileType = DataStream

# Use a channel which buffers events in memory
agent.channels.c1.type = memory
agent.channels.c1.capacity = 1000
agent.channels.c1.transactionCapacity = 100

# Bind the source and sink to the channel
agent.sources.r1.channels = c1
agent.sinks.k1.channel = c1
```

Starting/Stopping Flume

Option 1) Using flume-ng command

```
$ sudo flume-ng agent -c <config-dir> -f <config-file> -n <agent-name>

Example:
sudo flume-ng agent -c /etc/gphd/flume/conf -f /etc/gphd/flume/conf/
flume.conf -n agent
```

Option 2) Using service commands

Start/stop the Flume agent by running the following commands:

```
$ sudo service flume-agent start
$ sudo service flume-agent stop
$ sudo service flume-agent status
```

Verifying the Installation

```
$ sudo service flume-agent stop
$ sudo -u hdfs hdfs dfs -mkdir -p /user/flume
$ sudo -u hdfs hdfs dfs -chmod 777 /user/flume
$ sudo service flume-agent start
$ echo hello | nc localhost 44444; sleep 30; sudo -u hdfs hdfs dfs -cat /
user/flume/*
OK
hello
```

Sqoop

About Sqoop

Sqoop is a tool designed for efficiently transferring bulk data between *http://hadoop.apache.org/* and structured datastores such as relational databases.

For more details, refer to the Apache Sqoop page: *http://sqoop.apache.org/*

Installing Sqoop

This section specifies how to install Sqoop.

Prerequisites

As Sqoop is built on top of Hadoop and HBase, the Hadoop and HBase package must be installed to get Sqoop running correctly.

Sqoop RPM Packages

Sqoop consists of one core package and a sqoop-metastore sever daemon package.

sqoop-<PHD_SQOOP_VERSION>-<nn>.noarch.rpm	
Type	Core
Requires	Hadoop, HBase Core Packages
Description	Sqoop core package provides executable, libraries, configuration files and documentations.
Install on Nodes	Sqoop client workstation

sqoop-metastore-<PHD_SQOOP_VERSION>-<nn>.noarch.rpm	
Type	Daemon (Sqoop Metastore server)
Requires	Sqoop core Package
Description	Daemon scripts package to provide shared metadata repository for Sqoop.
Install on Nodes	Sqoop metastore server node

Sqoop Client Setup

Sqoop is a Hadoop client-side library. Install the Sqoop package on the client workstation:

```
$ sudo rpm -ivh working_dir/sqoop/rpm/sqoop-<PHD_SQOOP_VERSION>-
<nn>.noarch.rpm
```

Sqoop Metastore Setup

[OPTIONAL]

Install the Sqoop core package and Sqoop metastore package to provide shared metadata repository for Sqoop. sqoop-metastore has a dependency with sqoop-core package:

```
$ sudo rpm -ivh working_dir/sqoop/rpm/sqoop-<PHD_SQOOP_VERSION>-
<nn>.noarch.rpm
$ sudo rpm -ivh working_dir/sqoop/rpm/sqoop-metastore-<PHD_SQOOP_VERSION>-
<nn>.noarch.rpm
```

Sqoop Metastore Configuration

The Sqoop metastore configuration files are in the following location:

`/etc/gphd/sqoop/conf/`

These are the default configuration templates for quick reference and modification.

You can modify these configuration templates or create your own configuration set.

Using Sqoop

Starting/Stopping Sqoop Metastore Server

Start/stop Sqoop metastore server daemon by running the following commands:

```
$ sudo service sqoop-metastore start
$ sudo service sqoop-metastore stop
$ sudo service sqoop-metastore status
```

Starting Sqoop Client

To run Sqoop scripts on a client machine, use the command `sqoop` directly in the shell:

```
$ sqoop
```

Check the `sqoop` command usage by running:

```
$ sqoop help
```

Sqoop ClientExample

In this example, you are using Sqoop to import a MySQL database table into HDFS.

To run this example, in addition to a correctly installed and configured PHD, you also need:

1. Install and run MySQL instance:

   ```
   $ sudo yum -y install mysql
   $ sudo service mysqld start
   ```

2. Install MySQL official JDBC driver and copy `mysql-connector-java.jar` into `/usr/lib/gphd/sqoop/lib`:

   ```
   $ sudo yum -y install mysql-connector-java
   $ sudo cp /usr/share/java/mysql-connector-java.jar /usr/lib/gphd/sqoop/lib
   ```

3. Create MySQL database `test` and MySQL table `student`:

```
$ mysql
mysql> use test;
```

```
mysql> CREATE TABLE student (id INT PRIMARY KEY, name VARCHAR(100));
mysql> insert into student (id, name) values (1, "John");
mysql> insert into student (id, name) values (2, "Mike");
mysql> insert into student (id, name) values (3, "Tom");
mysql> exit
```

Then run `sqoop` to import the table to HDFS:

```
$ sudo -u hdfs hdfs dfs -mkdir -p /tmp
$ sudo -u hdfs hdfs dfs -chmod 777 /tmp
$ sqoop import --connect jdbc:mysql://<mysql_server_host>/test --table
 student --username <username> --target-dir hdfs://<namenode_host>/tmp/
sqoop_output
```

Where:

<mysql_server_host> is the host name on which your MySQL instance is running.

<username> is the user name of the user running this command.

<namenode_host> is the host name on which your name node is running.

Oozie

About Oozie

Oozie is a workflow scheduler system for managing Apache Hadoop jobs.

For more info, refer to the Apache Oozie page: *http://oozie.apache.org/*

Installing Oozie

This section specifies how to install Oozie.

Prerequisites

Oozie is built on top of Hadoop, so Hadoop packages must be installed to get Oozie running. See the Hadoop section for Hadoop installation instructions, Oozie can manipulate Hive jobs and Pig jobs in the workflow. So if you want to use Hive jobs or Pig jobs in your workflow, Hive and Pig packages must be installed. See the Hive section and Pig section for their installation instructions.

Oozie RPM Packages

Oozie contains an oozie-client rpm package and an oozie package. The Oozie package depends on the oozie-client package.

oozie-client-<PHD_OOZIE_VERSION>-<nn>.noarch.rpm	
Type	Client and Core
Requires	bigtop-util, hadoop-client
Description	Oozie client package provides the oozie library and client binary to connect to Oozie service.
Install on Nodes	Oozie service node and Oozie client node

oozie-<PHD_OOZIE_VERSION>-<nn>.noarch.rpm	
Type	Daemon(Oozie server)
Requires	bigtop-tomcat, hadoop-client, oozie-client
Description	Daemon package to provide Oozie service.
Install on Nodes	Oozie service node

Oozie client Setup

Install the oozie-client package on the client host that submits workflows to Oozie service.

```
$ sudo rpm -ivh working_dir/utility/rpm/bigtop-utils-
<PHD_BIGTOP_UTILS_VERSION>-<nn>.noarch.rpm
$ sudo rpm -ivh working_dir/oozie/rpm/oozie-client-<PHD_OOZIE_VERSION>-
<nn>.noarch.rpm
```

Note: User "oozie" and group "oozie" are created with correct configuration (uid oozie, gid oozie). It is a non-login user.

Oozie Server Setup [Optional]

Install the oozie-client package and oozie package to provide Oozie service:

```
$ sudo rpm -ivh working_dir/utility/rpm/bigtop-utils-
<PHD_BIGTOP_UTILS_VERSION>-<nn>.noarch.rpm
$ sudo rpm -ivh working_dir/utility/rpm/bigtop-tomcat-
<PHD_BIGTOP_TOMCAT_VERSION>-<nn>.noarch.rpm
$ sudo rpm -ivh working_dir/oozie/rpm/oozie-client-<PHD_OOZIE_VERSION>-
<nn>.noarch.rpm
$ sudo rpm -ivh working_dir/oozie/rpm/oozie-<PHD_OOZIE_VERSION>-
<nn>.noarch.rpm
```

Oozie Configuration

Oozie configuration files are located in the following directory:

`/etc/gphd/oozie/conf/`

This contains the default configuration templates for quick reference and modification.

You can modify these configuration templates or create your own configuration set.

Oozie Environment Configuration

You can overwrite the oozie environment as long as exporting vars in `/etc/gphd/oozie/conf/oozie-env.sh`

For example, if you want to define the oozie data directory, export `OOZIE_DATA` in `/etc/gphd/oozie/conf/oozie-env.sh`:

```
export OOZIE_DATA=<YOUR_PATH>
```

Make sure that the owner and user group of `<YOUR_PATH>` is `oozie:oozie`.

Setup Database

[OPTIONAL]

By default, Oozie is configured to use Embedded Derby, however Oozie also works with HSQL, Derby, MySQL, Oracle and PostgreSQL databases.

Oozie bundles the JDBC drivers for HSQL, Embedded Derby and PostgreSQL.

HSQL is normally used for testcases as it is an in-memory database and all data is lost everytime Oozie is stopped.

If you are using MySQL, Oracle or PostgreSQL, the Oozie database schema must be created. By default, Oozie creates its tables automatically.

The `bin/addtowar.sh` and the `oozie-setup.sh` scripts have an option `-jars` that can be used to add the Oracle or MySQL JDBC driver JARs to the Oozie WAR file.

The SQL database used by Oozie is configured using the following configuration properties (default values shown):

```
   oozie.db.schema.name=oozie
   oozie.service.JPAService.create.db.schema=true
   oozie.service.JPAService.validate.db.connection=false
   oozie.service.JPAService.jdbc.driver=org.apache.derby.jdbc.EmbeddedDriver
   oozie.service.JPAService.jdbc.url=jdbc:derby:${oozie.data.dir}/
${oozie.db.schema.name}-db;create=true
   oozie.service.JPAService.jdbc.username=sa
   oozie.service.JPAService.jdbc.password=
   oozie.service.JPAService.pool.max.active.conn=10
```

These values should be changed to match the database you are using.

- If the `oozie.db.schema.create` property is set to `true` (default) the Oozie tables are created automatically if they are not found in the database at Oozie start-up time. In a production system this option should be set to `false` once the database tables have been created.
- If the `oozie.db.schema.creat`e property is set to true, the `oozie.service.JPAService.validate.db.connection` property value is ignored and Oozie handles it as set to `false`.

Using Oozie

Oozie Client

To run Oozie scripts on a client machine, use the command `oozie` with the sub-command directly in shell. Each sub-command may have different arguments.

```
$ oozie [sub-command]
```

Check the oozie command usage by running:

```
$ oozie help
```

Initialize Oozie Server

[OPTIONAL]

Before starting Oozie service, follow the steps below to initialize Oozie server.

1. Add the following configuration to the Hadoop configuration `core-site.xml`. Then restart HDFS and Yarn

```
<property>
  <name>hadoop.proxyuser.oozie.hosts</name>
  <value>*</value>
</property>
<property>
  <name>hadoop.proxyuser.oozie.groups</name>
  <value>*</value>
</property>
```

2. `mkdir` for user `oozie` on HDFS:

```
$ sudo -u hdfs hdfs dfs -mkdir -p /user/oozie
$ sudo -u hdfs hdfs dfs -chown oozie /user/oozie
```

3. Create the oozie database:

```
$ sudo service oozie init
```

4. Download `extjs-2.2` from here *http://extjs.com/deploy/ext-2.2.zip*. Put the zip file in a new directory named `/tmp/oozie-libext`.

```
$ wget http://extjs.com/deploy/ext-2.2.zip
$ mkdir -p /tmp/oozie-libext
$ mv ext-2.2.zip /tmp/oozie-libext
$ sudo chown -R oozie:oozie /tmp/oozie-libext
```

5. Setup the oozie tomcat `war` file:

```
$ sudo -u oozie oozie-setup prepare-war -d /tmp/oozie-libext/
```

6. Setup sharelib for oozie service. Replace `namenode-host` with your name node hostname, and replace `namenode-port` with your name node port:

```
$ sudo -u oozie oozie-setup sharelib \
create -fs hdfs://<namenode-host>:<namdenode-port> \
-locallib /usr/lib/gphd/oozie/oozie-sharelib.tar.gz
```

Start/Stop Oozie Server [Optional]

Start/stop Oozie server by running the following commands:

```
$ sudo service oozie start
$ sudo service oozie stop
$ sudo service oozie status
```

Submit Oozie Example Workflows

1. Expand the examples:

   ```
   $ mkdir /tmp/oozie-example
   $ cd /tmp/oozie-example
   $ tar xzf /usr/lib/gphd/oozie/oozie-examples.tar.gz
   ```

2. Change the job properties in the examples.Change the following files:

   ```
   /tmp/oozie-example/examples/apps/map-reduce/job.properties
   /tmp/oozie-example/examples/apps/hive/job.properties
   /tmp/oozie-example/examples/apps/pig/job.properties
   ```

   In each file, set the following properties:

   ```
   nameNode=hdfs://<namenode-host>:<namenode-port>
   jobTracker=<resource-manager-host>:<resource-manager-port>
   ```

   Use the exact hostname and service port in your cluster.
3. Edit the Oozie `workflow.xml` as follows:The Oozie `workflow.xml` is in the following directory:

   `/tmp/oozie-example/examples/apps/hive`

   Add the NameNode variable as a prefix to all paths, for example:

   ```
   <param>INPUT=${nameNode}/user/${wf:user()}/${examplesRoot}/input-data/
   table</param>
   <param>OUTPUT=${nameNode}/user/${wf:user()}/${examplesRoot}/output-data/
   hive</param>
   ```

   Also make sure to reference the `hive-oozie-site.xml` using the `job-xml` tag in the workflow. The `<job-xml>` element needs to be put inside the `<hive>` element between the `<prepare>` and `<configuration>` elements in the `examples/apps/hive/workflow.xl` file, as shown below:

   ```
   <workflow-app xmlns="uri:oozie:workflow:0.2" name="hive-wf">
       <start to="hive-node"/>
       <action name="hive-node">
           <hive xmlns="uri:oozie:hive-action:0.2">
               <job-tracker>${jobTracker}</job-tracker>
               <name-node>${nameNode}</name-node>
               <prepare>
                   <delete path="${nameNode}/user/${wf:user()}/
   ${examplesRoot}/output-data/hive"/>
                   <mkdir path="${nameNode}/user/${wf:user()}/
   ${examplesRoot}/output-data"/>
               </prepare>
               <job-xml>${nameNode}/user/oozie/hive-oozie-site.xml</job-xml>
               <configuration>
                   <property>
                       <name>mapred.job.queue.name</name>
   ```

```
                    <value>${queueName}</value>
                </property>
            </configuration>
            <script>script.q</script>
            <param>INPUT=${nameNode}/user/${wf:user()}/${examplesRoot}/
input-data/table</param>
            <param>OUTPUT=${nameNode}/user/${wf:user()}/${examplesRoot}/
output-data/hive</param>
        </hive>
        <ok to="end"/>
        <error to="fail"/>
    </action>
    <kill name="fail">
        <message>Hive failed, error
 message[${wf:errorMessage(wf:lastErrorNode())}]</message>
    </kill>
    <end name="end"/>
</workflow-app>
```

4. Put example code onto HDFS:

   ```
   $ hdfs dfs -put examples /user/<username>
   ```

   Where `<username>` is the name of user who issues this command.

5. Submit a map reduce example workflow

   a. Submit workflow:

      ```
      $ oozie job -oozie http://localhost:11000/oozie -config examples/apps/
      map-reduce/job.properties  -run
      job: <oozie-job-id>
      ```

   b. Check workflow status. Where `<oozie-job-id>` is the same id in the output of the last command.

      ```
      $ oozie job -oozie http://localhost:11000/oozie -info <oozie-job-id>
      ```

6. Oozie Setup for Hive:

   - Remote Metastore Mode (recommended):

     Put the Hive jars into the Tomcat class loader path. Make the following change in the `/var/lib/gphd/oozie/tomcat-deployment/conf/catalina.properties` file:

     ```
     common.loader=${catalina.home}/lib,${catalina.home}/lib/*.jar,/var/lib/
     gphd/oozie/*.jar,
     /usr/lib/gphd/oozie/libtools/*.jar,/usr/lib/gphd/oozie/oozie-core/*.jar,
     /usr/lib/gphd/hadoop/client/*.jar,/usr/lib/gphd/hive/lib/*.jar
     ```

     Note: common loader classpath

     Make sure ${catalina.home}/lib,${catalina.home}/lib/*.jar are at the beginning of the classpath. Keep the jars in the classpath as the following order.

     - Tomcat Jars (the jars under ${catalina.home}/lib)
     - Oozie Jars (the jars under ${oozie.home}, ${oozie.home}/libtools, ${oozie.home}/oozie-core)
     - Hadoop Jars (the jars under ${hadoop.home}/client/)
     - Hive Jars (the jars under ${hive.home}/lib)

   - Local Metastore Mode:

     Upload the JDBC driver to Oozie sharelib. To enable the local metastore mode, comment out the `hive.metastore.uris` property and verify that Hive still works properly at the command-line.In local metastore mode, Oozie hive actions do not connect to the Hive Metastore, but instead talk to the database directly. In this setup, the appropriate JDBC driver (for example, for Postgres) needs to be made available to hive jobs running within Oozie:

```
sudo -u oozie hdfs dfs -put /usr/lib/gphd/hive/lib/postgresql-jdbc.jar /
user/oozie/share/lib/hive
```

7. Submit the Hive example workflow:

a. Upload the Hive configuration file onto HDFS:

```
$ sudo -u oozie hdfs dfs -put /etc/gphd/hive/conf/hive-site.xml /user/
oozie/hive-oozie-site.xml
```

Note: When uploading a Hive configuration file to HDFS, do not use `hive-site.xml` as the file name. This is because Hive action in Oozie overwrites the `hive-site.xml` file.

In the Oozie workflow file, use `<job-xml>${nameNode}/user/oozie/hive-oozie-site.xml</job-xml>` to refer to the Hive configuration file.

b. Submit the workflow:

```
$ oozie job -oozie http://localhost:11000/oozie -config examples/apps/
hive/job.properties  -run
job: <oozie-job-id>
```

c. Check the workflow status.

Where `<oozie-job-id>` is the same id in the output of last command.

```
$ oozie job -oozie http://localhost:11000/oozie -info <oozie-job-id>
```

8. Submit a Pig example workflow:

a. Submit the workflow:

```
$ oozie job -oozie http://localhost:11000/oozie -config examples/apps/
pig/job.properties  -run
job: <oozie-job-id>
```

b. Check the workflow status.

Where `<oozie-job-id>` is the same id in the output of the last command.

```
$ oozie job -oozie http://localhost:11000/oozie -info <oozie-job-id>
```

Oozie in HA Mode - Best Practices

- Ensure that HA is configured correctly and identically on all nodes, including client nodes. Specifically, ensure that the following variables are set appropriately in `hdfs-site.xml`:

```
dfs.nameservices
dfs.ha.namenodes.nameservice ID
dfs.namenode.rpc-address.nameservice ID.name node ID
dfs.namenode.http-address.nameservice ID.name node ID
dfs.namenode.shared.edits.dir
dfs.client.failover.proxy.provider.nameservice ID
dfs.ha.fencing.methods
```

And in `core-site.xml`:

```
fs.defaultFS
```

- Use the namenode HA service in `mapreduce.job.hdfs-servers` in `yarn-site.xml`:

```
<property>
    <name>mapreduce.job.hdfs-servers</name>
    <value>hdfs://test</value>
</property>
```

- While using Namenode HA, create all tables using the HA service as the HDFS location:

```
CREATE EXTERNAL TABLE test (a INT) STORED AS TEXTFILE LOCATION 'hdfs://
test/user/myuser/examples/input-data/table/';
```

- Verify that all tables in Hive are created using the HA service as the HDFS location (note the location in the example below refers to `hdfs://test/`, which is the HA service.)

