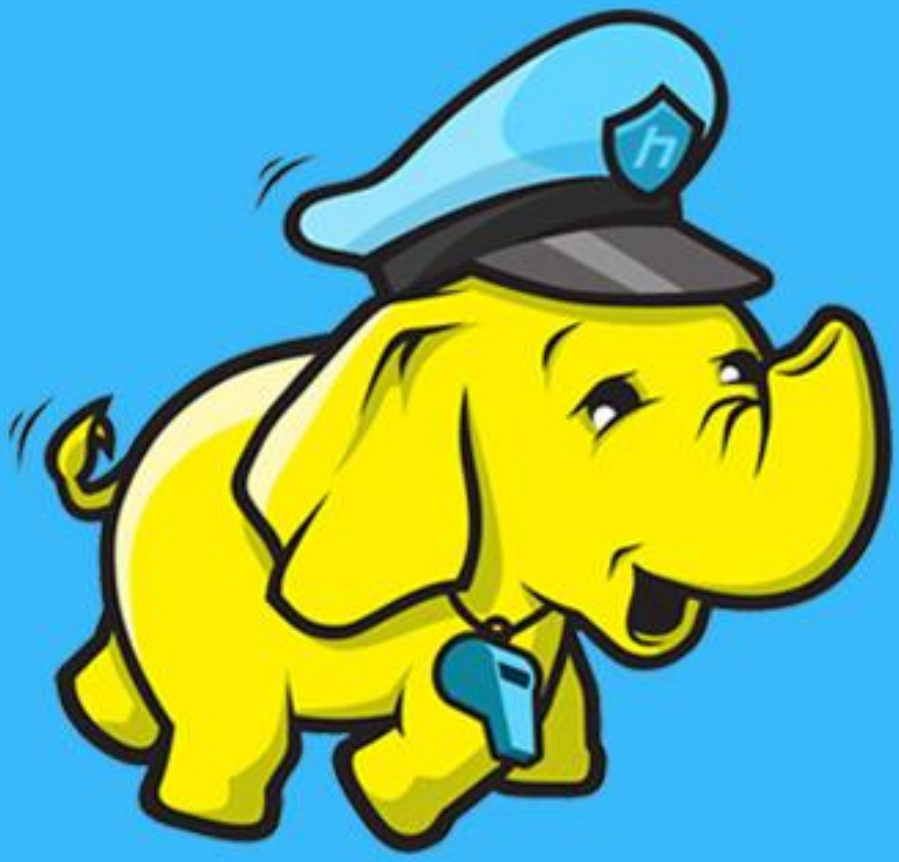

HADOOP

big data analysis framework

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About this tutorial

Hadoop is an open-source framework that allows to store and process big data in a distributed environment across clusters of computers using simple programming models. It is designed to scale up from single servers to thousands of machines, each offering local computation and storage.

This brief tutorial provides a quick introduction to Big Data, MapReduce algorithm, and Hadoop Distributed File System.

Audience

This tutorial has been prepared for professionals aspiring to learn the basics of Big Data Analytics using Hadoop Framework and become a Hadoop Developer. Software Professionals, Analytics Professionals, and ETL developers are the key beneficiaries of this course.

Prerequisites

Before you start proceeding with this tutorial, we assume that you have prior exposure to Core Java, database concepts, and any of the Linux operating system flavors.

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1. HADOOP – BIG DATA OVERVIEW

"90% of the world's data was generated in the last few years."

Due to the advent of new technologies, devices, and communication means like social networking sites, the amount of data produced by mankind is growing rapidly every year. The amount of data produced by us from the beginning of time till 2003 was 5 billion gigabytes. If you pile up the data in the form of disks it may fill an entire football field. The same amount was created in every two days in **2011**, and in every ten minutes in **2013**. This rate is still growing enormously. Though all this information produced is meaningful and can be useful when processed, it is being neglected.

What is Big Data?

Big Data is a collection of large datasets that cannot be processed using traditional computing techniques. It is not a single technique or a tool, rather it involves many areas of business and technology.

What Comes Under Big Data?

Big data involves the data produced by different devices and applications. Given below are some of the fields that come under the umbrella of Big Data.

