Data Science Course Exercise Workbook

Introduction to HDFS and MapReduce

Course Material

Stuart Brown, April 2017

Data Science – Introduction to HDFS

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08

**Fall**

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# Summary and Intro

This workbooks aim is to aid and facilitate Data Science trainees learning. This workbook will cover aspects from the 3rd and 4th lecture slides for the Data Science course:

1. Introduction to HDFS

2. Introduction to DEDPQ MapReduce

This workbook and subsequent workbooks will act as a record of the trainees work, learnings and understanding.

You should aim to complete all questions.

# Section 1: Introduction to HDFS

Please complete all exercises.

# **Exercise 1: Stock Data Ingestion Task**

This exercise is formed of 7 tasks that will involve transferring data into your personal HDFS location. Data in HDFS receives the benefits of being on distributed storage and of Hadoops accessibility and fault tolerance. Applications that we will be using later in the course (HIVE, PIG, and SPARK) will be utilising the HDFS as they are part of the Apache Hadoop ecosystem.

Please write the commands you used. It will be beneficial!

#### Task 1:

Start the Hadoop Services. You will be starting Hadoop to store, for example, large amounts of financial data.

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#### Answer

**su hduser**

**start-all.sh**

#### Task 2:

In the HDFS create a directory “firstname.lastname” in the user directory. By creating a personal storage repository within HDFS, you will have a place to store the financial data

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#### Answer

**hdfs dfs –mkdir /user/stuart.brown**

#### Task 3:

Create further subdirectories for some Apple stock data (stocks/apple). It is always a good idea to have a clean file system structure which leads to good data management.

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#### Answer

**hdfs dfs –mkdir /user/stuart.brown/stocks/apple**

#### Task 4:

On the local file system there should be a DataSets folder you can verify this by:

**ls /PublicStorage/**

In there should be stock data folder and in that a file called: “appl\_daily.csv”

Load this file into the HDFS directory you just created.

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#### Answer

**hdfs dfs –put /home/PublicStorage/DataSets/Stock\_Data/appl\_daily.csv /user/stuart.brown/stocks/apple**

#### Task 5:

Transfer the other stock csv’s into /stocks/<name>.

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#### Answer

**hdfs dfs –mkdir /user/stuart.brown/stocks/facebook**

**hdfs dfs –mkdir /user/stuart.brown/stocks/nasdaq**

**hdfs dfs –mkdir /user/stuart.brown/stocks/netflix**

**hdfs dfs –mkdir /user/stuart.brown/stocks/twitter**

**hdfs dfs –mkdir /user/stuart.brown/stocks/yahoo**

**hdfs dfs –put /home/PublicStorage/DataSets/Stock\_Data/face\_daily.csv /user/stuart.brown/stocks/facebook**

**hdfs dfs –put /home/PublicStorage/DataSets/Stock\_Data/nasdaq\_daily.csv /user/stuart.brown/stocks/nasdaq**

**hdfs dfs –put /home/PublicStorage/DataSets/Stock\_Data/nflx\_daily.csv /user/stuart.brown/stocks/netflix**

**hdfs dfs –put /home/PublicStorage/DataSets/Stock\_Data/twtr\_daily.csv /user/stuart.brown/stocks/twitter**

**hdfs dfs –put /home/PublicStorage/DataSets/Stock\_Data/yhoo\_daily.csv /user/stuart.brown/stocks/yahoo**

#### Task 6:

Ensure that you have full permissions on these files. This is so you can keep accessing the files later on without issue.

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#### Answer

**Hdfs dfs –chmod –r 777 /user/stuart.brown/stocks**

#### Task 7:

Create a backup of the stocks data that can be used for archive or auditing purposes.

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#### Answer

**hdfs dfs –cp /user/stuart.brown/stocks /user/stuart.brown/dataBackup/stocks**

# **Exercise 2: HDFS Project**

As you may have felt from section 1, ingesting files individually can be rather tiresome. At least with only 7 files it was manageable, but what if you had 20? 50? 1000?

Clearly we need a script that will do the data ingestion for us. Time to practise those unix skills!

#### Project Task:

1. Create a script that will transfer data files into hdfs.
2. This script should place existent, sized files into an individually appropriate directory on hdfs based on the file name.
3. Status messages and flow control should also be included.
4. An archive of the files should also be created.

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#### Answer- This is not an extensive answer

**vi hdfs-move.sh**

**#!/bin/bash**

**dir = $1**

**val=”/home/PublicStorage/DataSets/$dir/\*”**

**FOR vals in $val**

**do**

**if**

**test –e $val**

**then echo “files found”**

**hdfs dfs –put $val /user/stuart.brown/$dir/$(basename $val)/ $(basename $val)**

**hdfs dfs –put $val /user/stuart.brown/dataBackup/$dir/$(basename $val)/ $(basename $val)**

**echo “ingesting $(basename $val)”**

**fi**

**done**

**hdfs dfs –ls /user/stuart.brown/$dir**

# Section 2: HDFS & DEDPQ MapReduce

The following exercises are set to test your knowledge about HDFS and MapReduce. You will need to conduct some research in order to formulate accurate/appropriate answers.