```
hive> describe extended mytable;
OK
a                       int                     None

Detailed
Table Information      Table(tableName:mytable, dbName:default,
owner:gpadmin@PIVOTAL, createTime:1391839636, lastAccessTime:0,
retention:0, sd:StorageDescriptor(cols:[FieldSchema(name:a, type:int,
 comment:null)], location:hdfs://test/user/gpadmin/examples/input-data/
mytable,
inputFormat:org.apache.hadoop.mapred.TextInputFormat,
outputFormat:org.apache.hadoop.hive.ql.io.HiveIgnoreKeyTextOutputFormat,
compressed:false,
numBuckets:-1, serdeInfo:SerDeInfo(name:null,
serializationLib:org.apache.hadoop.hive.serde2.lazy.LazySimpleSerDe,
parameters:{serialization.format=1}),
bucketCols:[], sortCols:[], parameters:{},
skewedInfo:SkewedInfo(skewedColNames:[], skewedColValues:[],
skewedColValueLocationMaps:{}), storedAsSubDirectories:false),
partitionKeys:[], parameters:{EXTERNAL=TRUE,
transient_lastDdlTime=1391839636}, viewOriginalText:null,
viewExpandedText:null, tableType:EXTERNAL_TABLE)
```

GraphLab

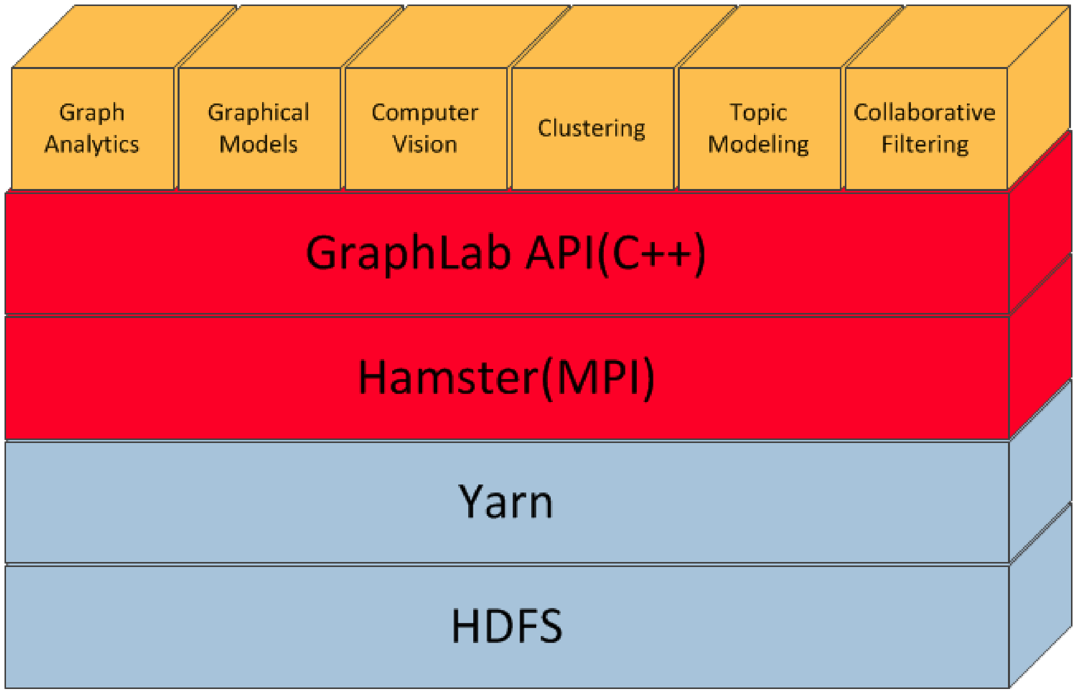
About GraphLab

GraphLab is a powerful new system for designing and implementing parallel algorithms in machine learning. It is a graph-based, high performance, distributed computation framework written in C++. It makes use of MPI and has its own programming model.

You can find more information about GraphLab here: *http://graphlab.org/*.

Because GraphLab itself cannot run on YARN, we have integrated GraphLab into Hadoop using Hamster.

Following is an architecture diagram for GraphLab on Hadoop:



Installing GraphLab

Prerequisites

- `hadoop-libhdfs*.rpm` and JRE package If GraphLab algorithm's input/output are from/to HDFS, then `hadoop-libhdfs*.rpm` and JRE package are required. When installing PHD, make sure that `hadoop-libhdfs*.rpm` is installed and `$JAVA_HOME/jre/lib/amd64/server/libjvm.so` is found.
- Hamster-1.1

GraphLab RPM Packages

GraphLab consists of the following graphlab `rpm` package:

graphlab-<PHD_GraphLab_VERSION>-1.x86_64.rpm	
Type	GraphLab
Requires	Hamster, hadoop-libhdfs*.rpm, jre package
Description	GraphLab installation package

Install on Nodes	Every node in the YARN cluster and the client workstation that will access the YARN service.

GraphLab Setup

```
$ sudo rpm -ivh working_dir/graphlab/rpm/graphlab-
<PHD_GraphLab_VERSION>-1.x86_64.rpm
```

Reconfigure YARN Virtual Memory

While the GraphLab process is running, it will consume a large amount of virtual memory. Once the amount of virtual memory it consumes exceeds the YARN virtual memory configuration, NodeManager will kill the container in which the GraphLab process is located. Therefore, we recommend that you set `yarn.nodemanager.vmem-pmem-ration` to a higher value (e.g. 100) or disable `yarn.nodemanager.vmem-check-enabled` in `$HADOOP_CONF_DIR/yarn-site.xml`. For example:

```
<property>   <name>yarn.nodemanager.vmem-pmem-ratio</name>   <value>100</
value> </property>
```

or:

```
<property>   <name>yarn.nodemanager.vmem-check-enabled</name>   <value>false</
value> </property>
```

After setting either of these properties, restart all NodeManagers to enable the configuration.

Running an Example

Following is an example to test that GraphLab is working:

Create a `connected_component.ini` file that contains the following:

```
1 2 4.0 2 3 1.0 3 4 5.0 4 5 2.0 5 3 3.0
```

Run the following commands to place this file in HDFS, and create a folder in HDFS for write output:

```
sudo -u hdfs hadoop fs -mkdir /graphlab
sudo -u hdfs hadoop fs -copyFromLocal /path/to/connected_component.ini /
graphlab/connected_component.ini
sudo -u hdfs hadoop fs -mkdir -p /graphlab/connected_component/output
sudo -u hdfs hadoop fs -chmod 777 /graphlab/connected_component/output
```

Run the following command to execute a GraphLab job:

```
mpirun -np 2 /${graphlab_installation_dir}/graph_analytics/
connected_component  --saveprefix=hdfs://${hdfs_hostname}:${hdfs_port}/
graphlab/connected_component/output/ --graph=hdfs://${hdfs_hostname}:
${hdfs_port}/graphlab/connected_component.ini --format=tsv
```

After the job has finished, you can check the output in HDFS.

```
hadoop fs -ls /graphlab/connected_component/output

Found 8 items
-rw-r--r--   3 yarn supergroup          4 2014-07-08 01:56 /graphlab/
connected_component/output/_1_of_8
-rw-r--r--   3 yarn supergroup          4 2014-07-08 01:56 /graphlab/
connected_component/output/_2_of_8
-rw-r--r--   3 yarn supergroup          0 2014-07-08 01:56 /graphlab/
connected_component/output/_3_of_8
```

```
-rw-r--r--   3 yarn supergroup          0 2014-07-08 01:56 /graphlab/
connected_component/output/_4_of_8
-rw-r--r--   3 yarn supergroup          4 2014-07-08 01:56 /graphlab/
connected_component/output/_5_of_8
-rw-r--r--   3 yarn supergroup          0 2014-07-08 01:56 /graphlab/
connected_component/output/_6_of_8
-rw-r--r--   3 yarn supergroup          0 2014-07-08 01:56 /graphlab/
connected_component/output/_7_of_8
-rw-r--r--   3 yarn supergroup          4 2014-07-08 01:56 /graphlab/
connected_component/output/_8_of_8
```

Using GraphLab

You can find Usage information for GraphLab's toolkits here: *http://docs.graphlab.org/toolkits.html*.

Recommended YARN Configurations for GraphLab on Hamster

Resource allocation / monitoring

In YARN, both virtual and physical memory usage for processes running on node managers are checked, if your program used more memory than requested, it will be killed by node manager. You can change your memory/cpu limit for your processes by specifying -mem (--mem-per-proc) and -cpu (--cpu-per-proc). For example, if you want your program using 2G memory and 2 cores, you can use following command to execute your job.

```
hamster -mem 2048 -cpu 2 -np N <your-program and parameters>
```

By default, `–mem` is 1024 (in MB) and `–cpu` is 1. But this is not enough, YARN itself has some properties that will take effect on resource allocation and monitoring, all in `yarn-site.xml` in `$HADOOP_CONF_DIR`.

- **yarn.scheduler.maximum-allocation-mb and yarn.scheduler.maximum-allocation-vcores** The two options will limit YARN's maximum resource allocation for each launched process. By default, they're 8192 (8GB memory) and 32 (cores), if your process need more than this limit, you need increase theirs values. GraphLab will consume lots of memory, **we suggest at least, specify maximum allocation memory in YARN to 16GB**. Otherwise, you may find your program frequently killed by node managers, which can be found in logs of node managers.
- **yarn.nodemanager.vmem-check-enabled and yarn.nodemanager.vmem-pmem-ratio** First option indicated if we need check virtual memory. For example, some program will use a lot of virtual memory but barely use physic memory (GraphLab is an example). If you think it's unnecessary to check virtual memory, you can set it to **false** to disable this checking (default is true). The second option is the ratio for physical memory to virtual memory, default is 2.1. For example, if you specified 2G memory (which can be specified by hamster -mem 2048 ...) for your processes, the limit of its physical memory is 2G, and the limit of its virtual memory is 2.1 * 2G = 4.2G. This process will be killed **either** it used 2G physical memory or 4.2G virtual memory. We suggest set a higher value of this to reduce your processes killed by node manager when it used too much virtual memory.

Fetch the log for the Hamster Job

A traditional OpenMPI program has a feature that allows you to get logs when jobs are running. In Hamster 1.0 we don't support this because we launch MPI processes in a different way, however you can still get all log files after the job is finished.

We recommend that you set `yarn.log-aggregation-enable` to `true` in the `yarn-site.xml` (by default this is disabled). If this is left disabled, fetching logs for Hamster jobs is more complicated, as you have to use the YARN web server to get your logs like other applications (for example, map-reduce).

When the `yarn.log-aggregation-enable` set to `true`, you need to be aware that the parent directory of `yarn.nodemanager.remote-app-log-dir` in HDFS should have write permission for the `yarn`user. By default, the `yarn.nodemanager.remote-app-log-dir` is set to `/tmp/logs`.

Once you have set the above properties, run the following command to get the log after your job has finished:

```
yarn logs -applicationId <application ID> -appOwner <Application Owner>
```

Note that `-appOwner` should be set to the user name used to submit Hamster job; when you used a different user name execute the `yarn logs` command.

Troubleshooting

Q: I'm unable to see Hadoop logs.

A: You need to add the following property in `yarn-site.xml`:

```
 <property>
    <description></description>
    <name>yarn.nodemanager.delete.debug-delay-sec</name>
    <value>1800</value>
  </property>
```

Then restart resource manager and nodemanager.

Q: When I run `hamster -np 3 /absolute/path/to/hello_c`, the following error is thrown:

```
Caused by:
 org.apache.hadoop.ipc.RemoteException(org.apache.hadoop.security.AccessControlExceptio
 Permission denied: user=root, access=WRITE, inode="/
user":hdfs:supergroup:drwxr-xr-x
at
 org.apache.hadoop.hdfs.server.namenode.FSPermissionChecker.check(FSPermissionChecker.ja
at
 org.apache.hadoop.hdfs.server.namenode.FSPermissionChecker.check(FSPermissionChecker.ja
at
 org.apache.hadoop.hdfs.server.namenode.FSPermissionChecker.checkPermission(FSPermissio
at
 org.apache.hadoop.hdfs.server.namenode.FSNamesystem.checkPermission(FSNamesystem.java:5
at
 org.apache.hadoop.hdfs.server.namenode.FSNamesystem.checkPermission(FSNamesystem.java:5
at
 org.apache.hadoop.hdfs.server.namenode.FSNamesystem.checkAncestorAccess(FSNamesystem.ja
at
 org.apache.hadoop.hdfs.server.namenode.FSNamesystem.mkdirsInternal(FSNamesystem.java:35
at
 org.apache.hadoop.hdfs.server.namenode.FSNamesystem.mkdirsInt(FSNamesystem.java:3553)
at
 org.apache.hadoop.hdfs.server.namenode.FSNamesystem.mkdirs(FSNamesystem.java:3525)
at
 org.apache.hadoop.hdfs.server.namenode.NameNodeRpcServer.mkdirs(NameNodeRpcServer.java
```

A: Run the following command:

```
sudo -u hdfs hadoop fs -chmod 777 /userhadoop fs -mkdir /user/root
```

Q: I see the following in the YARN logs:

```
14/02/17 09:52:30 ERROR event.HamsterEventHandler: exception when launch HNP
 process
java.io.IOException: Cannot run program "mpirun": error=13, Permission
 denied
at java.lang.ProcessBuilder.start(ProcessBuilder.java:1029)
at java.lang.Runtime.exec(Runtime.java:615)
at java.lang.Runtime.exec(Runtime.java:526)
at com.pivotal.hamster.appmaster.hnp.DefaultHnpLauncher
$1.run(DefaultHnpLauncher.java:84)
at java.lang.Thread.run(Thread.java:722)
Caused by: java.io.IOException: error=13, Permission denied
at java.lang.UNIXProcess.forkAndExec(Native Method)
at java.lang.UNIXProcess.<init>(UNIXProcess.java:135)
at java.lang.ProcessImpl.start(ProcessImpl.java:130)
at java.lang.ProcessBuilder.start(ProcessBuilder.java:1021)
... 4 more
```

A: Check if the node that is running the hamster application has openmpi installed.

Q: I see the following information in logs:

```
LogType: stderr
LogLength: 48
Log Contents:
/bin/bash: /bin/java: No such file or directory
LogType: stdout
LogLength: 0
Log Contents:
```

A: Make sure `$JAVA_HOME` is set:

Run this command:

```
echo $JAVA_HOME
```

You should see something like this:

```
/usr/java/latest
```

Q: I see the following information in logs:

```
ERROR: fiber_control.cpp(launch:229): Check failed: b<nworkers [1 < 1]
```

A: Find another machine which has more than 1 core, this is a limitation of GraphLab.

Hamster

About Hamster

Hamster is a framework that enables users running MPI programs on Apache Hadoop YARN platform.

This section specifies how to install, configure, and use Hamster.

Installing Hamster

Prerequisites

Hamster is dependent upon PHD-2.0/2.1 (Apache Hadoop 2.0.5 / 2.2.0).

Hamster RPM Packages

Hamster contains three packages: `hamster-core`, `hamster-rte`, and `openmpi`.

hamster-core-<PHD_HAMSTER-CORE_VERSION>-1.x86_64.rpm	
Type	Client and application master library
Requires	
Description	Hamster-core installation package.
Install on Nodes	Every node in the YARN cluster and the client workstation that will access the YARN service

hamster-rte-<PHD_HAMSTER-RTE_VERSION>-1.x86_64.rpm	
Type	Plugins for OpenMPI
Requires	
Description	Hamster runtime environment installation package.
Install on Nodes	Every node in the YARN cluster and the client workstation that will access the YARN service

openmpi-<PHD_OPENMPI_VERSION>-1.x86_64.rpm	
Type	OpenMPI
Requires	
Description	OpenMPI installation package.
Install on Nodes	Every node in the YARN cluster and the client workstation that will access the YARN service

Hamster-core Setup

Install the hamster-core package on the nodes in the YARN cluster and the client workstation that will access the YARN service:

```
$ sudo rpm -ivh working_dir/hamster/rpm/hamster-core-<PHD_HAMSTER-
CORE_VERSION>-1.x86_64.rpm
```

OpenMPI Setup

Install the OpenMPI package on the nodes in the YARN cluster and the client workstation that will access the YARN service:

```
$ sudo rpm -ivh working_dir/hamster/rpm/openmpi-
<PHD_OPENMPI_VERSION>-1.x86_64.rpm
```

Hamster-rte Setup

Install the hamster-rte package on the nodes in the YARN cluster and the client workstation that will access the YARN service:

```
$ sudo rpm -ivh working_dir/hamster/rpm/hamster-rte-<PHD_HAMSTER-
RTE_VERSION>-1.x86_64.rpm
```

Reconfig & Restart NodeManager

In Hamster-1.1, we have implemented an auxiliary in each NodeManager to launch `orted` (ORTE Daemon). Therefore,you need to deploy and configure the auxiliary service in the `yarn-site.xml` filoe for each NodeManager.

1. Copy `hamster-core-<VERSION>.jar` (by default, `/usr/local/hamster/lib/hamster/hamster-core-1.1.0-SNAPSHOT.jar`) to `/usr/lib/gphd/hadoop-yarn/`
2. Specify the auxiliary service in `yarn-site.xml`, as follows:

```
<property>
  <name>yarn.nodemanager.aux-services</name>
  <value>mapreduce_shuffle,hamster_aux</value>
  <description>shuffle service that needs to be set for Map Reduce to run
 </description>
</property>
<property>
  <name>yarn.nodemanager.aux-services.hamster_aux.class</name>
  <value>com.pivotal.hamster.aux.HamsterAuxService</value>
</property>
```

3. Restart NodeManager.

Set PATH in your env

After installing Hamster, set the `PATH` in your env.

1. Put `'export PATH=/usr/local/hamster/bin:$PATH'` in your `~/.bashrc` (only for you) or in `/etc/bashrc` (for all users in this node.)
2. `source ~/.bashrc` (or `source /etc/bashrc`)
3. Check the hamster by running:

```
$ which hamster

/usr/local/hamster/bin/hamster
```

Hamster Usage

Hamster command usage can be shown by running:

```
$hamster --help
```

	cmd	option	description	example
service mgmt	start		start the server(AppService/ JobService)	hamster start
	stop		stop the service(AppService/ JobService)	hamster stop
	status		check the status of server(AppService/ JobService)	hamster status
job mgmt	qsub		submit the job	hamster qsub / path/to/scripts \ -preload-files /path/ to/file1,/path/to/file2
		-preload-files, --preload-files	Preload the comma separated list of files to HDFS for job execution	
		-unmanaged, --unmanaged	Only register the job to JobService, Hamster server will not launch the job for the user. User needs to start their applications by their own.	
		-p, --policy	Policy for scheduling. Valid value: `{ simple, compute-locality/cl }`	
		-cpu, --cpu-per-proc	Specify how many v-cores allocated to each container	
		-mem, --mem-per-proc	Specify how many memory (in MB) allocated to each container	
		-parent-jobid, --parent-jobid	the new job will be associated with parent job as its child jobs, if parent job id is provided	
	qstat	-jobid, --jobid	query the job state.	hamster qstat --jobid 888
	qdel	-jobid, --jobid	cancel jobs	hamster qdel --jobid 888
other		-h, --help	print all options and descriptions	hamster --help

	cmd	option	description	example
		-V, --version	Print version and exit	hamster -V
		-v, --verbose	Be verbose	

Hamster Service

Before running any jobs, start the Hamster Service (JobService/AppMasterService).

To start the Hamster Service:

```
$ hamster start
```

To check the current status of the Hamster Service:

```
$ hamster status
```

To stop the Hamster Service:

```
$ hamster stop
```

Run job with mpirun/mpiexec (submitting job with mpirun/mpiexec directly)

Make sure Hamster Service's status is running.

```
$ mpirun -np 3 /path/to/mpi/executable
```

Run job with hamster qsub (submitting job described as a script file with qsub)

Suppose there are two mpirun job as batch job or pipeline in your scripts named `myjob.sh` as following:

```
vi myjob.sh
mpirun -np 2  /path/to/mpi/executable1
mpirun -np 4  /path/to/mpi/executable2
```

Submit the job script:

```
$ hamster qsub /path/to/myjob.sh
```

Run job with hamster (compatible with Hamster-1.0 command line options):

```
$ hamster -np 2 /path/to/mpi/executable
```

Currently, MPI processes in Hamster will redirect their output to files in the Hadoop log folder, you can access them in `yarn.nodemanager.log-dirs` in `yarn-site.xml` under `$HADOOP_CONF_DIR`.

Chapter 3

Manually Upgrading Pivotal HD Stack to 2.1.0

Pivotal HD Stack supports the following upgrade:

- Upgrade from PHD 1.1.1 to PHD 2.1
- Upgrade from PHD 2.0.1 to PHD 2.1

This section describes how to manually upgrade your Pivotal HD stack components.

PHD supports only stack-level upgrade; it doesn't support component-level upgrade. All PHD components should come from the same release package and all PHD components need to upgrade to same release version.

General Upgrade Tasks for Each Component

For each component upgrade, the following steps need to be followed:

- Back up Configuration
- Stop Service
- RPM upgrade
- Restore Configuration
- Start Service

Components to Upgrade (Supported by icm_client)

- Bigtop utilities
- Zookeeper
- Hadoop (HDFS and Yarn)
- HBase
- Hive
- Pig
- Mahout

Attention: Upgrade for these components is supported through the CLI. Manual RPM upgrade is risky and upgrade through the CLI is strongly recommended.

Upgrade Bigtop Utilities

RPM Upgrade Bigtop Utilities

Upgrade Zookeeper

1. Back up existing configuration files.
2. Stop the zookeeper-server service.
3. RPM Upgrade Zookeeper.
4. Restore backup configuration files and make sure configuration is compatible with the new installed version.
5. Restart the zookeeper-server service on Zookeeper server.

Upgrade Hadoop

Refer to *http://wiki.apache.org/hadoop/Hadoop_Upgrade* for Hadoop data upgrade/migration. The following steps only cover Hadoop configuration and packages upgrade.

1. Backup existing configuration files.
2. Stop Hadoop services.
3. RPM upgrade Hadoop.
4. Restore backup configuration files and make sure configuration is compatible with new installed version.
5. Restart Hadoop services.

Upgrade HBase

Refer to *http://hbase.apache.org/book/upgrading.html* for hbase data upgrade/migration. The following steps only cover hbase configuration and packages upgrade.

1. Back up existing configuration files.
2. Stop HBase master/region/thrift/restful service.
3. RPM upgrade Hbase.
4. Restore backup configuration files and make sure configuration is compatible with the new installed version.
5. Restart HBase master/region/thrift/restful service.

Upgrade Hive

Refer to *https://cwiki.apache.org/confluence/display/Hive/Hive+Schema+Tool* for Hive data upgrade/migration. The following steps only cover Hive configuration and packages upgrade.

1. Back up existing configuration files.
2. Stop Hive Server, Hive Server2, metastore services.
3. RPM upgrade Hive
4. Restore backup configuration files and make sure configuration is compatible with the new installed version.
5. If you use postgresql as the metastore DB, please copy postgresql-jdbc.jar to /usr/lib/gphd/hive/lib on hive-server node.
6. Restart Hive Server, Hive Server2, metastore services.

Upgrade Pig

1. Backup existing configuration files.
2. RPM upgrade Pig.
3. Restore backup configuration files and make sure configuration is compatible with new installed version.
4. Restore any customized UDF jars to lib directory.

Upgrade Mahout

1. Backup existing configuration files.
2. RPM upgrade Mahout
3. Restore backup configuration files and make sure configuration is compatible with new installed version.

Components to Upgrade (Not Supported by icm_client)

- Sqoop
- Flume
- Oozie
- Hcatlog

Upgrade of these components using RPM requires `root` privileges on the nodes to be upgraded. Unless specified, all the following operations should be run by user `root`.

Note: These instructions assume that the following components were already upgraded to PHD stack 2.1.0 and work correctly (see previous section):

- Zookeeper
- Hadoop
- Hbase
- Hive
- Pig
- Mahout

Upgrade Flume

1. **Backup existing configuration files:**