- **Black Box Data:** It is a component of helicopter, airplanes, and jets, etc. It captures voices of the flight crew, recordings of microphones and earphones, and the performance information of the aircraft.
- **Social Media Data:** Social media such as Facebook and Twitter hold information and the views posted by millions of people across the globe.
- **Stock Exchange Data:** The stock exchange data holds information about the 'buy' and 'sell' decisions made on a share of different companies made by the customers.
- **Power Grid Data:** The power grid data holds information consumed by a particular node with respect to a base station.
- **Transport Data:** Transport data includes model, capacity, distance and availability of a vehicle.
- **Search Engine Data:** Search engines retrieve lots of data from different databases.

Thus Big Data includes huge volume, high velocity, and extensible variety of data. The data in it will be of three types.

- **Structured data**: Relational data.
- **Semi Structured data**: XML data.
- **Unstructured data**: Word, PDF, Text, Media Logs.

Benefits of Big Data

- Using the information kept in the social network like Facebook, the marketing agencies are learning about the response for their campaigns, promotions, and other advertising mediums.
- Using the information in the social media like preferences and product perception of their consumers, product companies and retail organizations are planning their production.
- Using the data regarding the previous medical history of patients, hospitals are providing better and quick service.

Big Data Technologies

Big data technologies are important in providing more accurate analysis, which may lead to more concrete decision-making resulting in greater operational efficiencies, cost reductions, and reduced risks for the business.

To harness the power of big data, you would require an infrastructure that can manage and process huge volumes of structured and unstructured data in real-time and can protect data privacy and security.

There are various technologies in the market from different vendors including Amazon, IBM, Microsoft, etc., to handle big data. While looking into the technologies that handle big data, we examine the following two classes of technology:

Operational Big Data

These include systems like MongoDB that provide operational capabilities for real-time, interactive workloads where data is primarily captured and stored.

NoSQL Big Data systems are designed to take advantage of new cloud computing architectures that have emerged over the past decade to allow massive computations to be run inexpensively and efficiently. This makes operational big data workloads much easier to manage, cheaper, and faster to implement.

Some NoSQL systems can provide insights into patterns and trends based on real-time data with minimal coding and without the need for data scientists and additional infrastructure.

Analytical Big Data

These includes systems like Massively Parallel Processing (MPP) database systems and MapReduce that provide analytical capabilities for retrospective and complex analysis that may touch most or all of the data.

MapReduce provides a new method of analyzing data that is complementary to the capabilities provided by SQL, and a system based on MapReduce that can be scaled up from single servers to thousands of high and low end machines.

These two classes of technology are complementary and frequently deployed together.

Operational vs. Analytical Systems

	Operational	Analytical
Latency	1 ms - 100 ms	1 min - 100 min
Concurrency	1000 - 100,000	1 - 10
Access Pattern	Writes and Reads	Reads
Queries	Selective	Unselective

Data Scope	Operational	Retrospective
End User	Customer	Data Scientist
Technology	NoSQL	MapReduce, MPP Database

Big Data Challenges

The major challenges associated with big data are as follows:

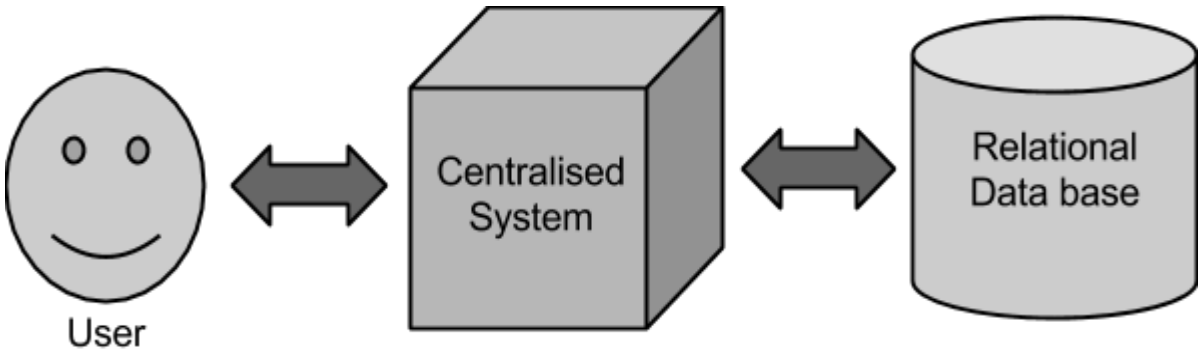
- Capturing data
- Curation
- Storage
- Searching
- Sharing
- Transfer
- Analysis
- Presentation

To fulfill the above challenges, organizations normally take the help of enterprise servers.