```
$ cp -r /etc/gphd/flume/conf <dir_to_save_Flume_configuration>
$ cp -r /etc/default/flume* <dir_to_save_Flume_environment>
```

2. **Stop Flume Agent Service:**

   Before you begin the upgrade, stop the `flume-agent` service:

```
$ sudo service flume-agent stop
```

3. **Upgrade Flume:**

```
$ sudo rpm -U flume-<PHD_FLUME_VERSIOIN>.noarch.rpm
$ sudo rpm -qa | grep flume
flume-<PHD_FLUME_VERSION>.noarch
```

4. **Upgrade the Flume Agent:**

```
$ sudo rpm -U flume-<PHD_FLUME_VERSION>.noarch.rpm flume-agent-
<PHD_FLUME_VERSION>.noarch.rpm
$ sudo rpm -qa | grep flume
flume-<PHD_FLUME_VERSION>.noarch
flume-agent-<PHD_FLUME_VERSION>.noarch
```

5. **Restore the old configurations:**

   After upgrading all Flume packages, you need to restore your configuration files in `/etc/gphd/flume/conf`, especially `flume.conf`. Check your previous backup configuration files, and manually add any change you made back to your upgraded configuration files.You also need to restore flume environment files in `/etc/default`, if they were changed.

6. **Restart Flume Agent Service:**

```
$ sudo service flume-agent start
```

Upgrade Sqoop

1. **Backup existing configuration files:**

   You are also required to back up the external jar files used to connect with the database for Sqoop:

```
$ cp -r /etc/gphd/sqoop/conf <dir_to_save_Sqoop_configuration>
$ cp -r /usr/lib/gphd/sqoop/lib <dir_to_save_external_jar_files>
$ cp -r /etc/default/sqoop* <dire_to_save_Sqoop_environment>
```

2. **Stop Sqoop Metastore Service:**

   Before you run the upgrade, first stop the `sqoop-metastore` service:

```
$ sudo service sqoop-metastore stop
```

3. **Upgrade Sqoop Client:**

```
$ rpm -U sqoop-<PHD_SQOOP_VERSION>.noarch.rpm
$ rpm -qa | grep sqoop
sqoop-<PHD_SQOOP_VERSION>.noarch
```

4. **Upgrade Sqoop Metastore:**

```
$ rpm -U sqoop-<PHD_SQOOP_VERSION>.noarch.rpm sqoop-metastore-
<PHD_SQOOP_VERSION>.noarch.rpm
$ rpm -qa | grep sqoop
sqoop-<PHD_SQOOP_VERSION>.noarch
sqoop-metastore-<PHD_SQOOP_VERSION>.noarch
```

5. **Restore old configurations:**

   After upgrading all Sqoop packages, you need to restore your configuration files in `/etc/gphd/sqoop/conf`, especially `sqoop-site.xml`.

   Check your previous backup configuration files, and manually add back any change you made to your upgraded configuration files.

   You also need to restore your external jar files to `/usr/lib/gphd/sqoop/lib` and restore Sqoop environment files in `/etc/default`, if they were changed.

6. **Restart Sqoop Metastore service:**

```
$ sudo service sqoop-metastore start
```

Upgrade Oozie

1. **Back up existing configuration files:**

```
$ cp -r /etc/gphd/oozie/conf <dir_to_save_Oozie_configuration>
```

2. **Stop Oozie service:**

   Before you run the upgrade, first stop the `Oozie` service:

```
$ sudo service oozie stop
```

3. **Upgrade Oozie RPMs:**

```
$ sudo rpm -U oozie-client-<PHD_OOZIE_VERSION>.noarch.rpm oozie-
<PHD_OOZIE_VERSION>.noarch.rpm
$ sudo rpm -qa | grep oozie
oozie-client-<PHD_OOZIE_VERSION>.noarch
oozie-<PHD_OOZIE_VERSION>.noarch
```

4. **Clean up Tomcat container files**

```
$ sudo rm -rf /usr/lib/gphd/oozie-<PHD_OOZIE_OLD_VERSION>
```

Note: `PHD_OOZIE_OLD_VERSION` is the old Oozie version in the previous PHD release.

5. **Copy Oozie Data:**

```
$ sudo -u oozie cp -r /var/lib/gphd/oozie-<PHD_OOZIE_OLD_VERSION>/* /var/
lib/gphd/oozie/
```

Note: `PHD_OOZIE_OLD_VERSION` is the old Oozie version in the previous PHD release. The default `OOZIE_DATA` is `/var/lib/gphd/oozie/`. If `OOZIE_DATA` is set to another path, you must put it into the path you set.

6. **Restore old configurations:**

After upgrading all Oozie packages, you need to restore your configuration files in `/etc/gphd/oozie/conf`. Check your previous backup configuration files, and manually add any change you made back to your upgraded configuration files. You also need to restore Oozie environment files in `/etc/default`, if they were changed.

7. **Upgrade Oozie database:**

```
$ sudo -u oozie oozie-setup db upgrade -run
$ sudo -u oozie oozie-setup db postupgrade -run
```

8. **Init new version of Oozie Service:**

```
$ sudo -u oozie oozie-setup prepare-war -d <ext-js-2.2-path>
$ sudo -u oozie hdfs dfs -rm -r share
Deleted share
$ sudo -u oozie oozie-setup sharelib create -fs hdfs://
<NameNodeHost>:<HDFSPort>
```

Note: Make sure that there is a file named `ext-2.2.zip` in `<ext-js-2.2-path>`.

9. **Restart Oozie service:**

```
$ sudo service oozie start
```

Upgrade HCatalog

1. **Backup existing configuration files:**

```
$ cp -r /etc/gphd/hcatalog/conf <dir_to_save_HCatlog_configuration>
$ cp -r /etc/default/hcatalog* <dir_to_save_HCatlog_environment>
$ cp -r /etc/default/webhcat* <dir_to_save_Webhcat_environment>
```

2. **Stop webhcat-server Service:**

```
$ sudo service webhcat-server stop
```

3. **Stop hcatalog-server Service:**

```
$ sudo service hcatalog-server stop
```

4. **Upgrade webhcat-server:**

```
$ rpm -U webhcat-server-<PHD_HCATALOG_VERSION>.noarch.rpm
$ rpm -qa | grep webhcat-server
webhcat-server-<PHD_HCATALOG_VERSION>.noarch.rpm
```

5. **Upgrade webhcat:**

```
$ rpm -U webhcat-<PHD_HCATALOG_VERSION>.noarch.rpm
$ rpm -qa | grep webhcat
webhcat-<PHD_HCATALOG_VERSION>.noarch.rpm
```

6. **Upgrade hcatalog-server:**

```
$ rpm -U hcatalog-server-<PHD_HCATALOG_VERSION>.noarch.rpm
$ rpm -qa | grep hcatalog-server
hcatalog-server-<PHD_HCATALOG_VERSION>.noarch.rpm
```

7. **Upgrade hcatalog:**

```
$ rpm -U hcatalog-<PHD_HCATALOG_VERSION>.noarch.rpm
$ rpm -qa | grep hcatalog
hcatalog-<PHD_HCATALOG_VERSION>.noarch.rpm
```

8. **Restore old configurations:**

   After upgrading all packages, you need to restore your configuration files in `/etc/gphd/hcatalog/conf`.

   Check your previous backup configuration files, and manually add any change you made back to your upgraded configuration files. You also need to restore hcatalog and webhcat environment files in `/etc/default` if they were changed.

9. **Restart webhcat-server service:**

```
$ sudo service webhcat-server start
```

10. **Restart hcatalog-server service:**

```
$ sudo service hcatalog-server start
```

Chapter

4

Pivotal Hadoop Enhancements

Pivotal HD is a full Apache Hadoop distribution with Pivotal add-ons and a native integration with the Pivotal Greenplum database.

HDFS Off-Cluster Client Rack Awareness

HDFS rack awareness is a key feature to achieve localized I/O (locality).

Overview of Rack Awareness

With respect to read and write separately, HDFS has:

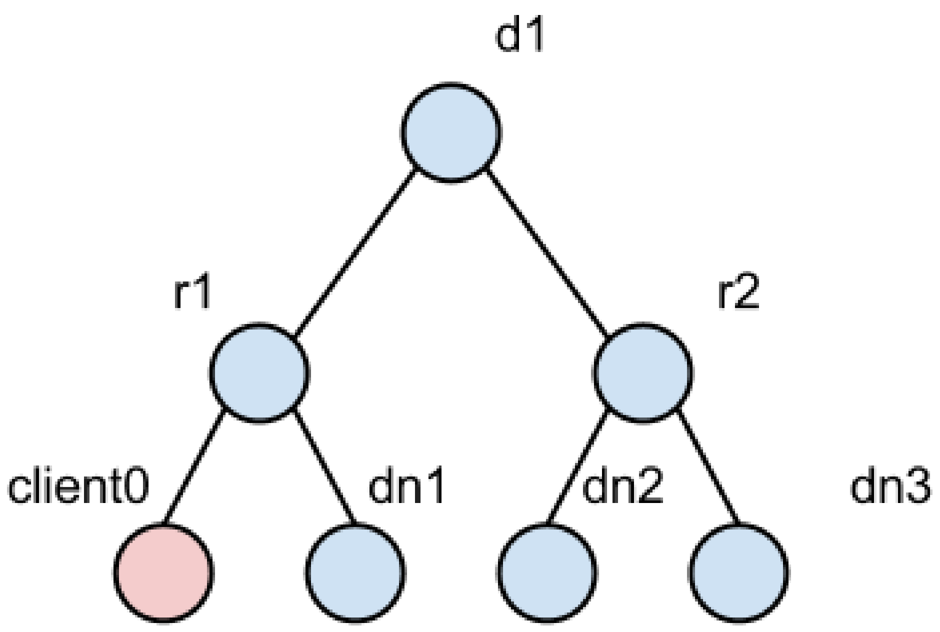
- BlockPlacementPolicy for write locality: namenode will look up network topology and construct a list of chosen nodes (pipeline) for requesting a block to locate, based on algorithms provided by a BlockPlacementPolicy.
- Block pseudo distance sort for read locality: when reading a block, after obtaining all the located blocks, namenode sorts these located blocks based on their topological distance from the client. The closer nodes get higher priority for read.

Both operations need to reference network topology, which is managed by the rack awareness feature. The rack awareness feature includes:

- A topology resolving framework: when datanodes register themselves on a namenode, that namenode will resolve their network location using their host name or ip, using DNSToSwitchMapping. This is a pluggable component that allows users to define their own topology based on their network layout. The most commonly used DNSToSwitchMapping is ScriptBasedMapping, which calls a shell script.
- An in-memory topology tree: all registered datanodes' network locations are kept in a topology tree.

Problem: Ignored Off-cluster Clients

The problem of the current implementation is that it does not support off-cluster clients. The figure below is an example of off-cluster clients:



In this figure, node **dn1** is a datanode and its network location is **/d1/r1**, and so on for **dn2** and **dn3**. Node **client0** is an off-cluster node, which means there is no datanode deployed on **client0**. In this case, **client0** has no chance to register itself in the topology tree of the namenode. Therefore, both read and write operations select random nodes even though **dn1** is closer (more preferable) than either **dn2** or **dn3**. This problem will cause performance issues in the following cases:

- **When a mapreduce cluster is not exactly co-located:** some mapreduce clusters share the same hdfs cluster with other mapreduce clusters, or in some cases a mapreduce cluster will cover several hdfs clusters. In those cases, a large portion of I/O will be off-cluster client operations, which cannot benefit from localized I/O.
- **When a physical cluster is not dedicated to Hadoop:** a physical cluster might not be dedicated to Hadoop and other supporting systems, such as data loading tools, might share the same cluster. In that case, the data loading tool can not benefit from localized I/O, even if the tool and hdfs shares the same rack/data center. The problem could be even more common in virtualized environments.

Solution: Design

To tackle this problem, we changed the logic in the block placement policy and the block pseudo distance sort. We also resolved the network location of the client.

Resolving client location

Resolving the client location: we reused the framework that resolves datanodes. However, since we did not add client network locations into the topology tree (as explained below), we have to cache client locations to avoid unnecessary resolve operations.

As a result, we introduced two LRU caches:

- A black list for those clients that have no valid location or whose locations do not share the same rack with any datanode.
- A white list, opposite to the black list, for those clients that are not datanodes but share the same rack with at least one datanode.

Referring to the diagram of ignored off-cluster clients, the table below lists some examples of location cache.

Location Cache Examples

HostName	Location	Cache
client1	d1/r1	white list
client2	d2/r1	black list
client3	null	black list

The size of the LRU cache is configurable, so you can limit the memory usage of namenode.

Block placement policy

The tables below demonstrate how the BlockPlacementPolicy has been changed to support non-datanode clients.

Former block placement algorithm

Replica	Rule
1	Client Local
2	Random node whose rack is different from replica 1
3	Random node who share the same rack with replica 2

>=4	Random node

Changed block placement algorithm	
Replica	**Rule**
1	Client Local if client is datanode, or a random node that shares the same rack with client, if client is not a datanode
2	Random node whose rack is different from replica 1
3	Random node who shares the same rack with replica 2
>=4	Random node

Enabling Off-Client Rack Awareness

The client rack aware feature is disabled by default. To enable, add the following to the `hdfs-site.xml` file:

```
<properties>
 <property>
   <name>dfs.rackawareness.with.client</name>
   <value>true</value>
 </property>
 </properties>
 <properties>
 <property>
   <name>dfs.rackawareness.with.client.blacklist.size</name>
   <description>Black list size of client cache, 5000 by default.</
description>
   <value>5000</value>
 </property>
 </properties>
 <properties>
 <property>
   <name>dfs.rackawareness.with.client.cache.size</name>
  <description>White list size of client cache, best set it equals
   the size of cluster. 2000 by default.</description>
   <value>2000</value>
 </property>
 </properties>
```

Note: You need to restart DFS after changing the configuration.

Vaidya

Overview

Vaidya is a diagnostic tool installed with PHD for Map/Reduce jobs. After a job is executed successfully, it uses a job history log and the job configuration information to identify any performance or scalability problems with the job. Upon execution, it provides a job analysis report indicating specific problems with the job, along with the remedy to correct them. The report element includes, "rule title", "rule description", "rule importance", "rule severity", "reference details" and "remedy/prescription" to rectify the problem. The "rule severity", is a product of rule impact and the rule importance.

Note: The Vaidya tool does **not** analyze failed jobs, either for performance or scalability problems, nor for the reason for failures.

The Vaidya tool includes diagnostic rules (also referred to as "tests") where each rule analyzes a specific problem with the M/R job. A diagnostic rule is written as a Java class and captures the logic of how to detect a specific problem condition with the M/R job. Each diagnostic rule uses the job history log and job configuration information provided to it using a standard structured interface. The standard interface allows administrators and developers to independently add more diagnostic rules in the Vaidya tool.

Installing Vaidya Files

By default, Vaidya files are installed at:

- The Vaidya JAR library is installed into `/usr/lib/gphd/hadoop-mapreduce/`.
- The Vaidya default configuration file is installed into `/etc/gphd/hadoop/conf/`.

Enabling Vaidya

On the history server node, go to the PHD configuration folder (by default, `/etc/gphd/hadoop/conf`), and add the following lines into the `mapred-site.xml` file.

Restart the job history server service to ensure the change takes effect.

mapred-site.xml Structure

```
<property>
  <name>mapreduce.vaidya.enabled</name>
  <value>true</value>
 </property>
 <property>
 <name>mapreduce.vaidya.jarfiles</name>
 <value>/usr/lib/gphd/hadoop-mapreduce/hadoop-vaidya.jar</value>
 </property>
 <property>
 <name>mapreduce.vaidya.testconf.file</name>
 <value>/etc/gphd/hadoop/conf/postex_diagnosis_tests.xml</value>
 </property>
```

Disabling Vaidya

To disable Vaidya:

Set the `mapreduce.vaidya.enabled` property value to `false`, or remove these lines from `mapred-site.xml`:

- The value of property `mapreduce.vaidya.enabled` should be changed to point to the correct jar file you installed. By default, this is `/usr/lib/gphd/hadoop-mapreduce/hadoop-vaidya-<HADOOP_PHD_VERSION>.jar`.
- Restart the job history server service to ensure the change takes effect.

Using Vaidya to Analyze Jobs

1. Ensure your job history server service is running.
2. Successfully run a MapReduce job for Vaidya to analyze.
3. Open the following URL in a web browser:

```
http://<historyserver_host>:<historyserver_port>/jobhistory
```

Where:

- `<historyserver_host>` refers to the host name or IP address of the machine where you run job history server service.
- `<historyserver_port>` refers to the HTTP port job history server web where the UI listens. By default, this value is 19888. Your browser should show you the job history server UI page.

4. You will see a list of jobs that have run, including the most recent job. Click the job id of any job in this list, and you should see the detailed information for the job.
5. On the left side of the navigation area, there should be a link called **Vaidya report** under the navigation item **Job**. Click the **Vaidya report** link and Vaidya will analyze the job for you and show a report.

Vaidya Configuration Rules

After you installed Vaidya with PHD, rules configuration is installed as a `postex_diagnosis_tests.xml` file in `/etc/gphd/hadoop/conf`.

You can find all rules to be run on a selected job in this file, where each rule is defined as an XML `PostExPerformanceDiagnosisTests/DiagnosticTest` element.

For example, a rule in `postex_diagnosis_tests.xml`:

```
<DiagnosticTest>
 <Title><![CDATA[Balanced Reduce Partitioning]]></Title>
 <ClassName>
 <!
[CDATA[org.apache.hadoop.vaidya.postexdiagnosis.tests.BalancedReducePartitioning]]></
ClassName>
 <Description><![CDATA[This rule tests as to how well the input to reduce
 tasks is balanced]]></Description>
 <Importance><![CDATA[High]]></Importance>
 <SuccessThreshold><![CDATA[0.40]]></SuccessThreshold>
 <Prescription><![CDATA[advice]]></Prescription>
 <InputElement>
 <PercentReduceRecords><![CDATA[85]]></PercentReduceRecords>
 </InputElement>
 </DiagnosticTest>
```

The `Title` and `Description` elements provide a brief summary about what this rule is doing.

By editing `postex_diagnosis_tests.xml`, you can configure the rules.

Note:

- Remember to back up the original configuration file before editing the configuration file. An invalid XML config file may cause Vaidya to behave incorrectly.
- Before you start editing rules, you should have background knowledge about XML syntax and how XML represents data (for example, what the CDATA element represents).

Disabling a Rule

Comment out or remove the entire `<DiagnosticTest>` element.

Changing the Importance of a Rule

Importance indicates how relatively important a rule is, relative to other rules in the same set. You can change the importance value by editing the `<Importance>` element in the XML file. A level serves as a factor, which is multiplied to impact the value returned by each rule.

There are three values valid for this attribute: Low (value of 0.33), Medium (value of 0.66), and High (value of 0.99).

In the displayed Vaidya report, there is a value named **Severity** for each rule. A severity level is the result of multiplying the impact value (returned by rule) and the importance factor (defined in the XML file).

For example, a rule returns an impact of 0.5, its importance is marked as Medium, then its severity is 0.5 * 0.66 = 0.33.

Changing Success Threshold

Each rule calculates a value between 0 and 1 (inclusively) to indicate how healthy a job is according to the specified rule; this value is called impact. The smaller the impact is (that is, closer to 0), the healthier the job is.

To give a more straightforward result, you can set a threshold for each rule. Therefore, a rule whose impact value is larger than the threshold will be marked as "failed"; otherwise, it is marked as "passed".

Note that the threshold is compared with the impact value, rather than severity (which means making a rule less important will not make a failed rule succeed).

You can change the threshold value by editing the `<SuccessThreshold>` element in the XML file.

Changing Input Parameters

Some rules might need additional input parameters to complete their logic. You can specify additional parameters by editing/adding elements under the `<InputElement>` element of each rule.

Other Elements

For a full explanation and instructions about the meaning of each XML element, as well as how to change them, see Apache's documentation (*https://hadoop.apache.org/docs/stable1/vaidya.html*) for more information.

Adding a New Rule

A Vaidya rule consists of the following two parts:

- A java class that consists of the logic of the rule
- A paragraph of XML in the configuration file

Creating a Java Binary for a New Rule

Important: This section assumes a working knowledge of how to write, compile, and package Java code.

1. From where you installed PHD, download the correct `hadoop-vaidya-<HADOOP_PHD_VERSION>.jar` file (which you specified in `mapred-site.xml`) to your development machine, if you plan on writing Java code on another machine than the one where you installed PHD. (This is a typical use case.)
2. Create a java file with an IDE or editor, which defines a class that extends the `org.apache.hadoop.vaidya.DiagnosticTest` class:

   myrule.java

```
package com.greenplum.vaidya.rules;
 import org.apache.hadoop.vaidya.DiagnosticTest;
 import org.apache.hadoop.vaidya.statistics.job.JobStatistics;
 public class MyRule extends DiagnosticTest {
 @Override
 public String getReferenceDetails() {
```

```
 return "";
 }
 @Override
 public String getPrescription() {
 return "";
 }
 @Override
 public double evaluate(JobStatistics jobStatistics) {
 return 0.5;
 }
 }
```

3. Edit the three methods `getReferenceDetails`, `getPrescription` and evaluate to construct the logic.evaluate method should return a **double** value between 0.0 and 1.0 and represents the impact as the analysis result.
   - `getPrescription` method should return some text providing user suggestions/remedies about how to optimize your Map/Reduce configuration accordingly.
   - `getReferenceDetails` method should return some text indicating the meaningful counters and their values which can help you to diagnose your MapReduce configuration accordingly.
4. Compile the java class and package compiled class to a jar file, for example `myrule.jar`. Note that you need to put the Vaidya jar file you just downloaded into your classpath to make your code compile.

Creating XML Configuration for a New Rule

Add a `DiagnosticTest` element into the `postex_diagnosis_tests.xml` file (the file you set in the `mapred-site.xml` file), according to the sample given in the configuration part. Ensure the value of the `<ClassName>` element is set to be the full class name of the java rule class you just created.

Deploying Files

1. Upload the packaged jar file (`myrule.jar` for example) to the node where you installed PHD job tracker, and store it in a folder where hadoop service has the permission to read and load it. We recommend you place it under `/usr/lib/gphd/hadoop-mapreduce/lib/`.
2. Edit `mapred-site.xml`, append the jar file you just uploaded to the `mapred.vaidya.jar` file or `mapreduce.vaidya.jar` files property value. For example:

```
mapred-site.xml
 <property>
 <name>mapreduce.vaidya.jarfiles</name>
 <value>/usr/lib/gphd/hadoop-mapreduce/hadoop-vaidya.jar:/usr/lib/gphd/
hadoop-mapreduce/lib/myrule.jar</value>
 </property>
```

Important:

- Do not remove the default Vaidya jar file from this property, Vaidya needs this property to load basic Vaidya classes to make it run.
- Multiple jar files are separated by different separator characters on different platforms. On the Linux/Unix platform, the ":" character should be used. You can look at the `theFile.pathSeparator` attribute of your java platform to verify it.
- To make your settings take effect, restart the job history server service.

HVE Topology Awareness

Hadoop Virtualization Extensions (HVE) allow Hadoop clusters implemented on virtualized infrastructure full awareness of the topology on which they are running, thus enhancing the reliability and performance of these clusters.

HVE should be enabled in the following situations:

- When there is more than one Hadoop VM per physical host in virtualized environments.
- When Datanodes and NodeManagers/TaskTrackers exist in separate virtual machines in virtualized environments, in order to achieve graceful scaling of the compute component of the Hadoop cluster.
- When there is a topology layer between host and rack (e.g. chassis), which can affect the failure/locality group between hosts, in non-virtualized environments.

Topology Awareness Configuration and Verification

Sample Setup:

This setup has 2 logical racks, 2 physical hosts (installed by ESXi and managed by vCenter) per rack, and 2 DN/NM (VM in ESXi) nodes per host. There is also one NameNode/ResourceManager and a client node that can be used to start jobs.

In this setup, each DN/NM node has 4 vCPUs, 16G memory, and 200G (Non-SSD) disks.

The NameNode and ResourceManager are installed on another dedicated VM with 4vCPU, 4G Memory and 100G disks.

Node Distribution on Hosts:

Rack 1	**Host 1**	**NameNode and ResourceManager**	**DN1**
	Host 2	**DN2**	**DN3**
Rack 2	**Host 3**	**DN4**	**DN5**
	Host 4	**DN6**	**DN7**

Enable topology awareness (Hadoop V2):

1. Add the following line to `core-site.xml`:

```
<property>
  <name>topology.script.file.name</name>
  <value>/hadoop/hadoop-smoke/etc/hadoop/topology.sh</value<!-- point to
 topology.sh location.-->
</property>
<property>
  <name>net.topology.impl</name>
  <value>org.apache.hadoop.net.NetworkTopologyWithNodeGroup</value>
  <description> The default implementation of NetworkTopology which is
 classic three layer one.
  </description>
</property>
<property>
  <name>net.topology.nodegroup.aware</name>
  <value>true</value>
  <description> By default, network topology is not aware of nodegroup
 layer.
  </description>
```

```
</property>
<property>
  <name>dfs.block.replicator.classname</name>

 <value>org.apache.hadoop.hdfs.server.blockmanagement.BlockPlacementPolicyWithNodeGro
value>
  <description> The default implementation of ReplicationTargetChooser.
  </description>
</property>
```

2. Add the following line to `yarn-site.xml`:

```
<property>
  <description>The class to use as scheduled requests.</description>
  <name>yarn.resourcemanager.scheduled.requests.class</name>

 <value>org.apache.hadoop.mapreduce.v2.app.rm.ScheduledRequestsWithNodeGroup</
value>
</property>
<property>
  <description> The boolean value to identify if the cluster is deployed
   on an environment which needs an additional layer (node group) between
 node
   and rack for network topology.
  </description>
  <name>net.topology.with.nodegroup</name>
  <value>true</value>
</property>
<property>
  <description>The class to use as AbstractSchedulerElementsFactory in RM
 scheduler.
  </description>
  <name>yarn.resourcemanager.scheduler.elements.factory.impl</name>
<value>org.apache.hadoop.yarn.server.resourcemanager.scheduler.
       SchedulerElementsFactoryWithNodeGroup</value>
</property>
```

Topology.data sample:

```
[root@namenode enable]# cat topology.data
10.111.57.223(VM IP)   /Rack1/NodeGroup1
10.111.57.224   /Rack1/NodeGroup1
10.111.57.225   /Rack1/NodeGroup2
10.111.57.226   /Rack2/NodeGroup1
10.111.57.227   /Rack2/NodeGroup1
10.111.57.228   /Rack2/NodeGroup2
10.111.57.229   /Rack2/NodeGroup2
```

Topology.sh sample:

```
[root@namenode enable]# cat topology.sh
#! /bin/bash
HADOOP_CONF=/hadoop/hadoop-smoke/etc/hadoop
# this is the location of topology.data
while [ $# -gt 0 ] ; do
  nodeArg=$1
  exec< ${HADOOP_CONF}/topology.data
  result=""
  while read line ; do
    ar=( $line )
    if [ "${ar[0]}" = "$nodeArg" ] ; then
      result="${ar[1]}"
    fi
```

```
      done
      shift
      if [ -z "$result" ] ; then
        echo -n "/default/rack "
      else
        echo -n "$result "
      fi
    done
```

3. Verify HVE is enabled:

   Run the TestDFSIO script. The output is as follows:

```
1)HVE enabled:
Job Counters
Launched map tasks=100
Launched reduce tasks=1
Data-local map tasks=26
NODEGROUP_LOCAL_MAPS=49
Rack-local map tasks=25
2)HVE disabled:
 Job Counters
Launched map tasks=100
Launched reduce tasks=1
Data-local map tasks=20
Rack-local map tasks=80
```

HVE Elasticity

HVE Elastic Resource Extension enables the adaption of MapReduce tasks to changing resources on nodes/clusters where Hadoop clusters are deployed to virtualized environments, by sharing resources with VMs from other clusters or applications.

Overview

Currently, the Hadoop resource model is static at the node level, assuming the node resources are not changed while the cluster is running. This design and implementation are based on an assumption that all cluster resources are dedicated for Hadoop MapReduce jobs, so they are fully available at all times. This assumption does not hold when users want to deploy multiple applications on the same cluster, e.g. deploying HBase and MapReduce on the same HDFS cluster. In particular, in an era of cloud computing, it is common for Hadoop clusters to be deployed on virtualized environments by sharing resource with VMs from other clusters or applications.

The HVE elastic resource feature addresses scenarios in which nodes' resources are possibly changed, so that scheduling of MapReduce tasks on these nodes can adapted to changing resources.

With this feature, APIs (CLI and JMX interface) and script tools are provided to get/set resources (memory, v-cores) on Hadoop cluster nodes for MR jobs.

Function List

Below are functionalities included in this elastic feature:

Function	Description
Configuration	Enable/disable elastic resource feature on Hadoop cluster by specifying a configuration property when starting MR cluster.

Function	Description
List nodes' status	List the status of all the nodes or nodes specified by user. The node status including its memory resource, v-core resource, hostname, health status, etc.
Set resource capacity in Node Manager node	Set resource capacity (memory, v-cores) of Node Manager to a node specified by user via CLI or JMX interface.

Configuration

To enable elastic resources, make the following changes to the Hadoop configuration.

In `yarn-site.xml`, add the following property to enable the elastic resource feature:

```
<property>
  <name>yarn.dynamic.resource.enable</name>
  <value>true</value>
</property>
```

Command-Line Interface for YARN Cluster

List all CLIs

```
yarn rmadmin
           [-refreshQueues]
           [-refreshNodes]
           [-refreshUserToGroupsMappings]
           [-refreshSuperUserGroupsConfiguration]
           [-refreshAdminAcls]
           [-refreshServiceAcl]
           [-getGroups [username]]
           [-updateNodeResource [NodeID][MemSize][Cores]]
           [-help [cmd]]

yarn node
 -all                Works with -list to list all nodes.
 -list               List all running nodes. Supports optional use of
                     -states to filter nodes based on node state, all -all
                     to list all nodes.
 -states <States>    Works with -list to filter nodes based on input
                     comma-separated list of node states.
 -status <NodeId>    Prints the status report of the node.
```

List Nodes

```
yarn node -list -all
```

Example

List all nodes:

```
yarn node -list -all
```

```
Total Nodes:8
         Node-Id      Node-State Node-Http-Address Number-of-Running-
Containers
hdsh2-a172.lss.emc.com:37804         RUNNING hdsh2-a172.lss.emc.com:8042
                        0
hdsh2-a173.lss.emc.com:45310         RUNNING hdsh2-a173.lss.emc.com:8042
                        0
hdsh2-a159.lss.emc.com:60596         RUNNING hdsh2-a159.lss.emc.com:8042
                        0
hdsh2-a158.lss.emc.com:51694         RUNNING hdsh2-a158.lss.emc.com:8042
                        0
hdsh2-a157.lss.emc.com:37348         RUNNING hdsh2-a157.lss.emc.com:8042
                        0
hdsh2-a174.lss.emc.com:33263         RUNNING hdsh2-a174.lss.emc.com:8042
                        0
hdsh2-a160.lss.emc.com:34460         RUNNING hdsh2-a160.lss.emc.com:8042
                        0
hdsh2-a171.lss.emc.com:49469         RUNNING hdsh2-a171.lss.emc.com:8042
                        0
```

Get Node Status

```
yarn node -status <NodeId>
```

Example

Get node status:

```
yarn node -status hdsh2-a172.lss.emc.com:37804

Node Report :
 Node-Id : hdsh2-a172.lss.emc.com:37804
 Rack : /dc/rc2
 Node-State : RUNNING
 Node-Http-Address : hdsh2-a172.lss.emc.com:8042
 Last-Health-Update : Wed 15/Jan/14 03:38:08:402CST
 Health-Report :
 Containers : 0
 Memory-Used : 0MB
 Memory-Capacity : 2048MB
 CPU-Used : 0 vcores
 CPU-Capacity : 2 vcores
```

Set Node Resource Capacity

```
yarn rmadmin -updateNodeResource [NodeID][MemSize][Cores]
```

Example

Set node resource capacity:

```
yarn rmadmin -updateNodeResource hdsh2-a172.lss.emc.com:37804 2048 2
```

Chapter 5

Security

This section describes how to secure a PHD cluster, including configuring Kerberos and LDAP authentication, and enabling auditing.

Security Overview

Starting with PHD 2.1, security setup for components installed via the Pivotal Command Center (PCC/ICM) is done as part of the installation process. For details, see the *PHD Installation and Administrator* Guide.

This section exists to provide a reference for (1) components that are not yet fully ICM managed; (2) default secure configuration for components; (3) troubleshooting assistance.

Securing a PHD cluster in the context of this document means configuring the following:

- Setting up and enabling the use of Kerberos for authentication. Kerberos is a network authentication protocol that provides strong authentication for client/server applications using secret-key cryptography.
- Setting up YARN containers to run as the invoking user within a Linux container.
- Setting datanode processes to run on system ports.
- [Optional] Setting up hosts to communicate with LDAP.
- [Optional] Setting up one way trust and hosts for Active Directory integration.

Standard configuration uses defaults for several values (such as allowed groups/hosts for a service); you may want to further restrict these parameters. These will be noted below.

Notes

- You must install and configure Kerberos to enable security in Pivotal HD 1.1.x. and higher. In PHD 2.1 and higher, this can be done as part of the install process.
- [Optional] Local OpenLDAP server installation is provided from PHD 2.1 onwards.
- For HAWQ to work with secure HDFS, the Pivotal ADS version must be 1.1.3 or greater.
- For more information about HAWQ secure configuration, see the *Kerberos Authentication* section of the *HAWQ Administrator Guide*.
- Note that Kerberos operation in Hadoop is very sensitive to proper networking configuration:
    - Host IP's for service nodes must reverse map to the FQDN's used to create the node principal for the service/FQDN.
    - `hostname -f` on a node must return the FQDN used to create the principal for the service/FQDN.
    - The cluster needs to have been created with FQDN's, not short names.
- Make sure your networking is properly configured before attempting to secure a cluster.

Kerberos Setup

This section describes how to set up Kerberos authentication.

Installing the KDC

If you have PHD 2.1 or later, the KDC was installed as part of the installation and you can skip this section. If you skipped this step during PHD installation, or want to set up your own MIT krb5 KDC, follow the instructions in this section.

Note: CentOS and RedHat use AES-256 as the default encryption strength. If you want to use AES-256, you will need to install the JCE security policy file (described below) on all cluster hosts. If not, disable this encryption type in the KDC configuration. To disable AES-256 on an MIT kerberos 5 KDC, remove aes256-cts:normal from thesupported_enctypesparameter inkdc.conf.

Install the MIT Kerberos 5 KDC

This section outlines a simple krb5 KDC setup, mainly for test and development purposes.

These instructions were largely derived from *Kerberos: The Definitive Guide* by James Garman, O'Reilly, pages 53-62.

1. Install the Kerberos packages (`krb5-libs`, `krb5-workstation`, and `krb5-server`) on the KDC host.
2. Define your REALM in `/etc/krb5.conf`.
   - For testing purposes, you can just use the `EXAMPLE.COM` REALM.
   - Set the `kdc` and `admin_server` variables to the resolvable hostname of the KDC host.
   - Set the `default_domain` to your REALM.

   In the following example, REALM was changed to `BIGDATA.COM` and the KDC host is `centos62-1.localdomain`:

```
[logging]
 default = FILE:/var/log/krb5libs.log
 kdc = FILE:/var/log/krb5kdc.log
 admin_server = FILE:/var/log/kadmind.log

[libdefaults]
 default_realm = BIGDATA.COM
 dns_lookup_realm = false
 dns_lookup_kdc = false
 ticket_lifetime = 24h
 renew_lifetime = 7d
 forwardable = true

[realms]
 BIGDATA.COM = {
  kdc = centos62-1.localdomain:88
  admin_server = centos62-1.localdomain:749
  default_domain = BIGDATA.COM
 }

[domain_realm]
 .bigdata.com = BIGDATA.COM
 bigdata.com = BIGDATA.COM
```

3. Set up `/var/kerberos/krb5kdc/kdc.conf`:

   - If you want to use AES-256, uncomment the `master_key_type` line.
   - If you do not want to use AES-256, remove it from the `supported_enctypes` line.
   - Add a `key_stash_file` entry: `/var/kerberos/krb5kdc/.k5.REALM`.
   - Set the maximum ticket lifetime and renew lifetime to your desired values (24 hours and 7 days are typical).
   - Add the `kadmind_port` entry: `kadmind_port = 749`.

   Important: The stash file lets the KDC server start up for root without a password being entered. The result (using AES-256) for the above REALM is:

```
[kdcdefaults]
 kdc_ports = 88
 kdc_tcp_ports = 88

[realms]
 BIGDATA.COM = {
  master_key_type = aes256-cts
  acl_file = /var/kerberos/krb5kdc/kadm5.acl
  dict_file = /usr/share/dict/words
  admin_keytab = /var/kerberos/krb5kdc/kadm5.keytab
  key_stash_file = /var/kerberos/krb5kdc/.k5.BIGDATA.COM
  max_life = 24h 0m 0s
  max_renewable_life = 7d 0h 0m 0s
  kadmind_port = 749
  supported_enctypes = aes256-cts:normal aes128-cts:normal des3-hmac-
sha1:normal arcfour-hmac:normal des-hmac-sha1:normal des-cbc-md5:normal
 des-cbc-crc:normal
 }
```

4. Create the KDC master password by running:

```
kdb5_util create -s
```

   Do *NOT* forget your password, as this is the root KDC password.This typically runs quickly, but can take 5-10 minutes if the code has trouble getting the random bytes it needs.

5. Add an administrator account as `username/admin@REALM`. Run the `kadmin.local` application from the command line:

```
.kadmin.local: addprinc username/admin@REALM
```

   Type `quit` to exit `kadmin.local`.

   Important: The KDC does not need to be running to add a principal.

6. Start the KDC by running:

```
/etc/init.d/krb5kdc start
```

   You should get an `[OK]` indication if it started without error.

7. Edit `/var/kerberos/krb5kdc/kadm5.acl` and change the admin permissions username from `*` to your admin. You can add other admins with specific permissions if you want (`man kadmind`). This is a sample ACL file:

```
joeit/admin@BIGDATA.COM       *
```

8. Use `kadmin.local` on the KDC to enable the administrator(s) remote access:

   ```
   kadmin.local: ktadd -k /var/kerberos/krb5kdc/kadm5.keytab kadmin/admin
    kadmin/changepw
   ```

   Important: `kadmin.local` is a KDC host-only version of `kadmin` that can do things remote `kadmin` cannot (such as use the `-norandkey` option in `ktadd`).

9. Start `kadmind`:

   ```
   /etc/init.d/kadmin start
   ```

   The KDC should now be done and ready to use, but you need to set up your clients first.

10. Install `krb5-libs` and `krb5-workstation` on all cluster hosts, including any client/gateway hosts.
11. Push your KDC `/etc/krb5.conf` to all workstation hosts.
12. Do a simple test, as follows:

    a. Log in as the admin you created:

       ```
       kinit username/admin.
       ```

    b. Run `kadmin` and make sure you can log in.

    If you get the message `kinit: Cannot contact any KDC for realm 'REALM' while getting initial credentials`, then the KDC is not running or the KDC host information in `/etc/kdc.conf` is incorrect.

You should now have a KDC that is functional for PHD secure cluster operations.

Install Kerberos Workstation and Libraries on Cluster Hosts

If you are using MIT krb5, run:

```
# yum install krb5-libs krb5-workstation
```

Distribute the Kerberos Client Configuration File to all Cluster Hosts

If you are using Kerberos 5 MIT, the file is `/etc/krb5.conf`. This file must exist on all cluster hosts. For PHD, you can use `massh` to push the files, and then to copy them to the proper place.

Integrating Cluster Security with an Organizational KDC

If your organization runs Active Directory or other Kerberos KDC, it is not recommended this be used for cluster security. Instead, install an MIT Kerberos KDC and realm for the cluster(s) and create all the service principals in this realm as per the instructions below. This KDC will be minimally used for service principals, whilst Active Directory (or your organizations's MIT KDC) will be used for cluster users. Next, configure one-way cross-realm trust from this realm to the Active Directory or corporate KDC realm.

Important: Though it is possible to use your corporate KDC infrastructure for Hadoop service principals, the local KDC with trust configuration is strongly recommended, as a large PHD cluster requires the IT manager to create large numbers of service principals for your organizations' Active Directory or organizational MIT KDC. For example, a 100 node PHD cluster requires 200+ service principals. In addition, when a large cluster starts up, it may impact the performance of your organizations' IT systems, as all the service principals make requests of the AD or MIT Kerberos KDC at once.

Some useful references:

http://technet.microsoft.com/en-us/library/bb742433.aspx *http://www.kerberos.org/software/mixenvkerberos.pdf*

https://access.redhat.com/documentation/en-US/Red_Hat_Enterprise_Linux/5/html/Deployment_Guide/sec-kerberos-crossrealm.html

Configure MIT krb5 Kerberos Trust

One-way trust is established in Kerberos by creating trust principals in both KDCs that allow one KDC to request authentication from another KDC. You may want to configure MIT KDC to MIT KDC trust to allow one cluster access to another cluster or if you are using MIT Kerberos for your corporate KDC.

Caution: Some Java versions are not compatible with some later Kerberos versions. For example, Java 6 is not compatible with newer MIT krb5 releases. If you are using an older version of PHD with Java 6, this may cause problems if you have a newer version KDC.

The trust principals should be created at the same time and if one needs to change both should be recreated. In the MIT krb5 KDC, principals are of the form:

```
krbtgt/REALM_OF_TRUSTING_KDC@REALM_OF_TRUSTED_KDC
```

To create a trust principal:

1. Run:

   ```
   addprinc -e <supported_encryption_types> krbtgt/
   REALM_OF_TRUSTING_KDC@REALM_OF_TRUSTED_KDC
   ```

   This principal must be created with the same encryption types, same password, and same key version on both the trusting and trusted KDC.
2. Next, you need to add an entry in all host `/etc/krb5.conf` files on the cluster to point to the trusted KDC for the trusted realm:

   ```
   [realms]
       REALM_OF_TRUSTED_KDC = {
           kdc = trusted_kdc.mydomain:88
           admin_server = trusted_kdc.mydomain:749
           default_domain = mydomain
       }
       ...
   ```

   This allows the cluster nodes to look up the KDC they should contact for logins from this realm.

To create two-way trust, you simply need to repeat the process with the trusted and trusting KDCs reversed.

Configure One-way Trust with Active Directory

To set up an MIT cluster to use AD for user logins, you will need to run some commands on all domain controllers advertising the domains that will have access to the Hadoop cluster. This will also have to be part of the process when new domain controllers are added.

To configure one-way trust with AD:

1. Add the cluster KDC to the domain controllers:

   ```
   ksetup /addkdc <cluster_realm> <cluster_kdc_fqdn>
   ```
2. Set up one-way trust between the MIT Kerberos Realm and the Active Directory domain:

   ```
   netdom trust <cluster_realm> /Domain:<active_directory_realm> /add /
   realm /passwordt:<trust_password>
   ```

Note: The passwordt option is correctly spelled; the "t" at the end is required.

3. Set the encryption types (AES256-CTS-HMAC-SHA1-96, AES128-CTS-HMAC-SHA1-96, RC4-HMAC-MD5):

```
ksetup /SetEncTypeAttr <cluster_realm> <enc_type_list_space_separated>
```

Note: The format used in this command for types is different from the format used in MIT krb5, but the essentials are the same. For example, AES256-CTS-HMAC-SHA1-96 for AD is aes256-cts:normal in MIT krb5.

4. Now Active Directory knows about the KDC and has the trust key, so next you need to tell your cluster KDC about AD. On the MIT Kerberos KDC:

```
addprinc -e <supported_encryption_types> krbtgt/
CLUSTER_REALM@AD.CORP.BIGDATA.COM
```

Where the encryption types are the same and the same trust password as was given in the netdom command is used and the AD realm is AD.CORP.BIGDATA.COM.

5. Next edit the krb5.conf file on all cluster hosts to add the realm. On all cluster nodes:

```
[realms]
    AD.CORP.BIGDATA.COM = {
        kdc = ad_server.mydomain:88
        admin_server = ad_server.mydomain:749
        default_domain = mydomain
    }
    ...
```

6. Finally, edit core-site.xml on the cluster hosts (use the icm_client reconfigure option if possible) to allow for mapping of the AD realm to local names in the cluster:

```
<property>
  <name>hadoop.security.auth_to_local</name>
  <value>
    RULE:[1:$1@$0](^.*@AD\.CORP\.BIGDATA\.COM$)s/^(.*)@AD\.CORP\.BIGDATA
\.COM$/$1/g
    RULE:[2:$1@$0](^.*@AD\.CORP\.BIGDATA\.COM$)s/^(.*)@AD\.CORP\.BIGDATA
\.COM$/$1/g
    DEFAULT
  </value>
</property>
```

LDAP Setup

Overview

This section describes how to set up sssd to allow integrated LDAP/KDC login to cluster hosts. The sssd module is a wrapper for the Linux PAM authentication module that handles login process for various authentication methods. After setting up sssd, user logins will be served via LDAP; passwords will be authenticated via Kerberos. After logging in to a host (e.g. via ssh), users will automatically have a Kerberos ticket.

Note: This topic applies only to PHD 2.1 or greater. It assumes you have run icm_client security -i and selected to install the OpenLDAP server when prompted, or that you have installed an LDAP server on your own.

Configuring Local LDP

Run the following commands on the PCC node to configure local LDAP.

Start the LDAP Server

On the PCC node, start the local LDAP server process:

```
chkconfig slapd on
service slapd start
```

Configure the Cluster Nodes

On the PCC node, run the `icmdriver` tool with the `sssdconfig` option to configure `sssd` on all the cluster nodes hosts.

Provide your domain (`-b`) and realm (`-r`) as shown in the example below along with a file indicating the cluster nodes to configure.

Host SSSD Configuration Example

```
/usr/lib/gphd/tools/security/bin/icmdriver sssdconfig -b
 "ou=phdusers,dc=phddev,dc=local" -r PHDDEV.LOCAL -f HostFile.txt
```

Verify LDAP configuration

After the above command is compete, you can test the setup as follows.

1. Add an LDAP user on the PCC node and the corresponding principal into Kerberos.
2. `ssh` as that user into a cluster host.
3. After logging in, you should already have a Kerberos ticket (verify using `klist`).
4. Validate the login by running a simple Hadoop command; for example:

   ```
   hdfs dfs -ls /
   ```

Configuring Kerberos for HDFS and YARN (MapReduce)

At a minimum, Kerberos provides protection against user and service spoofing attacks, and allows for enforcement of user HDFS access permissions. The installation is not difficult, but requires very specific instructions with many steps, and suffers from the same difficulties as any system requiring distributed configuration. Pivotal is working to automate the process to make it simple for users to enable/disable secure PHD clusters. Until then, these instructions are intended to provide a step-by-step process for getting a cluster up and running in secure mode.

Note that after the initial HDFS/YARN configuration, other services that need to be set up to run on secure HDFS (for example, HBase), or that you want to also secure (for example, Zookeeper), need to configured.

Important: Save your command history; it will help in checking for errors when troubleshooting.

Creating the Principals and Keytabs

These instructions are for MIT Kerberos 5; command syntax for other Kerberos versions may be different.

Principals (Kerberos users) are of the form: `name/role@REALM`. For our purposes, the name will be a PHD service name (for example, `hdfs`), and the role will be a DNS-resolvable fully-qualified hostname (`host_fqdn`); one you could use to connect to the host in question.

Important:

- Replace `REALM` with the KDC realm you are using for your PHD cluster, where it appears.
- The host names used *must* be resolvable to an address on all the cluster hosts and *must* be of the form `host.domain`, as some Hadoop components require at least one period ('.') part in the host names used for principals.
- The names of the principals seem to matter, as some processes may throw exceptions if you change them. Hence, it is safest to use the specified Hadoop principal names.
- Hadoop supports an `_HOST` tag in the site XML that is interpreted as the `host_fqdn`, but this must be used properly. See *Using _HOST in Site XML*.

For the HDFS services, you will need to create an `hdfs/host_fqdn` principal for each host running an HDFS service (name node, secondary name node, data node).

For YARN services, you will need to create a `yarn/host_fqdn` principal for each host running a YARN service (resource manager, node manager, proxy server).

For MapReduce services, you need to create a principal, `mapred/host_fqdn` for the Job History Server.

Create the Principals

To create the required secure HD principals (running `kadmin.local`):

- **Cluster Hosts**

  For each cluster host (except client-only hosts), run:

  ```
  addprinc -randkey HTTP/<host_fqdn>@<REALM>
  ```

- **HDFS (name node, secondary name node, data nodes)**

  For each HDFS service host, run:

  ```
  addprinc -randkey hdfs/<host_fqdn>@<REALM>
  ```

- **YARN (resource manager, node managers, proxy server)**

For each YARN service host, run:

```
addprinc -randkey yarn/<host_fqdn>@<REALM>
```

- **MapReduce (job history server)**

  For each JHS service host, run:

```
addprinc -randkey  mapred/<host_fqdn>@<REALM>
```

Note: If you have 1000 cluster hosts running HDFS and YARN, you will need 2000 HDFS and YARN principals, and need to distribute their keytab files. It is recommended that you use a cluster-local KDC for this purpose and configure cross-realm trust to your organizational Active Directory or other Kerberos KDC. For more information, see *Kerberos Setup* on page 90.

Create the Keytab Files

Important: You *must* use `kadmin.local` (or the equivalent in your KDC) for this step on the KDC, as `kadmin` does not support `-norandkey`.

Also, you can put the keytab files anywhere during this step. In this document, we created a directory `/etc/security/phd/keytab/` and are using this directory on cluster hosts, and so, for consistency, are placing them in a similarly-named directory on the KDC. If the node you are using already has files in `/etc/security/phd/keytab/`, it may be advisable to create a separate, empty directory for this step.

Each service's keytab file for a given host will have the service principal for that host and the HTTP principal for that host in the file.

- **HDFS key tabs**

  For each host having an HDFS process (name node, secondary name node, data nodes), run:

```
kadmin.local: ktadd -norandkey -k /etc/security/phd/keytab/hdfs-
hostid.service.keytab  hdfs/<host_fqdn>@<REALM> HTTP/<host_fqdn@<REALM>
```

  Where `hostid` is the short name for the host, for example, `vm1`, `vm2`, etc. This is to differentiate the files by host. You can use the hostname if desired.

  For example, for a three node cluster (one name node, two data nodes):

```
kadmin.local: ktadd -norandkey -k /etc/security/phd/keytab/hdfs-
vm2.service.keytab hdfs/centos62-2.localdomain@BIGDATA.COM HTTP/
centos62-2.localdomain@BIGDATA.COM
kadmin.local: ktadd -norandkey -k /etc/security/phd/keytab/hdfs-
vm3.service.keytab hdfs/centos62-3.localdomain@BIGDATA.COM HTTP/
centos62-3.localdomain@BIGDATA.COM
kadmin.local: ktadd -norandkey -k /etc/security/phd/keytab/hdfs-
vm4.service.keytab hdfs/centos62-4.localdomain@BIGDATA.COM HTTP/
centos62-4.localdomain@BIGDATA.COM
```

- **YARN keytabs**

  For each host having a YARN process (resource manager, node manager or proxy server), run:

```
kadmin.local:  ktadd -norandkey -k /etc/security/phd/keytab/yarn-
hostid.service.keytab yarn/<host_fqdn>@<REALM>   HTTP/<host_fqdn>@<REALM>
```

For example, for a three node cluster (one node resource manager, two node managers):

```
kadmin.local: ktadd -norandkey -k /etc/security/phd/keytab/yarn-
vm2.service.keytab yarn/centos62-2.localdomain@BIGDATA.COM HTTP/
centos62-2.localdomain@BIGDATA.COM
kadmin.local: ktadd -norandkey -k /etc/security/phd/keytab/yarn-
vm3.service.keytab yarn/centos62-3.localdomain@BIGDATA.COM HTTP/
centos62-3.localdomain@BIGDATA.COM
kadmin.local: ktadd -norandkey -k /etc/security/phd/keytab/yarn-
vm4.service.keytab yarn/centos62-4.localdomain@BIGDATA.COM HTTP/
centos62-4.localdomain@BIGDATA.COM
```

- **MapReduce keytabs**

  For each host having a MapReduce job history server, run:

```
kadmin.local:  ktadd -norandkey -k /etc/security/phd/keytab/mapred-
hostid.service.keytab  mapred/host_fqdn@REALM  HTTP/host_fqdn@REALM
```

  For example:

```
kadmin.local: ktadd -norandkey -k /etc/security/phd/keytab/mapred-
vm2.service.keytab mapred/centos62-2.localdomain@BIGDATA.COM HTTP/
centos62-2.localdomain@BIGDATA.COM
```

Distribute the Keytab Files

1. On each cluster node, create the directory for the keytab files; here, we are using `/etc/security/phd/keytab`.
2. Move all the keytab files for a given host to the keytab directory on that host. For example: `hdfs-vm2.service.keytab`, `yarn-vm2.service.keytab` and `mapred-vm2.service.keytab` go to host vm2
3. On each host:

   a. Change the permissions on all key tabs to read by owner only:

```
chmod 400 *.keytab
```

   b. Change the group on all keytab files to hadoop:

```
chgrp hadoop *
```

   c. Change the owner of each keytab to the relevant principal name. For example, for `yarn-vm2.service.keytab`, run:

```
chown yarn yarn-vm2.service.keytab
```

   d. Create links to the files of the form `principalname.service.keytab`. For example, for `yarn-vm2.service.keytab`, run:

```
ln -s yarn-vm2.service.keytab yarn.service.keytab
```

Important: The last step above allows you to maintain clear identification of each keytab file while also allowing you to have common site xml files across cluster hosts.

Cluster Control Node Example:

This is an example keytab directory for a cluster control node (namenode, resource manager, JHS):

```
lrwxrwxrwx 1 root      root    23 Jun 10 23:50 hdfs.service.keytab -> hdfs-
vm2.service.keytab
-r-------- 1 hdfs      hadoop 954 Jun 10 23:44 hdfs-vm2.service.keytab
lrwxrwxrwx 1 root      root    25 Jun 10 23:51 mapred.service.keytab ->
 mapred-vm2.service.keytab
-r-------- 1 mapred    hadoop 966 Jun 10 23:44 mapred-vm2.service.keytab
lrwxrwxrwx 1 root      root    23 Jun 10 23:51 yarn.service.keytab -> yarn-
vm2.service.keytab
-r-------- 1 yarn      hadoop 954 Jun 10 23:44 yarn-vm2.service.keytab
```

Cluster Node Example:

This is an example keytab directory for a cluster node (datanode, node manager, proxy server):

```
lrwxrwxrwx 1 root root    23 Jun 11 01:58 hdfs.service.keytab -> hdfs-
vm3.service.keytab
-r-------- 1 hdfs hadoop 954 Jun 10 23:45 hdfs-vm3.service.keytab
lrwxrwxrwx 1 root root    23 Jun 11 01:58 yarn.service.keytab -> yarn-
vm3.service.keytab
-r-------- 1 yarn hadoop 954 Jun 10 23:45 yarn-vm3.service.keytab
```

Installing Java Support Items

Install JCE on all Cluster Hosts

Important: This step is only if you are using AES-256.

These files will already exist in your environment and look the same, but are the **limited strength** encryption files; you must replace them with the unlimited strength files to use AES-256:

1. Download and unzip the JCE file for your JDK version: Java Cryptography Extension (JCE) Unlimited Strength Jurisdiction Policy Files 7 for JDK 7).
2. Place the `local_policy.jar` and `US_export_policy.jar` files in the `/usr/java/default/jre/lib/security/` directory on all cluster hosts.

Check JSVC on all Datanodes

JSVC allows a Java process to start as root and then switch to a less privileged user, and is required for the datanode process to start in secure mode. Your distribution comes with a pre-built JSVC; you need to verify it can find a JVM as follows:

1. Run:

   ```
   /usr/libexec/bigtop-utils/jsvc  -help
   ```

2. Look under the printed `-jvm` item in the output and you should see something like:

   ```
   use a specific Java Virtual Machine. Available JVMs:
   'server'
   ```

3. If you do not see the `server` line, this JSVC will not work for your platform; try the following actions:

   a. Install JSVC using yum and run the check again; if it fails, try the next step.
   b. Build from source and install manually (see *Building and Installing JSVC*).

If you have datanode start-up problems and no other errors are obvious, it might be a JSVC problem and you may need to perform step 2, above, another time. JSVC is very picky about platform and JDK matching, so use the *Building and Installing JSVC* instructions for your system OS and JDK.

Modifying the Container and Script

Configure the Linux Container

1. Edit the `/usr/lib/gphd/hadoop-yarn/etc/hadoop/container-executor.cfg` file as follows:

```
# NOTE: these next two should be set to the same values they have in yarn-
site.xml
yarn.nodemanager.local-dirs=/data/1/yarn/nm-local-dir
yarn.nodemanager.log-dirs=/data/1/yarn/userlogs
# configured value of yarn.nodemanager.linux-container-executor.group
yarn.nodemanager.linux-container-executor.group=yarn
# comma separated list of users who can not run applications
banned.users=hdfs,yarn,mapred,bin
# Prevent other super-users
min.user.id=500
```

Note: The `min.user.id` varies by Linux distribution; for CentOS it is 500, RedHat is 1000.

2. Check the permissions on `/usr/lib/gphd/hadoop-yarn/bin/container-executor`. They should look like:

```
---Sr-s--- 1 root yarn   364 Jun 11 00:08 container-executor
```

If they do not, then set the owner, group and permissions as:

```
chown root:yarn container-executor
chmod 050 container-executor
chmod u+s container-executor
chmod g+s container-executor
```

3. Check the permissions on `/usr/lib/gphd/hadoop-yarn/etc/hadoop/container-executor.cfg`. They should look like:

```
-rw-r--r-- 1 root root 363 Jul  4 00:29 /usr/lib/gphd/hadoop-yarn/etc/
hadoop/container-executor.cfg
```

If they do not, then set them as follows:

```
chown root:root container-executor.cfg
chmod 644 container-executor.cfg
```

Edit the Environment on the Datanodes

Important:

- At this point you should STOP the cluster, if it is running.
- You only need to perform the steps below on the data nodes.

1. Uncomment the lines at the bottom of `/etc/default/hadoop-hdfs-datanode`:

```
# secure operation stuff
export HADOOP_SECURE_DN_USER=hdfs
export HADOOP_SECURE_DN_LOG_DIR=${HADOOP_LOG_DIR}/hdfs
export HADOOP_PID_DIR=/var/run/gphd/hadoop-hdfs/
export HADOOP_SECURE_DN_PID_DIR=${HADOOP_PID_DIR}
```

2. Set the JSVC variable:

   ```
   export JSVC_HOME=/usr/libexec/bigtop-utils
   ```

   If you are using the included `jsvc`, the `JSVC_HOME` variable in `/etc/default/hadoop` should already be properly set.

   If, however, you built or hand-installed JSVC, your `JSVC_HOME` will be `/usr/bin` , so you must set it appropriately. Modify `/etc/default/hadoop` and set the proper `JSVC_HOME`:

   ```
   export JSVC_HOME=/usr/bin
   ```

   Important: Make sure `JSVC_HOME` points to the correct `jsvc` binary.

Attention: As long as `HADOOP_SECURE_DN_USER` is set, the datanode will try to start in secure mode.

Editing the Site XML

Use _HOST in Site XML

You can maintain consistent site XML by using the `_HOST` keyword for the `host_fqdn` part in the site XML if:

- Your cluster nodes were identified with fully-qualified domain names when configuring the cluster.
- `hostname -f` on all nodes yields the proper fully-qualified hostname (same as the one used when creating the principals).

You cannot use constructs like `_HOST.domain`; these will be interpreted literally.

You can only use `_HOST` in the site XML; files such as `jaas.conf`, needed for Zookeeper and HBase, must use actual FQDN's for hosts.

Edit the Site XML

Finally, you are ready to edit the site XML to turn on secure mode. Before starting this task, it is good to understand who needs to talk to whom. By "talk", we mean using authenticated Kerberos to initiate establishment of a communication channel. Doing this requires you to know your own principal, to identify yourself, and know the principal of the service you want to talk to. To be able to use its principal, a service needs to be able to log in to Kerberos without a password, using a keytab file:

- Each service needs to know its own principal name.
- Each running service on a node needs a service/host specific keytab file to start up.
- Each data node needs to talk to the name node.
- Each node manager needs to talk to the resource manager and the job history server.
- Each client/gateway node needs to talk to the name node, resource manager and job history server.

Important:

- Redundant keytab files on some hosts do no harm and it makes management easier to have constant files. Remember, though, that the `host_fqdn` *must* be correct for each entry. Remembering this helps when setting up and troubleshooting the site xml files.
- Before making changes, back up the current site xml files so that you can return to non-secure operation, if needed.

Most of the changes can be consistent throughout the cluster site XML. Unfortunately, since data node and node manager principals are hostname-dependent (or more correctly the role for the YARN principal is set to the `host_fqdn`), the `yarn-site.xml` for data node and node manager principals will differ across the cluster:

1. **Core Site**

   Edit `/usr/lib/gphd/hadoop/etc/hadoop/core-site.xml` as follows:

```
<property>
  <name>hadoop.security.authentication</name>
  <value>kerberos</value>
</property>

<property>
  <name>hadoop.security.authorization</name>
  <value>true</value>
</property>

<!-- THE PROPERTY BELOW IS OPTIONAL: IT ENABLES ON WIRE RPC ENCRYPTION -->

<property>
  <name>hadoop.rpc.protection</name>
  <value>privacy</value>
</property>
```

2. **HDFS Site**

   Edit `/usr/lib/gphd/hadoop/etc/hadoop/hdfs-site.xml` as follows:

```
<!-- WARNING: do not create duplicate entries: check for existing entries
 and modify if they exist! -->

<property>
  <name>dfs.block.access.token.enable</name>
  <value>true</value>
</property>

<!-- short circuit reads do not work when security is enabled for PHD
 VERSION LOWER THAN 2.0 so disable ONLY for them -->
<!-- For PHD greater than or equal to 2.0, set this to true -->

<property>
  <name>dfs.client.read.shortcircuit</name>
  <value>false</value>
</property>
<!-- name node secure configuration info -->

<property>
  <name>dfs.namenode.keytab.file</name>
  <value>/etc/security/phd/keytab/hdfs.service.keytab</value>
</property>

<property>
  <name>dfs.namenode.kerberos.principal</name>
  <value>hdfs/_HOST@REALM</value>
</property>

<property>
  <name>dfs.namenode.kerberos.http.principal</name>
  <value>HTTP/_HOST@REALM</value>
</property>

<property>
```

```
  <name>dfs.namenode.kerberos.internal.spnego.principal</name>
  <value>HTTP/_HOST@REALM</value>
</property>

<!-- (optional) secondary name node secure configuration info -->

<property>
  <name>dfs.secondary.namenode.keytab.file</name>
  <value>/etc/security/phd/keytab/hdfs.service.keytab</value>
</property>

<property>
  <name>dfs.secondary.namenode.kerberos.principal</name>
  <value>hdfs/_HOST@REALM</value>
</property>

<property>
  <name>dfs.secondary.namenode.kerberos.http.principal</name>
  <value>HTTP/_HOST@REALM</value>
</property>

<property>
  <name>dfs.secondary.namenode.kerberos.internal.spnego.principal</name>
  <value>HTTP/_HOST@REALM</value>
</property>

<!-- data node secure configuration info -->

<property>
  <name>dfs.datanode.data.dir.perm</name>
  <value>700</value>
</property>