2. HADOOP – BIG DATA SOLUTIONS

Traditional Enterprise Approach

In this approach, an enterprise will have a computer to store and process big data. For storage purpose, the programmers will take the help of their choice of database vendors such as Oracle, IBM, etc. In this approach, the user interacts with the application, which in turn handles the part of data storage and analysis.

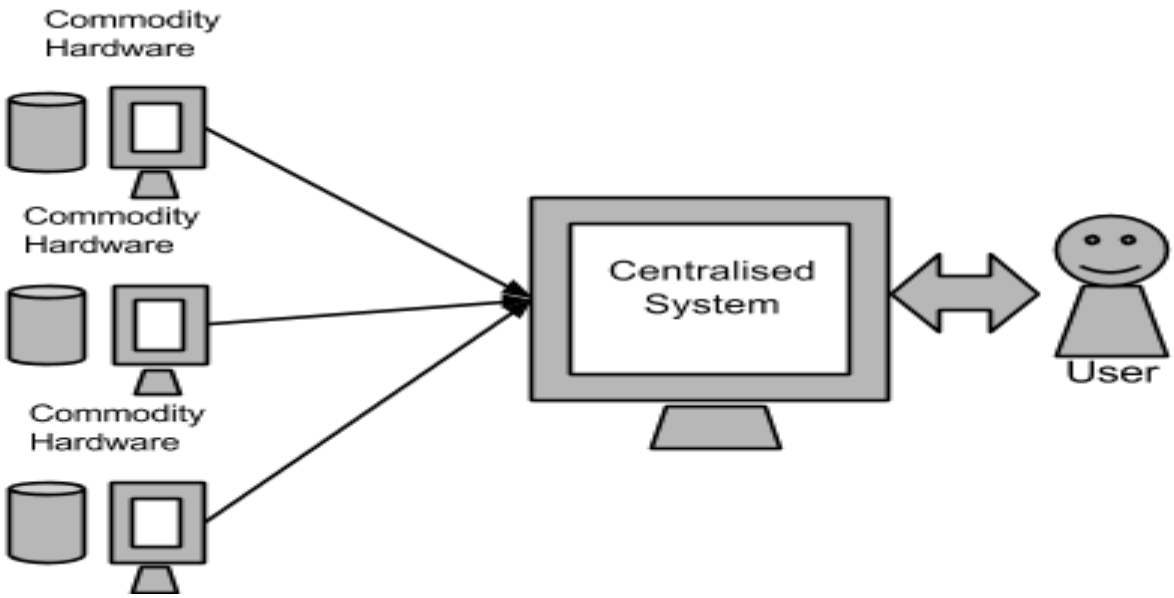


Limitation

This approach works fine with those applications that process less voluminous data that can be accommodated by standard database servers, or up to the limit of the processor that is processing the data. But when it comes to dealing with huge amounts of scalable data, it is a hectic task to process such data through a single database bottleneck.

Google's Solution

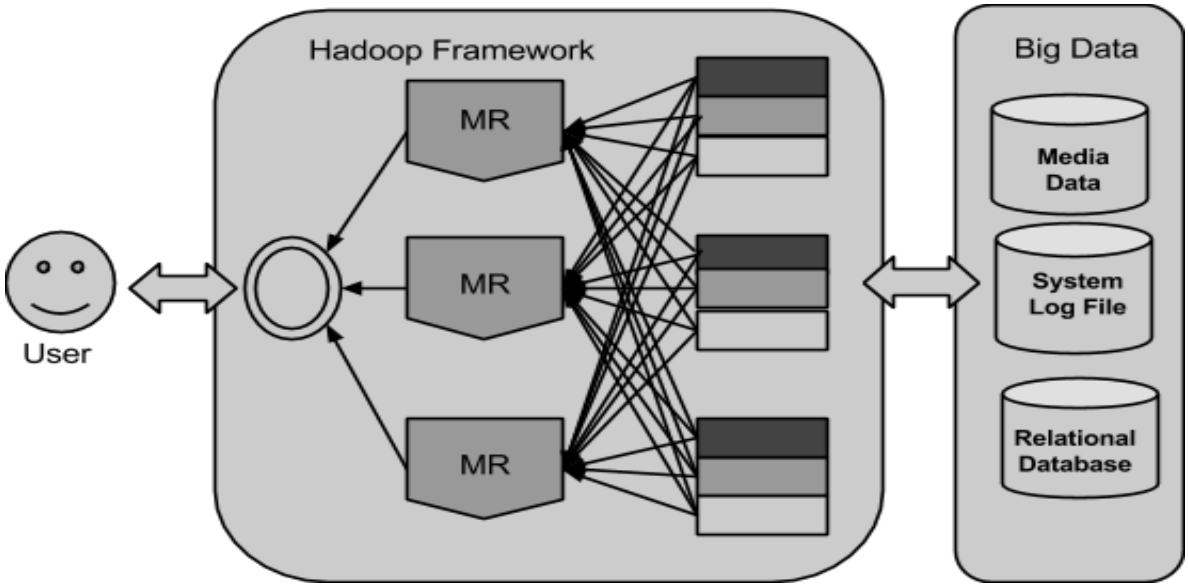
Google solved this problem using an algorithm called MapReduce. This algorithm divides the task into small parts and assigns them to many computers, and collects the results from them which when integrated, form the result dataset.