<!-- these ports must be set < 1024 for secure operation -->
<!-- conversely they must be set back to > 1024 for non-secure operation
 -->
<property>
  <name>dfs.datanode.address</name>
  <value>0.0.0.0:1004</value>
</property>

<property>
  <name>dfs.datanode.http.address</name>
  <value>0.0.0.0:1006</value>
</property>

<!-- remember the principal for the datanode is the principal this hdfs-
site.xml file is on -->

<!-- these (next three) need only be set on data nodes -->

<property>
  <name>dfs.datanode.kerberos.principal</name>
  <value>hdfs/_HOST@REALM</value>
</property>

<property>
  <name>dfs.datanode.kerberos.http.principal</name>
  <value>HTTP/_HOST@REALM</value>
</property>

<property>
  <name>dfs.datanode.keytab.file</name>
  <value>/etc/security/phd/keytab/hdfs.service.keytab</value>
```

```
</property>

<!-- OPTIONAL - set these to enable secure WebHDSF -->

<!-- on all HDFS cluster nodes (namenode, secondary namenode, datanode's)
 -->

<property>
  <name>dfs.webhdfs.enabled</name>
  <value>true</value>
</property>

<property>
  <name>dfs.web.authentication.kerberos.principal</name>
  <value>HTTP/_HOST@REALM</value>
</property>

<!-- since we included the HTTP principal all keytabs we can use it here
 -->

<property>
  <name>dfs.web.authentication.kerberos.keytab</name>
  <value>/etc/security/phd/keytab/hdfs.service.keytab</value>
</property>

<!-- THE PROPERTIES BELOW ARE OPTIONAL AND REQUIRE RPC PRIVACY (core-
site): THEY ENABLE ON WIRE HDFS BLOCK ENCRYPTION -->

<property>
  <name>dfs.encrypt.data.transfer</name>
  <value>true</value>
</property>

<property>
  <name>dfs.encrypt.data.transfer.algorithm</name>
  <value>rc4</value>
  <description>may be "rc4" or "3des" - 3des has a significant performance
 impact</description>
</property>
```

3. **YARN Site**

   Edit `/usr/lib/gphd/hadoop/etc/hadoop/yarn-site.xml` as follows:

```
<!-- resource manager secure configuration info -->

<property>
  <name>yarn.resourcemanager.principal</name>
  <value>yarn/_HOST@REALM</value>
</property>

<property>
  <name>yarn.resourcemanager.keytab</name>
  <value>/etc/security/phd/keytab/yarn.service.keytab</value>
</property>

<!-- remember the principal for the node manager is the principal for the
 host this yarn-site.xml file is on -->

<!-- these (next four) need only be set on node manager nodes -->

<property>
  <name>yarn.nodemanager.principal</name>
  <value>yarn/_HOST@REALM</value>
```

```
</property>

<property>
  <name>yarn.nodemanager.keytab</name>
  <value>/etc/security/phd/keytab/yarn.service.keytab</value>
</property>

<property>
  <name>yarn.nodemanager.container-executor.class</name>

 <value>org.apache.hadoop.yarn.server.nodemanager.LinuxContainerExecutor</
value>
</property>

<property>
  <name>yarn.nodemanager.linux-container-executor.group</name>
  <value>yarn</value>
</property>

<!-- OPTIONAL - set these to enable secure proxy server node -->

<property>
  <name>yarn.web-proxy.keytab</name>
  <value>/etc/security/phd/keytab/yarn.service.keytab</value>
</property>

<property>
  <name>yarn.web-proxy.principal</name>
  <value>yarn/_HOST@REALM</value>
</property>
```

4. **MapReduce Site**

   Edit `/usr/lib/gphd/hadoop/etc/hadoop/mapred-site.xml` as follows:

```
<!-- job history server secure configuration info -->

<property>
  <name>mapreduce.jobhistory.keytab</name>
  <value>/etc/security/phd/keytab/mapred.service.keytab</value>
</property>

<property>
  <name>mapreduce.jobhistory.principal</name>
  <value>mapred/_HOST@REALM</value>
</property>
```

Completing the HDFS/YARN Secure Configuration

1. Start the cluster:

```
$ icm_client start
```

2. Check that all the processes listed below start up:

- Control processes: namenode, resourcemanager, historyserver should all be running.
- Cluster worker processes: datanode and namenode should be running.

Note: Until you do HBase security configuration, HBase will not start up on a secure cluster.

If the process do not start up, see the *Security - Troubleshooting* on page 137 section.

3. Create a principal for a standard user (the user must exist as a Linux user on all cluster hosts):

   ```
   kadmin: addprinc testuser
   ```

   Set the password when prompted.
4. Log in as that user on a client box (or any cluster box, if you do not have specific client purposed systems).
5. Get your Kerberos TGT by running `kinit` for the user and entering the user's password:

   ```
   kinit testuser
   ```

6. Test simple HDFS file list and directory create:

   ```
   hadoop fs -ls
   hadoop fs -mkdir testdir
   ```

   If these do not work, see the *Security - Troubleshooting* on page 137 section.
7. **[Optional]** Set the sticky bit on the `/tmp` directory (prevents non-super-users from moving or deleting other users' files in `/tmp`):

   a. Log in as `gpadmin` on any HDFS service node (namenode, datanode).
   b. Execute the following:

      ```
      sudo -u hdfs kinit -k -t /etc/security/phd/keytab/hdfs.service.keytab
       hdfs/this-host_fqdn@REALM
      ```

   c. Execute the following:

      ```
      sudo -u hdfs hadoop fs -chmod 1777 /tmp
      ```

   d. Run a simple MapReduce job such as the Pi example:

      ```
      hadoop jar /usr/lib/gphd/hadoop-mapreduce/hadoop-mapreduce-
      examples-2.0.2-alpha-gphd-2.0.1.0.jar pi 10 100
      ```

If everything works, then you are ready to configure other services. If not, see the *Security - Troubleshooting* on page 137 section.

Turning Secure Mode Off

To turn off secure mode:

1. Stop the cluster:

   ```
   icm_client stop
   ```

2. Comment out `HADOOP_SECURE_DN_USER` in `hadoop-env.sh` and `/etc/init.d/hadoop-hdfs-datanode` on all data nodes.
3. Either:

   a. If you made backups as suggested above, restore the original site xml files, or:
   b. If you do not have backups, then edit the site xml as follows:

      i. Set the Linux container executable to `org.apache.hadoop.yarn.server.nodemanager.DefaultContainerExecutor` on all data nodes.
      ii. Set `dfs.block.access.token.enable` to `false` on all data nodes.
      iii. Return the datanode ports modified above so they are > 1024 again.

- **iv.** Set `hadoop.security.authentication` to `simple` and `hadoop.security.authorization` to `false` in `core-site.xml` on all cluster nodes.
- **v.** Undo the changes to the Zookeeper site xml and configuration files.
- **vi.** If applicable, revert the changes to the `hdfs-client.xml` and `gpinisystem_config` for HAWQ.
- **vii.** If applicable, undo the changes to the Hive and HBase site xml, configuration, and environments.

4. Start the cluster.

Building and Installing JSVC

In order for the data nodes to start as root to get secure ports, then switch back to the HDFS user, JSVC must be installed (*http://commons.apache.org/proper/commons-daemon/download_daemon.cgi*). If the packaged JSVC binary is not working, we recommend building JSVC from source for your platform.

You only need to perform the `make` on one node, then the binary can be distributed to the other nodes (assuming all systems are using the same basic image):

1. Install `gcc` and `make` (you can remove them after this process if desired):

```
yum install gcc make
```

2. Download the Apache commons daemon. For example, `commons-daemon-1.0.15-src.zip` was tested.

   The daemon is available here: *http://commons.apache.org/proper/commons-daemon/download_daemon.cgi*
3. `scp` the file to one of your data node cluster systems.
4. Uncompress it.
5. Change to the install directory:

```
cd commons-daemon-1.0.15-src/src/native/unix
```

6. If you are on a 64-bit machine and using a 64 bit JVM, run these exports before configure/make:

```
export CFLAGS=-m64
export LDFLAGS=-m64
```

7. Configure and make it:

```
./configure --with-java=/usr/java/default
make
```

8. Manually install it to the following location:

```
mv ./jsvc  /usr/bin/jsvc
```

9. Check that the correct JSVC was found by running:

```
which jsvc
```

   The correct output is:

```
/usr/bin/jsvc
```

10. Run:

```
jsvc -help
```

Look under the printed `-jvm` item and you should see something like:

```
use a specific Java Virtual Machine. Available JVMs:
'server'
```

If the line under `Available JVMs` (where `server` is above) is blank, there is a problem, as it cannot find the JVM. Check that the JDK is installed properly in `/usr/java/default`.

Configuring Kerberos for HDFS High Availability

Note: Currently, only Quorum Journal-based storage is support for high availability.

To configure Kerberos for HDFS HA, add the following Quorum Journal-based storage configuration properties to the `hdfs-site.xml` file on all machines in the cluster:

```
<property>
  <name>dfs.journalnode.keytab.file</name>
  <value>/etc/security/phd/keytab/hdfs.service.keytab</value> <!-- path to
 the HDFS keytab -->
</property>
<property>
  <name>dfs.journalnode.kerberos.principal</name>
  <value>hdfs/_HOST@REALM.COM</value>
</property>
<property>
  <name>dfs.journalnode.kerberos.internal.spnego.principal</name>
  <value>HTTP/_HOST@REALM.COM</value>
</property>
```

Configuring Secure Zookeeper

Zookeeper secure configuration for server is recommended for HBase.

Important: *Stop* cluster services before performing this configuration.

Zookeeper Servers

Create the Zookeeper Principals

Create a principal for each Zookeeper Quorum Server host:

```
kadmin: addprinc -randkey zookeeper/host_fqdn@REALM
```

Create the Zookeeper Keytab Files

For each Zookeeper server host, run:

```
ktadd -norandkey -k /etc/security/phd/keytab/zookeeper-hostid.service.keytab
 zookeeper/host_fqdn@REALM
```

Distribute the Zookeeper Keytab Files

For each Zookeeper server host:

1. Move the appropriate keytab file for each host to that hosts' `/etc/security/phd/keytab` directory
2. Run the following:

```
chgrp hadoop zookeeper-hostid.service.keytab

chown zookeeper zookeeper-hostid.service.keytab

chmod 400 zookeeper-hostid.service.keytab

ln -s zookeeper-hostid.service.keytab zookeeper.service.keytab
```

Edit the Zookeeper Configuration File

1. Add the following lines to `/etc/gphd/zookeeper/conf/zoo.cfg`:

```
authProvider.1=org.apache.zookeeper.server.auth.SASLAuthenticationProvider
jaasLoginRenew=3600000
```

2. Create a file in `/etc/gphd/zookeeper/conf/jaas.conf` and add the following entry to the file:

```
Server {
  com.sun.security.auth.module.Krb5LoginModule required
  useKeyTab=true
  keyTab="/etc/security/phd/keytab/zookeeper-hostid.service.keytab"
  storeKey=true
  useTicketCache=false
  principal="zookeeper/host_fqdn@REALM";
};
```

3. Add the following line to `/etc/gphd/zookeeper/conf/java.env` (create the file if it does not exist):

```
export JVMFLAGS="-Djava.security.auth.login.config=/etc/gphd/zookeeper/
conf/jaas.conf"
```

If `JVMFLAGS` already exists in the file, then modify the property by adding new values within quotes separated by spaces. For example, modify `export JVMFLAGS="-Xmx2048m"` to:

```
export JVMFLAGS="-Xmx2048m -Djava.security.auth.login.config=/etc/gphd/
zookeeper/conf/jaas.conf"
```

Verify the Zookeeper Configuration

1. Start up the cluster and connect using a client.

Note: You do not need to set up clients to use Kerberos, but if you want to use this functionality, see *Zookeeper Clients*.

2. Connect as:

```
zookeeper-client -server hostname:port
```

Note: The port is defined in `/etc/gphd/zookeeper/conf/zoo.cfg` and is typically 2181.

3. Create a protected znode:

```
create /testznode testznodedata sasl:zkcli@REALM:cdwra
```

4. Verify the znode:

```
getAcl /testznode:
```

You should see something like this:

```
'sasl,'zkcli@{{BIGDATA.COM%7D%7D
: cdrwa
```

Zookeeper Clients

[Optional]

1. Add a principal for the client on the client host:

```
kadmin.local: addprinc -randkey zclient/host_fqdn@REALM
```

2. Add the keytab:

```
kadmin.local: ktadd -norandkey -k /etc/security/phd/keytab/zclient-
hostid.client.keytab zclient/host_fqdn@REALM
```

3. Move the file to the `/etc/security/phd/keytab` directory on the host and change the owner and group appropriately, so that only users of the client can access the file:

```
chmod 400 /etc/security/phd/keytab/zclient-hostid.client.keytab
```

4. Create a link:

```
ln -s zclient-hostid.client.keytab zclient.client.keytab
```

5. Add the following entry to `/etc/gphd/zookeeper/conf/jaas.conf` (create the file if it doesn't exist):

```
Client {
  com.sun.security.auth.module.Krb5LoginModule required
  useKeyTab=true
  keyTab="/etc/security/phd/keytab/zclient.client.keytab"
  storeKey=true
  useTicketCache=false
  principal="zclient/host_fqdn@REALM";
};
```

If you get a failure message indicating a name lookup failure, that indicates you should add a name service setting.

Add or edit the following line to `/etc/gphd/zookeeper/conf/java.env` (create the file if it doesn't exist):

```
export JVMFLAGS="-Djava.security.auth.login.config=/etc/gphd/zookeeper/conf/
jaas.conf -Dsun.net.spi.nameservice.provider.1=dns,sun"
```

Important: You cannot do this on a server node, as the –`Dsun.net.spi.nameservice.provider.1=dns,sun` line could cause the server to fail to start.

You should now be able to establish a secure session with zookeeper-client. Test this by starting zookeeper-client and insuring no errors occur while connecting.

You may have issues with addressing or be forced to use the actual server IP address with the `-server` option for zookeeper-client to handle incompatibilities between the settings needed to make the Kerberos lookups work (`-Dsun.net.spi.nameservice.provider.1=dns,sun`) and what makes the Java host resolution work.

This problem also may be encountered in trying to set up HBase to communicate with a secure Zookeeper, where it is more difficult to resolve.

Configuring Secure HBase

If you are running secure HBase, you should also also run a secure Zookeeper (see *Configuring Secure Zookeeper* on page 109). You can, however, set up the HBase master and region servers to use Kerberos and test that they start without a secure Zookeeper.

This section covers the basics of how to get HBase up and running in secure mode; for further information see the HBase documentation (*http://hbase.apache.org/book/security.html*).

HBase Master and Regionservers

Create the HBase Principals

For the HBase master and each region server host, run:

```
kadmin.local: addprinc -randkey hbase/host_fqdn@REALM
```

Where `host_fqdn` refers to the service principal (master, region server) host.

Create the HBase Keytab files

For the HBase master and each region server host, run:

```
kadmin.local: ktadd -norandkey -k /etc/security/phd/keytab/hbase-
hostid.service.keytab hbase/host_fqdn@REALM
```

Distribute the HBase Keytab Files

For each host:

1. Move the appropriate keytab file for each host to that hosts' `/etc/security/phd/keytab` directory.
2. Run:

   ```
   chown hbase:hadoop hbase-hostid.service.keytab

   chmod 400 hbase-hostid.service.keytab

   ln -s hbase-hostid.service.keytab hbase.service.keytab
   ```

Edit the HBase Site XML

For each master and region server host, add the following properties to `/etc/gphd/hbase/conf/hbase-site.xml`:

```
<property>
  <name>hbase.security.authentication</name>
  <value>kerberos</value>
</property>

<property>
  <name>hbase.security.authorization</name>
  <value>true</value>
</property>

<property>
  <name>hbase.coprocessor.region.classes</name>
  <value>org.apache.hadoop.hbase.security.token.TokenProvider</value>
</property>

<!-- HBase secure region server configuration -->
<property>
  <name>hbase.regionserver.kerberos.principal</name>
  <value>hbase/_HOST@REALM</value>
</property>

<property>
  <name>hbase.regionserver.keytab.file</name>
  <value>/etc/security/phd/keytab/hbase.service.keytab</value>
</property>

<!-- HBase secure master configuration -->
<property>
  <name>hbase.master.kerberos.principal</name>
  <value>hbase/_HOST@REALM</value>
</property>

<property>
  <name>hbase.master.keytab.file</name>
  <value>/etc/security/phd/keytab/hbase.service.keytab</value>
```

```
</property>
```

Test HBase Startup

You can now test HBase startup. Start the cluster services and check that the HBase Master and Region servers start properly. If they do not, look at the `.log` file in the `/var/log/gphd/hbase/` directory for hints as to why. Also make sure HDFS came up properly.

As you fix issues, you can run `/etc/init.d/hbase-master start` or `/etc/init.d/hbase-regionserver start` to check that the issue is resolved.

HBase Clients

Add the following property to the `hbase-site.xml` file on every client host:

```
<property>
  <name>hbase.security.authentication</name>
  <value>kerberos</value>
</property>
```

Enable Encrypted Communication

[Optional]

If you are running secure HBase, you can enable encryption from clients to the server. To do so, add the following property to `hbase-site.xml` on all clients:

```
<property>
  <name>hbase.rpc.protection</name>
  <value>privacy</value>
</property>
```

This can also be set on a per-connection basis. Set it in the configuration supplied to HTable:

```
Configuration conf = HBaseConfiguration.create();
conf.set("hbase.rpc.protection", "privacy");
HTable table = new HTable(conf, tablename);
```

The Apache HBase documentation indicates you should expect a ~10% performance penalty when encryption is enabled.

REST Gateway

You can set up the REST Gateway to use Kerberos to authenticate itself as a principal to HBase. Note that all client access will use the REST Gateway's credentials set below, and these will have this user's privileges.

For every REST Gateway, add the following to the `hbase-site.xml` file:

```
<property>
  <name>hbase.rest.keytab.file</name>
  <value>path-to-rest-users-keytab</value>
</property>

<property>
  <name>hbase.rest.kerberos.principal</name>
  <value>rest-users-principal-name</value>
</property>
```

You must also give the REST principal access privileges. Do this by adding the rest-principal-name to the `acl` table in HBase. Adding the permissions below are sufficient, according to the HBase documentation:

```
grant 'rest-principal-name', 'RWCA'
```

Thrift Client Configuration

See the HBase documentation (*http://hbase.apache.org/book/security.html*) for instructions on configuring Thrift clients.

Configuring HBase with Secure Zookeeper

For secure HBase, you should also run a secure Zookeeper (see *Configuring Secure Zookeeper* on page 109). If you do so, you will need to execute the steps in this section.

Note: These steps *must* be done on the HBase master and all region servers.

1. Create a file called `/etc/gphd/hbase/conf/jaas.conf` and add the following entry:

```
Client {
  com.sun.security.auth.module.Krb5LoginModule required
  useKeyTab=true
  useTicketCache=false
  keyTab="/etc/security/phd/keytab/hbase.service.keytab"
  principal="hbase/host_fqdn@REALM";
};
```

Important: Make sure to replace `host_fqdn@REALM` with the `host_fqdn` of the server and the correct `REALM`.

2. Add the following at the bottom of `/etc/gphd/hbase/conf/hbase-env.sh`:

```
export HBASE_OPTS="$HBASE_OPTS -Djava.security.auth.login.config=/etc/
gphd/hbase/conf/jaas.conf"
export HBASE_MANAGES_ZK=false
```

3. Edit the site XML and add the following properties:

```
<property>
  <name>hbase.zookeeper.quorum</name>
  <value>comma-separated-list-of-zookeeper-hosts</value>
</property>

<property>
  <name>hbase.cluster.distributed</name>
  <value>true</value>
</property>
```

4. Edit `/etc/gphd/zookeeper/conf/zoo.cfg` and add: the following lines

```
kerberos.removeHostFromPrincipal=true
kerberos.removeRealmFromPrincipal=true
```

Access Control and PXF External Tables

The version of HBase distributed with PHD supports access control. Basic mappings of permissions (RWCA) to operations allowed are as follows:

Permission	Operations
Read	
	Get
	Exists
	Scan
Write	
	Put
	Delete
	Lock/UnlockRow
	IncrementColumnValue
	CheckAndDelete/Put
	Flush
	Compact
Create	
	Admin
	Alter
	Drop
Admin	
	Enable/Disable
	>Snapshot/Restore/Clone
	Split
	Major Compact
	Grant
	Revoke
	Shutdown

Scope of Permissions

Table permissions:

- Read: User can read from any column family in a table
- Write: User can write to any column family in a table
- Create: User can alter table attributes; add, alter, or drop column families; and drop the table.
- Admin: User can alter table attributes; add, alter, or drop column families; and enable, disable, or drop the table. User can also trigger region (re)assignments or relocation.

Column Family:

- Read: User can read from the column family
- Write: User can write to the column family

For PHD, the Hbase superuser is the "hbase" user/principal. There is an implicit global scope for permissions granted by the superuser.

Tables have an `OWNER` attribute that defaults to the table creator, but may be changed with an `ALTER` operation.

See the HBase documentation (*http://hbase.apache.org/book/security.html*) for further details on configuring and using access controls.

Set the properties shown below to enable access control:

```
<property>
  <name>hbase.security.authorization</name>
  <value>true</value>
</property>

<property>
  <name>hbase.coprocessor.master.classes</name>
  <value>org.apache.hadoop.hbase.security.access.AccessController</value>
</property>