Hadoop

Using the solution provided by Google, **Doug Cutting** and his team developed an Open Source Project called **HADOOP**.

Hadoop runs applications using the MapReduce algorithm, where the data is processed in parallel with others. In short, Hadoop is used to develop applications that could perform complete statistical analysis on huge amounts of data.



3. HADOOP – INTRODUCTION

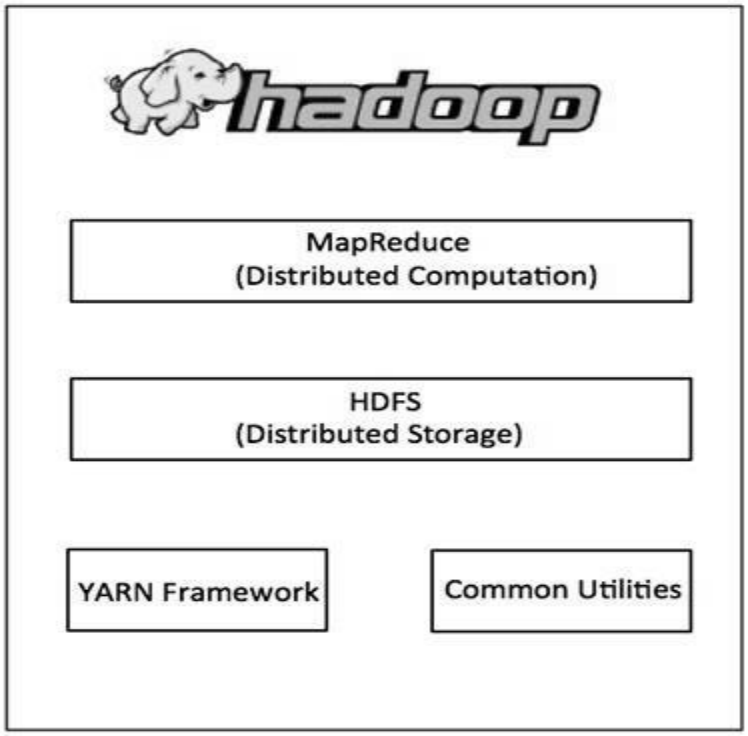
Hadoop is an Apache open source framework written in java that allows distributed processing of large datasets across clusters of computers using simple programming models. The Hadoop framework application works in an environment that provides distributed *storage* and *computation* across clusters of computers. Hadoop is designed to scale up from single server to thousands of machines, each offering local computation and storage.

Hadoop Architecture

At its core, Hadoop has two major layers namely:

(a) Processing/Computation layer (MapReduce), and

(b) Storage layer (Hadoop Distributed File System).



MapReduce

MapReduce is a parallel programming model for writing distributed applications devised at Google for efficient processing of large amounts of data (multi-terabyte data-sets), on large

clusters (thousands of nodes) of commodity hardware in a reliable, fault-tolerant manner. The MapReduce program runs on Hadoop which is an Apache open-source framework.

Hadoop Distributed File System

The Hadoop Distributed File System (HDFS) is based on the Google File System (GFS) and provides a distributed file system that is designed to run on commodity hardware. It has many similarities with existing distributed file systems. However, the differences from other distributed file systems are significant. It is highly fault-tolerant and is designed to be deployed on low-cost hardware. It provides high throughput access to application data and is suitable for applications having large datasets.

Apart from the above-mentioned two core components, Hadoop framework also includes the following two modules:

- **Hadoop Common:** These are Java libraries and utilities required by other Hadoop modules.
- **Hadoop YARN:** This is a framework for job scheduling and cluster resource management.

How Does Hadoop Work?