<property>
  <name>hbase.coprocessor.region.classes</name>
  <value>org.apache.hadoop.hbase.security.access.AccessController,
 org.apache.hadoop.hbase.security.token.TokenProvider</value>
</property>
```

When access control is enabled, you will need to explicitly grant users permissions to the database as shown below (example assumes it is being run on an HBase service host). You may also choose to create a specific hbase principal (hbase@REALM) for HBase administration rather than using the service keytab as shown below; this would allow administration from any client host:

```
# sudo -u hbase kinit -kt /etc/security/phd/keytab/hbase.service.keytab
 hbase/<host_fqdn>
# sudo -u hbase hbase shell
hbase> grant 'myuser', 'RWCA'
# kdestroy
```

PXF Access

If you are using PXF external HBase tables, you will need to grant user `hdfs` permissions as follows:

```
# sudo -u hbase kinit -kt /etc/security/phd/keytab/hbase.service.keytab
 hbase/<host_fqdn>
# sudo -u hbase hbase shell
hbase> grant 'hdfs', 'RWCA'
# kdestroy
```

Configuring Secure Hive

The Hive MetaStore supports Kerberos authentication for Thrift clients. You can configure a standalone Hive MetaStoreServer instance to force clients to authenticate with Kerberos by setting the `hive.metastore.sasl.enabled` property in the `hive-site.xml` configuration file to `true`, as shown in the example below.

Note: Hive Server 1 (hiveserver) does not support Kerberos, so you will need to switch to using Hive Server 2 in a secured cluster. For more information, see *Changing to Hive Server 2* on page 119 later in this section.

1. Add the Kerberos principals and their locations to `hive-site.xml`. For example:

```
<property>
```

```
   <name>hive.server2.authentication</name>
   <value>KERBEROS</value>
 </property>

 <property>
   <name>hive.server2.authentication.kerberos.principal</name>
   <value>hive/_HOST@REALM</value>
 </property>

 <property>
   <name>hive.server2.authentication.kerberos.keytab</name>
   <value>/etc/security/phd/keytab/hive.keytab</value>
 </property>

 <property>
   <name>hive.server2.enable.impersonation</name>
   <value>true</value>
 </property>

 <property>
   <name>hive.server2.enable.doAs</name>
   <value>true</value>
 </property>

 <property>
   <name>hive.metastore.sasl.enabled</name>
   <value>true</value>
   <description>If true, the metastore thrift interface will be secured
  with SASL. Clients
    must authenticate with Kerberos.</description>
 </property>

 <property>
   <name>hive.security.authorization.enabled</name>
   <value>true</value>
   <description>enable or disable the hive client authorization</
 description>
 </property>

 <property>
   <name>hive.security.authorization.createtable.owner.grants</name>
   <value>ALL</value>
   <description>the privileges automatically granted to the owner whenever
  a table gets created.
    An example like "select,drop" will grant select and drop privilege to
  the owner of the table.
    You may change this value if you desire lower privileges on create.</
 description>
 </property>

 <property>
   <name>hive.metastore.kerberos.keytab.file</name>
   <value>/etc/security/phd/keytab/hive.keytab</value>
   <description>The path to the Kerberos Keytab file containing the
  metastore thrift
    server's service principal.</description>
 </property>

 <property>
   <name>hive.metastore.kerberos.principal</name>
   <value>hive-metastore/_HOST@REALM</value>
   <description>The service principal for the metastore thrift server. The
  special string _HOST will be replaced automatically with the correct host
  name.</description>
```

```
</property>
```

2. Add the following parameters to `core-site.xml` (Hadoop configuration) to enable users to run Hive queries:

```
<property>
  <name>hadoop.proxyuser.hive.hosts</name>
  <value>*</value>
</property>
<property>
  <name>hadoop.proxyuser.hive.groups</name>
  <value>*</value>
</property>

<!-- you may of course add more restrictive values here -->
```

Changing to Hive Server 2

You will need to change to Hive Server 2 in order to use Hive in non-local mode with Kerberos. On the Hive server, edit the `/etc/gphd/init.d/hive-server` file and change the following line:

```
server_name="server"
```

to:

```
server_name="server2"
```

Then restart the Hive Server:

```
/etc/init.d/hive-server restart
```

Hive Warehouse Permissions Issues

As of this version, there is a known issue with Hive permissions such that the default 775 warehouse permissions on `/hive/gphd/warehouse` will prevent write access by non-superuser users. The simplest way to resolve this is, as the `hdfs` user, change the permissions to 777. If this is not acceptable, then Hive external tables could provide a solution.

Note: You must have created an `hdfs` principal to do HDFS administration work, such as changing permissions on other users' or root-level directories.

Connecting and Using Secure Hive with Beeline

In order to use secure Hive, you should create a Kerberos principal for the `hive` user; this is your Hive administrator principal.

Whenever you want to grant privileges to an ordinary user, you need to be logged in as the `hive` superuser.

To log in as a particular user using beeline:

1. Make sure there are no tickets for any other user in your cache (run `kdestroy` and the `knit` user to ensure this).
2. `kinit` as the Hive user you want to log in as.
3. Connect to beeline using the form:

```
!connect jdbc:hive2://<hive_server2_fqdn>:10000/<database>;principal=hive/
<hive_server2_fqdn>@REALM
```

Where:

`<hive_server2_fqdn>` is the FQDN of the host for the Hive Server role.

`<database>` is the database to connect to (for example, default).

`REALM` is your Kerberos realm.

Note:

- Unless you already have performed `kinit` as the user you want to connect as, and have ensured that only that user has a ticket in the cache (using `klist`), you will need to enter your Kerberos principal name and password twice: once before starting beeline, by doing `kinit`, and again when queried by Hive during connect.
- Remember that in order for an ordinary user to do anything, you must first follow the above sequence for user `hive` (Hive administrator) and use `GRANT` to grant the user privileges.
- As of the version tested, `SHOW GRANT` does not show any actual information in beeline, so you can only tell if a `GRANT` worked by testing as that user (or looking for errors in the hive log).
- Using `GRANT` as another user will not have any effect on databases that are not owned by that user. For example, if your grant creates permissions in database `default` as user `tester`, that user will not actually have permissions on database `default` (and you may not receive an error).

Configuring HCatalog (WebHCat) on Secure Hive

HCatalog is a tool that operates on the Hive metastore. If you want to use the HCatalog RESTFul APIs (WebHCat), security configuration is required to enable the security functionality of the WebHCat server.

Prerequisites

- Hive is installed and configured properly on your cluster.
- Hive metastore is configured to work in remote mode.
- Security is properly enabled for Hive, as described in the *Configuring Secure Hive* on page 117 section.
- HCatalog and WebHCat are installed and configured properly on your cluster.

Create Keytab File for the WebHCat Server

Create a keytab file that contains the `HTTP` principal:

```
> kadmin.local
kadmin.local: ktadd -norandkey -k /etc/security/phd/keytab/webhcat-
hostid.service.keytab  HTTP/host_fqdn@REALM
```

Distribute the Keytab File to the WebHCat Server

Copy the generated `/etc/security/phd/keytab/webhcat-hostid.service.keytab` file to the machine where the WebHCat server is running. Put it under `/etc/security/phd/keytab/`. Then, create a symbolic link and adjust the file owner and permissions.

For example:

```
> chown hive:hadoop /etc/security/phd/keytab/webhcat-hostid.service.keytab
> chmod 400 /etc/security/phd/keytab/webhcat-hostid.service.keytab
> ln -s /etc/security/phd/keytab/webhcat-hostid.service.keytab /etc/
security/phd/keytab/webhcat.service.keytab
```

Configure WebHCat and Proxy Users

On the WebHCat server machine, edit the `/etc/gphd/webhcat/conf/webhcat-site.xml` file and add the following properties:

webhcat-site.xml

```
<property>
    <name>templeton.kerberos.secret</name>
    <value>SuPerS3c3tV@lue!</value>
</property>

<property>
    <name>templeton.kerberos.keytab</name>
    <value>/etc/security/phd/keytab/webhcat.service.keytab</value>
</property>

<property>
    <name>templeton.kerberos.principal</name>
    <value>HTTP/_HOST@<REALM></value>
</property>
```

In the above code snippet, you need to replace `<FQDN>` with the correct FQDN of your WebHCat server machine. Replace `<REALM>` with the Kerberos realm name you are using for your cluster. You may set the `templeton.kerberos.secret` property value to any random secret value.

Note: In most cases, when the WebHCat server starts, it reads the Hive metastore information from the corresponding Hive configuration files (`/etc/gphd/hive/conf/hive-site.xml`). If your WebHCat server is not running on the same machine as the Hive server, you may need manually copy `/etc/gphd/hive/conf/hive-site.xml` from the Hive server machine to the WebHCat server machine before restarting the WebHCat server.

After editing the `webhcat-site.xml` file, you need to restart the WebHCat server to make the changes take effect:

```
> service webhcat-server restart
```

Because WebHCat will access the HDFS NameNode, you need configure Hadoop to allow impersonation as the `HTTP` user. Edit `/etc/gphd/hadoop/conf/core-site.xml` on all your HDFS node machines and add the following properties if they don't already exist:

core-site.xml

```
<property>
    <name>hadoop.proxyuser.HTTP.hosts</name>
    <value>*</value>
</property>
```

```
<property>
    <name>hadoop.proxyuser.HTTP.groups</name>
    <value>*</value>
</property>
```

After you edit `core-site.xml`, restart all HDFS services to enable your changes.

Verify WebHCat is Working

Ensure you have an installed version of `curl` that supports GSS-negotiation by calling `curl -V`:

```
> curl 7.19.7 (x86_64-redhat-linux-gnu) libcurl/7.19.7 NSS/3.13.6.0
 zlib/1.2.3 libidn/1.18 libssh2/1.4.2
Protocols: tftp ftp telnet dict ldap ldaps http file https ftps scp sftp
Features: GSS-Negotiate IDN IPv6 Largefile NTLM SSL libz
```

Then do:

```
> kinit <username>
<output omitted, you will need enter password to login>
> curl -i -u : --negotiate 'http://<FQDN>:<PORT>/templeton/v1/ddl/database'
HTTP/1.1 401
WWW-Authenticate: Negotiate
Set-Cookie: hadoop.auth=;Path=/;Expires=Thu, 01-Jan-1970 00:00:00 GMT
Cache-Control: must-revalidate,no-cache,no-store
Content-Type: text/html;charset=ISO-8859-1
Content-Length: 1274
Server: Jetty(7.6.0.v20120127)

HTTP/1.1 200 OK
Set-Cookie:
 hadoop.auth="u=root&p=root@EXAMPLE.COM&t=kerberos&e=1393939264464&s=mJG9x4mE4S9BMDCbSeF
Expires: Thu, 01 Jan 1970 00:00:00 GMT
Content-Type: application/json
Transfer-Encoding: chunked
Server: Jetty(7.6.0.v20120127)

{"databases":["default"]}
```

In the above code snippet, replace `<FQDN>` with the real FQDN of your WebHCat server machine, and replace `<PORT>` with your WebHCat server port (50111 by default).

If you see output similar to the above (a `401` response followed by a `200` response), your secured WebHCat installation is functioning properly.

Configuring HAWQ on Secure HDFS

Requirements

- A secure HDFS installation
- HDFS on wire encryption (`dfs.encrypt.data.transfer`) MUST be set to `false`.
- A new un-initialized HAWQ instance or a stopped already initialized HAWQ instance that was previously running on non-secured HDFS

Preparation

1. If HAWQ is already initialized and running, stop HAWQ by running `service hawq stop` or `<HAWQ_installation_directory>/bin/gpstop`.
2. Secure the HDFS cluster using the instructions provided in this guide or using available security tools.
3. Ensure HDFS is running properly in secured mode.
4. Ensure that the `dfs.encrypt.data.transfer` property is set to `false` in `hdfs-site.xml` for your cluster.

Configuration

1. Generate a `postgres` principal and keytab file as shown below:

   Note: The form of principal for the HAWQ master is `postgres@REALM`, where `postgres` is the default service name of HAWQ and REALM is the default realm in the cluster's Kerberos configuration. In the examples below, we use `EXAMPLE.COM` for the REALM; this should be replaced by your cluster's actual REALM.

   ```
   kadmin: addprinc -randkey postgres@EXAMPLE.COM
   kadmin: ktadd -k /etc/security/phd/keytab/hawq.service.keytab
    postgres@EXAMPLE.COM
   ```
2. Move this keytab file to the appropriate keytab directory on the HAWQ master node (for example, `/etc/security/phd/keytab/`).
3. Set the ownership of the keytab file to `gpadmin:gpadmin` and the permissions to 400.
4. Refer to your `gpinitsystem_config` file (typically in `/etc/gphd/hawq/conf`) to determine your configured HAWQ HDFS data directory (typically `/hawq_data`). This will be the last part of the `DFS_URL` value in the file. For example, if `DFS_URL` is set to `centos61-2:8020/hawq_data`, then your HAWQ HDFS data directory is `/hawq_data`.
5. Create (if required) the HAWQ HDFS data directory in HDFS, and assign ownership as `postgres:gpadmin` and permissions `755`.
   - If HAWQ has already been initialized and the directory exists, just modify the owner and permissions as shown.
   - You need to have HDFS super-user permissions to create or modify a directory in HDFS root. If necessary, create an `hdfs` principal to accomplish this task.
6. If not present, create the `/user/gpadmin` directory in HDFS with ownership `gpadmin:gpadmin` and permissions `777`.
7. Modify the `hdfs-client.xml` file (typically in `/usr/lib/gphd/hawq/etc`), on the master node and *all* segment server nodes, by adding the following properties:

   ```
   <property>
     <name>hadoop.security.authentication</name>
     <value>kerberos</value>
   </property>

   <property>
     <name>dfs.namenode.kerberos.principal</name>
     <value>HDFS_NAMENODE_PRINCIPAL</value>
   </property>
   ```

   Note:

   - `hdfs-client.xml` is in the `<HAWQ_installation_directory>/etc`, typically `/usr/lib/gphd/hawq/etc`.
   - These property blocks should be in the file, but commented out; if so, uncomment and edit the values.

- HDFS_NAMENODE_PRINCIPAL should be value from your cluster's hdfs-site.xml file.
- Make sure the namenode principal value is correct.

8. Edit your gpinitsystem_config file (typically in /etc/gphd/hawq/conf) and add (or uncomment if they are present and commented out):

```
KERBEROS_KEYFILE=/path/to/keytab/file
ENABLE_SECURE_FILESYSTEM=on
```

Note:

- Make sure there is *no* space between the key=value pairs; for example, ENABLE_SECURE_FILESYSTEM = on will cause errors because there are spaces.
- Make sure the value of KERBEROS_KEYFILE is the full path where you placed the hawq.service.keytab file on the master.

9. If HAWQ has already been initialized prior to being secured, run the following commands on the HAWQ master as the gpadmin user:

```
service hawq start
source /usr/local/hawq/greenplum_path.sh
gpconfig --masteronly -c krb_server_keyfile -v "'/path/to/keytab/file'"
service hawq stop
```

Important: The single quotes ' after/before the double quotes " in the keytab string above are required!

10. After you have completed all these steps, you can start or initialize HAWQ:
    a. If HAWQ was already initialized on non-secured HDFS before this process, start it by running service hawq start or <HAWQ_installation_directory>/bin/gpstart.
    b. If HAWQ has not been initialized, initialize it now.
11. Verify HAWQ is operating properly; if not, see the next section.

Troubleshooting

If initialization or start-up fails, you can look into the gpinitsystem log output and the namenode logs to see if you can pinpoint the cause. Some possible causes include:

- Incorrect values in your hdfs-client.xml file.
- hdfs-client.xml was not updated on the master and *all* segment servers.
- Unable to log in with Kerberos:

  This may indicate a possible bad keytab or principal for postgres. You can validate on the master by entering the following:

  ```
   kinit -k <keytab dir path>/hawq.service.keytab postgres@EXAMPLE.COM
  ```
- Wrong HAWQ HDFS data directory or directory permissions:

  Check the gpinitsystem_config file and the DFS_URL value and the directory permissions.
- Unable to create the HAWQ HDFS data directory errors:

  Ensure that you have created the proper directory as specified in gpinitsystem_config and that the ownership and permissions are correct.

Enabling Auditing

You can enable auditing before deployment or re-configuration of a cluster.

To enable auditing:

1. Locate your templates directory (by default `ClusterConfigDir`). This directory is created during initial installation, see the *PHD Installation and Administrator Guide* for details.
2. For HDFS and MapReduce, locate the `hdfs` subdirectory and edit the `log4j.properties` file as follows:

   - For HDFS, change the following line from:

     ```
      hdfs.audit.logger=INFO,NullAppender
     ```

     to:

     ```
     hdfs.audit.logger=INFO,RFAAUDIT
     ```
   - For MapReduce, change the following line from:

     ```
     mapred.audit.logger=INFO,NullAppender
     ```

     to:

     ```
     mapred.audit.logger=INFO,RFAAUDIT
     ```
   - For other components, locate the component sub-directory in the template and its corresponding `log4j.properties` file and make similar edits.

   To specify the auditing output location:

   - By default, log files and other auditing information are output to `/var/log/gphd/`.
   - To set up logging to go to syslog, define the following:

     ```
     # Configure syslog appender
     log4j.appender.SYSLOG=org.apache.log4j.net.SyslogAppender
     log4j.appender.SYSLOG.syslogHost=loghost
     log4j.appender.SYSLOG.layout=org.apache.log4j.PatternLayout
     log4j.appender.SYSLOG.layout.ConversionPattern=%d{ISO8601} %p %c: %m%n
     log4j.appender.SYSLOG.Facility=LOCAL1
     ```

     You can now log audit information to syslog. For example:

     ```
     hdfs.audit.logger=INFO,SYSLOG
     ```

     You can also log to file and syslog. For example:

     ```
     hdfs.audit.logger=INFO,RFAAUDIT,SYSLOG
     ```

   Note: These changes only go into effect after deployment or re-configuration.

Secure Web Access

This section describes how to configure WebHDFS on a secure PHD cluster.

Overview

WebHDFS is a REST API that allows a user to perform various HDFS operations.

More details about these APIs are available from the Apache Hadoop documentation: *http://hadoop.apache.org/docs/r1.0.4/webhdfs.html*

On an insecure cluster, you can run any `webhdfs` command as any user, including `root`. For example:

```
$ curl -i "http://<HOST>:<PORT>/webhdfs/v1/?user.name=root&op=LISTSTATUS"
```

Where `<HOST>:<PORT>` is the HTTP address of the namenode (the value of `dfs.http.address` in `hdfs-site.xml`); by default, the port number is 50070.

The client receives a JSON response that looks like this:

```
HTTP/1.1 200 OK
Content-Type: application/json
Content-Length: 427

{
  "FileStatuses":
  {
    "FileStatus":
    [
      {
        "accessTime"      : 1320171722771,
        "blockSize"       : 33554432,
        "group"           : "supergroup",
        "length"          : 24930,
        "modificationTime": 1320171722771,
        "owner"           : "webuser",
        "pathSuffix"      : "a.patch",
        "permission"      : "644",
        "replication"     : 1,
        "type"            : "FILE"
      },
      {
        "accessTime"      : 0,
        "blockSize"       : 0,
        "group"           : "supergroup",
        "length"          : 0,
        "modificationTime": 1320895981256,
        "owner"           : "szetszwo",
        "pathSuffix"      : "bar",
        "permission"      : "711",
        "replication"     : 0,
        "type"            : "DIRECTORY"
      },
      ...
    ]
  }
}
```

Prerequisites

Before accessing WebHDFS in secure mode, you need to secure the underlying Hadoop cluster, starting with *Configuring Kerberos for HDFS and YARN (MapReduce)* on page 96.

Note that as part of the procedure to secure your cluster, you will *edit the site.xml file*. The `dfs.webhdfs.enabled` and `dfs.web.authentication.kerberos.principal` properties in this file must be set correctly to enable secure WebHDFS.

After security is enabled, all WebHDFS operations will fail with a 401 error until you use WebHDFS in secure mode.

Configuring Secure WebHDFS

Once the cluster is secured, perform the following steps.

Create a Principal

To access WebHDFS in secure mode, a new Kerberos user (or principal) must be created in Kerberos. To do this, use the `kadmin.local` command on the host where Kerberos is installed, and then run the `addprinc <username>` command. For example:

```
# kadmin.local
Authenticating as principal root/admin@TESTREALM.COM with password.
kadmin.local:  addprinc testuser
WARNING: no policy specified for testuser@TESTREALM.COM; defaulting to no
 policy
Enter password for principal "testuser@TESTREALM.COM":
Re-enter password for principal "testuser@TESTREALM.COM":
Principal "testuser@TESTREALM.COM" created.
```

Add to Groups

[Optional]

Group information is accessed on the Namenode. If you need the principal you just created (`testuser` in the example above) to reside in specific groups (for example, if you need permission to run a `GETCONTENTSUMMARY` command), you need to create an OS user on the Namenode that belongs to the groups you need: for example, `hadoop`.

To add a regular user on the NameNode, run the `adduser` command, as follows:

```
adduser -N -g hadoop testuser
```

Using WebHDFS in Secure Mode

To verify WebHDFS works in secure mode, perform the following tasks.

Authenticate Yourself

You must authenticate yourself as a valid Kerberos user. Do this by running `kinit` command with your user name. In this example, the user is `testuser`:

```
$ kinit testuser
Password for testuser@TESTREALM.COM:
```

Verify your Authentication

[Optional]

If `kinit` is successful, you will be able to validate that you have a valid Kerberos ticket by using the `klist` command, as follows:

```
$ klist
Ticket cache: FILE:/tmp/krb5cc_0
Default principal: testuser@TESTREALM.COM