It is quite expensive to build bigger servers with heavy configurations that handle large scale processing, but as an alternative, you can tie together many commodity computers with single-CPU, as a single functional distributed system and practically, the clustered machines can read the dataset in parallel and provide a much higher throughput. Moreover, it is cheaper than one high-end server. So this is the first motivational factor behind using Hadoop that it runs across clustered and low-cost machines.

Hadoop runs code across a cluster of computers. This process includes the following core tasks that Hadoop performs:

- Data is initially divided into directories and files. Files are divided into uniform sized blocks of 128M and 64M (preferably 128M).
- These files are then distributed across various cluster nodes for further processing.
- HDFS, being on top of the local file system, supervises the processing.
- Blocks are replicated for handling hardware failure.
- Checking that the code was executed successfully.
- Performing the sort that takes place between the map and reduce stages.

- Sending the sorted data to a certain computer.
- Writing the debugging logs for each job.

Advantages of Hadoop

- Hadoop framework allows the user to quickly write and test distributed systems. It is efficient, and it automatic distributes the data and work across the machines and in turn, utilizes the underlying parallelism of the CPU cores.
- Hadoop does not rely on hardware to provide fault-tolerance and high availability (FTHA), rather Hadoop library itself has been designed to detect and handle failures at the application layer.
- Servers can be added or removed from the cluster dynamically and Hadoop continues to operate without interruption.
- Another big advantage of Hadoop is that apart from being open source, it is compatible on all the platforms since it is Java based.

4. HADOOP – ENVIRONMENT SETUP

Hadoop is supported by GNU/Linux platform and its flavors. Therefore, we have to install a Linux operating system for setting up Hadoop environment. In case you have an OS other than Linux, you can install a Virtualbox software in it and have Linux inside the Virtualbox.

Pre-installation Setup

Before installing Hadoop into the Linux environment, we need to set up Linux using **ssh** (Secure Shell). Follow the steps given below for setting up the Linux environment.

Creating a User

At the beginning, it is recommended to create a separate user for Hadoop to isolate Hadoop file system from Unix file system. Follow the steps given below to create a user:

- Open the root using the command "su".
- Create a user from the root account using the command "useradd username".
- Now you can open an existing user account using the command "su username".

Open the Linux terminal and type the following commands to create a user.

```
$ su
  password:
# useradd hadoop
# passwd hadoop
 New passwd:
 Retype new passwd
```

SSH Setup and Key Generation

SSH setup is required to do different operations on a cluster such as starting, stopping, distributed daemon shell operations. To authenticate different users of Hadoop, it is required to provide public/private key pair for a Hadoop user and share it with different users.

The following commands are used for generating a key value pair using SSH. Copy the public keys form id_rsa.pub to authorized_keys, and provide the owner with read and write permissions to authorized_keys file respectively.

```
$ ssh-keygen -t rsa
$ cat ~/.ssh/id_rsa.pub >> ~/.ssh/authorized_keys
$ chmod 0600 ~/.ssh/authorized_keys
```

Installing Java

Java is the main prerequisite for Hadoop. First of all, you should verify the existence of java in your system using the command "java -version". The syntax of java version command is given below.

```
$ java -version
```

If everything is in order, it will give you the following output.

```
java version "1.7.0_71"
Java(TM) SE Runtime Environment (build 1.7.0_71-b13)
Java HotSpot(TM) Client VM (build 25.0-b02, mixed mode)
```

If java is not installed in your system, then follow the steps given below for installing java.

Step 1

Download java (JDK <latest version> - X64.tar.gz) by visiting the following link http://www.oracle.com/technetwork/java/javase/downloads/jdk7-downloads-1880260.html.

Then **jdk-7u71-linux-x64.tar.gz** will be downloaded into your system.

Step 2

Generally you will find the downloaded java file in Downloads folder. Verify it and extract the **jdk-7u71-linux-x64.gz** file using the following commands.

```
$ cd Downloads/
$ ls
jdk-7u71-linux-x64.gz

$ tar zxf jdk-7u71-linux-x64.gz
$ ls
jdk1.7.0_71   jdk-7u71-linux-x64.gz
```

Step 3

To make java available to all the users, you have to move it to the location "/usr/local/". Open root, and type the following commands.

```
$ su
password:
# mv jdk1.7.0_71 /usr/local/
# exit
```

Step 4

For setting up **PATH** and **JAVA_HOME** variables, add the following commands to **~/.bashrc** file.

```
export JAVA_HOME=/usr/local/jdk1.7.0_71
export PATH=PATH:$JAVA_HOME/bin
```