Valid starting     Expires            Service principal
09/19/13 01:36:40  09/20/13 01:36:40  krbtgt/TESTREALM.COM@TESTREALM.COM
        renew until 09/26/13 01:36:40
```

Verify Curl Supports Kerberos Negotiate

Your version of curl must support Keberos's GSS-Negotiate feature; you can verify this by running the following:

```
$ curl -V
curl 7.24.0 (x86_64-apple-darwin12.0) libcurl/7.24.0 OpenSSL/0.9.8x
 zlib/1.2.5
Protocols: dict file ftp ftps gopher http https imap imaps ldap ldaps pop3
 pop3s rtsp smtp smtps telnet tftp
Features: AsynchDNS GSS-Negotiate IPv6 Largefile NTLM NTLM_WB SSL libz
```

Run Secure WebHDFS

You can now run a secure WebHDFS command.

For example, the `--negotiate` parameter in curl, which turns on Kerberos negotiate:

```
curl -i --negotiate -u testuser "http://<HOST>:50070/webhdfs/v1/?
op=GETCONTENTSUMMARY"
```

You should see a response like this:

```
Enter host password for user 'testuser':
HTTP/1.1 401
Date: Thu, 19 Sep 2013 01:45:55 GMT
Pragma: no-cache
Date: Thu, 19 Sep 2013 01:45:55 GMT
Pragma: no-cache
WWW-Authenticate: Negotiate
Set-Cookie: hadoop.auth=;Path=/;Expires=Thu, 01-Jan-1970 00:00:00 GMT
Content-Type: text/html;charset=ISO-8859-1
Cache-Control: must-revalidate,no-cache,no-store
Content-Length: 1358
Server: Jetty(7.6.10.v20130312)

HTTP/1.1 200 OK
Date: Thu, 19 Sep 2013 01:45:55 GMT
Pragma: no-cache
Cache-Control: no-cache
Date: Thu, 19 Sep 2013 01:45:55 GMT
Pragma: no-cache
Set-Cookie:
 hadoop.auth="u=testuser&p=testuser@SMUNGEEREALM.COM&t=kerberos&e=1379591155709&s=zlzr9,
EuqluQ9C2F6Yg8Fex9YzI=";Path=/
```

```
Expires: Thu, 01 Jan 1970 00:00:00 GMT
Content-Type: application/json
Transfer-Encoding: chunked
Server: Jetty(7.6.10.v20130312)

{"ContentSummary":{"directoryCount":29,"fileCount":9,"length":3156,
"quota":2147483647,"spaceConsumed":9468,"spaceQuota":-1}}
```

This response verifies that you are accessing WebHDFS in secure mode. Note the initial `401` response above, followed by the `200` response. This is a result of the curl Kerberos negotiation.

Secure Web Access via HttpFS

HttpFS is another set of RESTful APIs that enable you to operate HDFS via the HTTP protocol. It has APIs that are compatible with WebHDFS. You also need to make some configuration changes to make it work with security.

Prerequisites

- Hadoop and HDFS are installed and security enabled.
- HttpFS is installed correctly.

Add Principal for HttpFS

HttpFS needs two principals, one for secured HTTP access and another for secured Hadoop access. In secured Hadoop, there is already an `HTTP/<host FQDN>@<realm>` principal for all HTTP access, so only one new principal needs to be added. Run the following commands on KDC host (or use `kadmin` from another host):

```
> kadmin.local
kadmin.local : addprinc -randkey httpfs/host_fqdn@REALM
```

Create and Distribute Keytab

Put the new `httpfs/host_fqdn@REALM` principal and the existing `HTTP/host_fqdn@REALM` principal keys into one keytab file:

```
kadmin.local : ktadd -norandkey -k /etc/security/phd/keytab/httpfs-
hostid.service.keytab httpfs/host_fqdn@REALM HTTP/host_fqdn@REALM
```

The above command should create the file `/etc/security/phd/keytab/httpfs-hostid.service.keytab`. Distribute this keytab file to the node where you installed HttpFS as `/etc/security/phd/keytab/httpfs.<host_fqdn>.service.keytab`.

Set the Keytab File Ownership and Permissions

Owner and permissions need to be properly set up for the distributed keytab file to make it readable by HttpFS service. It is also recommended to create a symbol link as follows:

```
> chown httpfs:hadoop /etc/security/phd/keytab/
httpfs.<host_fqdn>.service.keytab
> chmod 400 /etc/security/phd/keytab/httpfs.<host_fqdn>.service.keytab
> ln -s /etc/security/phd/keytab/httpfs.<host_fqdn>.service.keytab /etc/
security/phd/keytab/httpfs.service.keytab
```

Configuration

Edit the `/etc/gphd/hadoop-httpfs/conf/httpfs-site.xml` file by adding the following properties to the file:

httpfs-site.xml

```
<property>
    <name>httpfs.authentication.type</name>
    <value>kerberos</value>
</property>
<property>
    <name>httpfs.hadoop.authentication.type</name>
    <value>kerberos</value>
</property>
<property>
    <name>httpfs.authentication.kerberos.principal</name>
    <value>HTTP/<host_fqdn>@<REALM></value>
</property>
<property>
    <name>httpfs.authentication.kerberos.keytab</name>
    <value>/etc/security/phd/keytab/httpfs.service.keytab</value>
</property>
<property>
    <name>httpfs.hadoop.authentication.kerberos.principal</name>
    <value>httpfs/<host_fqdn>@<REALM></value>
</property>
<property>
    <name>httpfs.hadoop.authentication.kerberos.keytab</name>
    <value>/etc/security/phd/keytab/httpfs.service.keytab</value>
</property>
<property>
    <name>httpfs.authentication.kerberos.name.rules</name>
    <value>DEFAULT</value>
    <!-- same as the value of hadoop.security.auth_to_local in your core-
site.xml -->
</property>
```

Note:

- You should replace `<host_fqdn>@<REALM>` with your actual FQDN and REALM in the above example.
- The value of the `httpfs.authentication.kerberos.name.rules` property should be the same as the value of the `hadoop.security.auth_to_local` property in your `/etc/gphd/hadoop/conf/core-site.xml` file.

Restart HttpFS

Next, restart HttpFS service to apply the configuration changes:

```
> service hadoop-httpfs restart
```

Verify HttpFS is Working

You need curl with GSS negotiation enabled to verify that secured HttpFS is working. Check your curl features with:

```
> curl -V
curl 7.19.7 (x86_64-unknown-linux-gnu) libcurl/7.19.7 NSS/3.12.7.0
 zlib/1.2.3 libidn/1.18 libssh2/1.2.2
Protocols: tftp ftp telnet dict ldap ldaps http file https ftps scp sftp
Features: GSS-Negotiate IDN IPv6 Largefile NTLM SSL libz
```

Now, you need to log in as a user who has a corresponding principal in the KDC. In this example, we use the `hadoop` user:

```
> su - hadoop
hadoop> kinit
<output omitted, you need password to login>
hadoop> curl -i --negotiate -u : "http://<host_fqdn>:<PORT>/webhdfs/v1/user?
op=LISTSTATUS"
HTTP/1.1 401 Unauthorized
Server: Apache-Coyote/1.1
WWW-Authenticate: Negotiate
Set-Cookie: hadoop.auth=""; Expires=Thu, 01-Jan-1970 00:00:10 GMT; Path=/
Content-Type: text/html;charset=utf-8
Content-Length: 951
Date: Wed, 26 Feb 2014 09:37:51 GMT

HTTP/1.1 200 OK
Server: Apache-Coyote/1.1
Set-Cookie: hadoop.auth="u=hadoop&p=hadoop@EXAMPLE.COM&t=kerberos-
dt&e=1393443472388&s=18UnRj4g0DqUTHyPqC7kC3amsr0="; Version=1; Path=/
Content-Type: application/json
Transfer-Encoding: chunked
Date: Wed, 26 Feb 2014 09:37:51 GMT

{"FileStatuses":{"FileStatus":[{"pathSuffix":"hadoop","type":"DIRECTORY",
"length":0,"owner":"hadoop","group":"hadoop","permission":"755","accessTime":0,
"modificationTime":1393384282224,"blockSize":0,"replication":0},
{"pathSuffix":"history",
"type":"DIRECTORY","length":0,"owner":"mapred","group":"hadoop",
"permission":"1777","accessTime":0,"modificationTime":1393384456756,
"blockSize":0,"replication":0},{"pathSuffix":"hive","type":"DIRECTORY",
"length":0,"owner":"hive","group":"hadoop","permission":"755","accessTime":0,
"modificationTime":1393384258263,"blockSize":0,"replication":0},
{"pathSuffix":"oozie",
"type":"DIRECTORY","length":0,"owner":"oozie","group":"hadoop","permission":"755",
"accessTime":0,"modificationTime":1393384338240,"blockSize":0,"replication":0}]}}
```

Note: In the above example:

- Ensure you replace `<host_fqdn>` with an actual FQDN in your environment (it *must* be a FQDN; any short name or alias such as `localhost` will not work)
- Replace `<PORT>` with the actual port (14000 by default).

If you see output similar to the above (a `401` response followed by a `200` response), your secured HttpFS is working.

Configuring Secure Flume

This section describes the Flume security configurations.

Prerequisites

- Flume must be installed on the cluster.
- Security has been enabled for HDFS on the cluster.

Create the Flume Principal

On the KDC admin server, create a principal for the flume server:

```
kadmin.local: addprinc -randkey flume/host_fqdn@REALM
```

Create the Flume Keytab Files

On the KDC admin server, create the Flume keytab files:

```
kadmin.local: ktadd -norandkey -k /etc/security/phd/keytab/flume-
hostid.service.keytab flume/host_fqdn@REALM
```

Distribute the Flume Keytab Files and Change Ownership and Permissions

Move the keytab file created in the previous step to the `/etc/security/phd/keytab` directory on the host running the Flume server, then run the following commands on the Flume server:

```
cd /etc/security/phd/keytab
chgrp flume flume-hostid.service.keytab
chown flume flume-hostid.service.keytab
chmod 400 flume-hostid.service.keytab
ln -s flume-hostid.service.keytab flume.service.keytab
```

Single User for All HDFS Sinks

For a single user for all HDFS sinks, add the following properties in `/etc/gphd/flume/conf/flume.conf` in the Flume server:

```
agentName.sinks.sinkName.hdfs.kerberosPrincipal = flume-hostid/
host_fqdn@REALM
agentName.sinks.sinkName.hdfs.kerberosKeytab = /etc/security/phd/keytab/
flume.service.keytab
```

Flume configuration example:

```
agent.sources = r1
agent.sinks = k1
agent.channels = c1

# Describe/configure the source
agent.sources.r1.type = netcat
agent.sources.r1.bind = localhost
agent.sources.r1.port = 44444

# Describe the sink
agent.sinks.k1.type = hdfs
agent.sinks.k1.hdfs.path = hdfs://centos64-1.localdomain/user/flume
agent.sinks.k1.hdfs.fileType = DataStream
agent.sinks.k1.hdfs.kerberosPrincipal = flume/_HOST@REALM.COM
agent.sinks.k1.hdfs.kerberosKeytab = /etc/security/phd/keytab/
flume.service.keytab

# Use a channel which buffers events in memory
agent.channels.c1.type = memory
agent.channels.c1.capacity = 1000
agent.channels.c1.transactionCapacity = 100

# Bind the source and sink to the channel
agent.sources.r1.channels = c1
agent.sinks.k1.channel = c1
```

Different Users Across Multiple HDFS Sinks

For different users across multiple HDFS sinks, the same keytab path must be used across all HDFS sinks in the same agent because Flume does not support using multiple Kerberos principals or keytabs in the same agent.

If multiple users on HDFS are used, impersonation in `core-site.xml` in Hadoop must be configured.

Configure Impersonation in core-site.xml

To configure impersonation in `core-site.xml`, add the following properties to the file:

```
property>
     <name>hadoop.proxyuser.flume.groups</name>
     <value>group1,group2</value>
     <description>Allow the flume user to impersonate any members of group1
 and group2</description>
</property>
<property>
     <name>hadoop.proxyuser.flume.hosts</name>
     <value>host1,host2</value>
     <description>Allow the flume user to connect only from host1 and host2
 to impersonate a user</description>
</property>
```

Flume Configuration for Multiple Sinks

To configure Flume for multiple sinks:

```
agent.sinks.sink-1.type = HDFS
agent.sinks.sink-1.hdfs.kerberosPrincipal = flume-hostid/_HOST@REALM
agent.sinks.sink-1.hdfs.kerberosKeytab = /etc/security/phd/keytab/
flume.service.keytab
agent.sinks.sink-1.hdfs.proxyUser = log1

agent.sinks.sink-2.type = HDFS
agent.sinks.sink-2.hdfs.kerberosPrincipal = flume-hostid/_HOST@REALM
agent.sinks.sink-2.hdfs.kerberosKeytab = /etc/security/phd/keytab/
flume.service.keytab
agent.sinks.sink-2.hdfs.proxyUser = log2
```

Flume configuration example:

```
agent.sources = r1
agent.sinks = k1
agent.channels = c1

# Describe/configure the source
agent.sources.r1.type = netcat
agent.sources.r1.bind = localhost
agent.sources.r1.port = 44444

# Describe the sink
agent.sinks.k1.type = hdfs
agent.sinks.k1.hdfs.path = hdfs://centos64-1.localdomain/user/flume1
agent.sinks.k1.hdfs.fileType = DataStream
agent.sinks.k1.hdfs.kerberosPrincipal = flume/_HOST@REALM
agent.sinks.k1.hdfs.kerberosKeytab = /etc/security/phd/keytab/
flume.service.keytab
agent.sinks.k1.hdfs.proxyUser = log1

# Use a channel which buffers events in memory
agent.channels.c1.type = memory
agent.channels.c1.capacity = 1000
agent.channels.c1.transactionCapacity = 100

# Bind the source and sink to the channel
agent.sources.r1.channels = c1
agent.sinks.k1.channel = c1

agent.sources = r2
agent.sinks = k2
agent.channels = c2

# Describe/configure the source
agent.sources.r2.type = netcat
agent.sources.r2.bind = localhost
agent.sources.r2.port = 55555

# Describe the sink
agent.sinks.k2.type = hdfs
agent.sinks.k2.hdfs.path = hdfs://centos64-1.localdomain/user/flume2
agent.sinks.k2.hdfs.fileType = DataStream
agent.sinks.k2.hdfs.kerberosPrincipal = flume/_HOST@REALM
agent.sinks.k2.hdfs.kerberosKeytab = /etc/security/phd/keytab/
flume.service.keytab
agent.sinks.k2.hdfs.proxyUser = log2

# Use a channel which buffers events in memory
agent.channels.c2.type = memory
agent.channels.c2.capacity = 1000
agent.channels.c2.transactionCapacity = 100

# Bind the source and sink to the channel
agent.sources.r2.channels = c2
agent.sinks.k2.channel = c2
```

Configuring Secure Oozie

This section describes Oozie security configuration.

Prerequisites

- The Oozie server must be installed on the cluster.
- Security must be enabled for HDFS and YARN on the cluster.

Create the Oozie Principal

On the KDC admin server, create a principal for the Oozie server:

```
kadmin.local: addprinc -randkey oozie/<host_fqdn>@REALM
```

Where `<host_fqdn>` is the host where the Oozie server is running.

Create the HTTP Principal for the Oozie Server

On the KDC admin server, create the HTTP principal for the host running the Oozie server:

Note: This principal may have been created when enabling security for other services. Skip this step if that is the case.

```
kadmin.local: addprinc -randkey HTTP/<host_fqdn>@REALM
```

Create the Oozie Keytab Files

On the KDC admin server, create the Oozie keytab files:

```
kadmin.local: ktadd -norandkey -k /etc/security/phd/keytab/oozie-
<host_fqdn>.service.keytab oozie/<host_fqdn>@REALM HTTP/<host_fqdn>@REALM
```

Copy the Oozie Keytab Files and Change Ownership and Permissions

Move the keytab file created in the previous step to the `/etc/security/phd/keytab` directory on the host running the Oozie server:

```
scp /ect/security/phd/keytab/oozie-<host_fqdn>.service.keytab
 <oozie.host.name>:/etc/security/phd/keytab/
```

Then run the following commands on the Oozie server:

```
cd /etc/security/phd/keytab
chgrp hadoop oozie-<host_fqdn>.service.keytab
chown oozie oozie-<host_fqdn>.service.keytab
chmod 400 oozie-<host_fqdn>.service.keytab
ln -s oozie-<host_fqdn>.service.keytab oozie.service.keytab
```

Edit the Oozie Configuration File

On the Oozie server, locate the Oozie configuration file (`/etc/gphd/oozie/conf/oozie-site.xml`), and change the following properties to configure Oozie to run in secure mode:

Property	Value
`oozie.service.HadoopAccessorService.kerberos.enabled`	`true`
`local.realm`	`<YOUR-REALM>`
`oozie.service.HadoopAccessorService.keytab.file`	`/etc/security/phd/keytab/oozie.service.keytab`
`oozie.service.HadoopAccessorService.kerberos.principal`	`oozie/_HOST@<YOUR-REALM>`
`oozie.authentication.type`	`simple`
`oozie.authentication.kerberos.principal`	`HTTP/`_HOST`@<YOUR-REALM>`
`oozie.authentication.kerberos.name.rules`	Use the value configured for `hadoop.security.auth_to_local` in `core-site.xml`. The default value is `DEFAULT` if not set in the `core-site.xml`.

Using Oozie with a Secure Hive Metastore Server

For Hive actions to connect to a secure Hive metastore, you need to add credential configuration to the `/etc/gphd/oozie/conf/oozie-site.xml` file, as follows:

```
<property>
  <name>oozie.credentials.credentialclasses</name>
  <value>
 hcat=org.apache.oozie.action.hadoop.HCatCredentials,hive=org.apache.oozie.action.hadoop
  </value>
</property>
```

Verify Secure Oozie

Log in as the authorized user, `kinit`, `cd` into the home directory of the authorized user, then run the Oozie Hive action:

```
oozie job -oozie http://<oozier_hostname>:11000/oozie -config examples/apps/
hive/job.properties -run
```

Check Oozie job status using the `job_ID` returned after running the above command:

```
oozie job -oozie http://<oozie.host.name>:11000/oozie -info <JOBID>
```

Configuring Secure Sqoop

Users invoking Sqoop must have a valid Kerberos ticket. Otherwise no Sqoop-specific configuration is required on secured clusers.

Note that Sqoop with Hbase or Hive proper authorization must exist for the user to create and write to the relevant tables in these services.

Note: Sqoop 2 and Whirr do not support Kerberos at this time.

Configuring Secure Pig

Users invoking Pig must have a valid Kerberos ticket. Otherwise no Pig-specific configuration is required on secured clusers.

Configuring Secure Mahout

Kerberos configuration is required for users submitting Mahout jobs.

Security - Troubleshooting

Log Files

A good first step is to look for exceptions that may give you a clue as to the problem in the log files (where `hostname` is the host where the log file is located):

- namenode: `/var/log/gphd/hadoop-hdfs/hadoop-hdfs-namenode-hostname.log`
- resourcemanager: `/var/log/gphd/hadoop-yarn/yarn-yarn-resourcemanager-hostname.log`
- historyserver: `/var/log/gphd/hadoop-mapreduce/mapred-mapred-historyserver-hostname.log`
- datanode: `/var/log/gphd/hadoop-hdfs/hadoop-hdfs-datanode-hostname.log`
- nodemanager: `/var/log/gphd//hadoop-yarn/yarn-yarn-nodemanager-hostname.log`

You can enable debug level logging for the Java Kerberos classes by editing `/etc/default/hadoop` and setting the following value:

```
HADOOP_OPTS="$HADOOP_OPTS -Dsun.security.krb5.debug=true"
```

Networking Configuration

Kerberos operation in Hadoop is very sensitive to proper networking configuration:

- Host IP's for service nodes must reverse map to the FQDN's used to create the node principal for the service/FQDN.
- `hostname -f` on a node must return the FQDN used to create the principal for the service/FQDN.

Make sure your networking is properly configured before attempting to secure a cluster!

Data Node Does Not Start

- If you are getting a message about a data node requiring privileged resources to start, check that your ports are < 1024 in `yarn-site.xml`.
- Make sure you only changed the ports indicated in the instructions to be < 1024.
- Make sure `core-site.xml` is configured to use Kerberos.
- Check that the keytab and principal entries in site XML, and the keytab directory owner/group is correct. To inspect keytab files run:

  ```
  klist -e -k -t pathtokeytab
  ```
- Check that you modified `hadoop-env.sh` and `/etc/init.d/hadoop-hdfs-datanode` properly:
  - If they are correct, run:

    ```
    /etc/init.d/hadoop-hdfs-datanode start
    ```
  - If there are no printed errors in the output or it complains that no VM can be found, it is a JSVC problem. See *Building and Installing JSVC*.

Cannot Find Principal

- Check keytab and principal entries in the site xml, and the keytab directory permissions.
- Cannot get password for username:
  1. Check keytab and principal entries in the site xml, and the keytab directory permissions perms.
  2. If these all look OK, then run:

     ```
     kinit -k -t ./etc/security/phd/keytab/servicename.service.keytab
     ```

     You should get no errors (just a prompt back).
  3. If there is an error, check that the principal and keytab are correct.
  4. Check to make sure you used `–norandkey` when creating keytab files.

Node Manager Will Not Start

- Login failure due to policy error exceptions in logs (typically seen as a remote exception to node manager for resource manager):

  Check `/usr/lib/gphd/hadoop/etc/hadoop/hadoop-policy.xml` and replace any occurrences of `${HADOOP_HDFS_USER}` with `hdfs` and `${HADOOP_YARN_USER}` with `yarn`.