Now apply all the changes into the current running system.

```
$ source ~/.bashrc
```

Step 5

Use the following commands to configure java alternatives:

```
# alternatives --install /usr/bin/java java usr/local/java/bin/java 2
# alternatives --install /usr/bin/javac javac usr/local/java/bin/javac 2
# alternatives --install /usr/bin/jar jar usr/local/java/bin/jar 2

# alternatives --set java usr/local/java/bin/java
# alternatives --set javac usr/local/java/bin/javac
# alternatives --set jar usr/local/java/bin/jar
```

Now verify the installation using the command **java -version** from the terminal as explained above.

Downloading Hadoop

Download and extract Hadoop 2.4.1 from Apache software foundation using the following commands.

```
$ su
```

```
password:
# cd /usr/local
# wget http://apache.claz.org/hadoop/common/hadoop-2.4.1/
hadoop-2.4.1.tar.gz
# tar xzf hadoop-2.4.1.tar.gz
# mv hadoop-2.4.1/* to hadoop/
# exit
```

Hadoop Operation Modes

Once you have downloaded Hadoop, you can operate your Hadoop cluster in one of the three supported modes:

- **Local/Standalone Mode**: After downloading Hadoop in your system, by default, it is configured in a standalone mode and can be run as a single java process.
- **Pseudo Distributed Mode**: It is a distributed simulation on single machine. Each Hadoop daemon such as hdfs, yarn, MapReduce etc., will run as a separate java process. This mode is useful for development.
- **Fully Distributed Mode**: This mode is fully distributed with minimum two or more machines as a cluster. We will come across this mode in detail in the coming chapters.

Installing Hadoop in Standalone Mode

Here we will discuss the installation of **Hadoop 2.4.1** in standalone mode.

There are no daemons running and everything runs in a single JVM. Standalone mode is suitable for running MapReduce programs during development, since it is easy to test and debug them.

Setting Up Hadoop

You can set Hadoop environment variables by appending the following commands to **~/.bashrc** file.

```
export HADOOP_HOME=/usr/local/hadoop
```

Before proceeding further, you need to make sure that Hadoop is working fine. Just issue the following command:

```
$ hadoop version
```

If everything is fine with your setup, then you should see the following result:

```
Hadoop 2.4.1
Subversion https://svn.apache.org/repos/asf/hadoop/common -r 1529768
Compiled by hortonmu on 2013-10-07T06:28Z
Compiled with protoc 2.5.0
From source with checksum 79e53ce7994d1628b240f09af91e1af4
```

It means your Hadoop's standalone mode setup is working fine. By default, Hadoop is configured to run in a non-distributed mode on a single machine.

Example

Let's check a simple example of Hadoop. Hadoop installation delivers the following example MapReduce jar file, which provides basic functionality of MapReduce and can be used for calculating, like Pi value, word counts in a given list of files, etc.

```
$HADOOP_HOME/share/hadoop/mapreduce/hadoop-mapreduce-examples-2.2.0.jar
```

Let's have an input directory where we will push a few files and our requirement is to count the total number of words in those files. To calculate the total number of words, we do not need to write our MapReduce, provided the .jar file contains the implementation for word count. You can try other examples using the same .jar file; just issue the following commands to check supported MapReduce functional programs by hadoop-mapreduce-examples-2.2.0.jar file.

```
$ hadoop jar $HADOOP_HOME/share/hadoop/mapreduce/hadoop-mapreduce-examples-
2.2.0.jar
```

Step 1

Create temporary content files in the input directory. You can create this input directory anywhere you would like to work.

```
$ mkdir input
$ cp $HADOOP_HOME/*.txt input
$ ls -l input
```

It will give the following files in your input directory:

```
total 24
-rw-r--r-- 1 root root 15164 Feb 21 10:14 LICENSE.txt
-rw-r--r-- 1 root root   101 Feb 21 10:14 NOTICE.txt
-rw-r--r-- 1 root root  1366 Feb 21 10:14 README.txt
```

These files have been copied from the Hadoop installation home directory. For your experiment, you can have different and large sets of files.

Step 2

Let's start the Hadoop process to count the total number of words in all the files available in the input directory, as follows:

```
$ hadoop jar $HADOOP_HOME/share/hadoop/mapreduce/hadoop-mapreduce-examples-
2.2.0.jar  wordcount input ouput
```