# **Exercise 1: MapReduce**

This exercise follows on from the lecture content.

#### Question 1:

Detail 3 aspects of MapReduce?

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#### Answer This is not an exhaustive list

It is the programming paradigm that allows for the potentially massive scalability across servers (nodes) in the hadoop cluster.

It is one of 3 core components of Hadoop

It is written in Java

It takes a large complex task and breaks it out into smaller, more manageable task.

#### Question 2:

What is the role of the Job and Task Tracker daemons.

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#### Answer

JT: Oversees how the MapReduce jobs are divided into tasks and distributed among nodes within the cluster

TT: Accepts the task from the Job Tracker and performs the work, the Job Tracker is then alerted when the task is completed

#### Question 3:

Outline the process of a MapReduce Task.

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#### Answer

When running a MapReduce operation, the task is first mapped (spread across multiple nodes), work is done (counts), then reduced (combine the results), work is done (aggregation) and the output is given.

#### Question 4:

What are 3 advantages of the MapReduce methodology.

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#### Answer

The mappers can work independently

The reducers can work independently

The Grouper can work really fast, because the Grouper didn’t have to do any counting of words, all they had to do was to look at the first number and put an X on the appropriate sheet.

The process can be easily applied to other kinds of problems.

#### Question 5:

What value does YARN add to the Hadoop Core?

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#### Answer

YARN decouples MapReduce resource management from data processing component.

As part of the Hadoop core it can now simultaneously run interactive queries while a scheduled MapReduce batch operation is running. Value is given by being able to return on multiple business questions simultaneously.

#### Question 6:

What are the 4 step to writing a MapReduce job and how do applications like HIVE and PIG ease the process.

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#### Answer

1. Script the MapReduce job in Java

2. Set the Environmental Variables

3. Compile and create the Jar

4. Execute the application

HIVE and PIG are abstraction applications that utilise HQL and PIG Latin respectively to write the MapReduce Jobs in the background

# **Exercise 2: Interview Questions**

In this section you will be provided with interview style questions about Hadoop, HDFS and MapReduce. You will need to research into these answers.

#### Question 1:

What is Hadoop Map Reduce ?

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#### Answer

For processing large data sets in parallel across a hadoop cluster, Hadoop MapReduce framework is used.  Data analysis uses a two-step map and reduce process.

#### Question 2:

How does Hadoop MapReduce work?

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#### Answer

In MapReduce, during the map phase it counts the words in each document, while in the reduce phase it aggregates the data as per the document spanning the entire collection. During the map phase the input data is divided into splits for analysis by map tasks running in parallel across Hadoop framework.

#### Question 3:

Explain what is shuffling in MapReduce ?

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#### Answer

The process by which the system performs the sort and transfers the map outputs to the reducer as inputs is known as the shuffle

#### Question 4:

 Explain what is distributed Cache in MapReduce Framework ?

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#### Answer

Distributed Cache is an important feature provided by map reduce framework. When you want to share some files across all nodes in Hadoop Cluster, DistributedCache  is used.  The files could be an executable jar files or simple properties file.

#### Question 5:

Explain what is NameNode in Hadoop?

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#### Answer

NameNode in Hadoop is the node, where Hadoop stores all the file location information in HDFS (Hadoop Distributed File System).  In other words, NameNode is the centrepiece of an HDFS file system.  It keeps the record of all the files in the file system, and tracks the file data across the cluster or multiple machines

#### Question 6:

 Explain what is JobTracker in Hadoop? What are the actions followed by Hadoop?

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#### Answer

In Hadoop for submitting and tracking MapReduce jobs,  JobTracker is used. Job tracker run on its own JVM process

Hadoop performs following actions in Hadoop

Client application submit jobs to the job tracker

JobTracker communicates to the Namemode to determine data location

Near the data or with available slots JobTracker locates TaskTracker nodes

On chosen TaskTracker Nodes, it submits the work

When a task fails, Job tracker notify and decides what to do then.

The TaskTracker nodes are monitored by JobTracker

#### Question 7:

Explain what is heartbeat in HDFS?

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#### Answer

Heartbeat is referred to a signal used between a data node and Name node, and between task tracker and job tracker, if the Name node or job tracker does not respond to the signal, then it is considered there is some issues with data node or task tracker

#### Question 8:

What happens when a datanode fails ?

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#### Answer

When a datanode fails

Jobtracker and namenode detect the failure

On the failed node all tasks are re-scheduled

Namenode replicates the users data to another node

#### Question 9:

Explain what is Speculative Execution?

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

#### Answer

In Hadoop during Speculative Execution a certain number of duplicate tasks are launched.  On different slave node, multiple copies of same map or reduce task can be executed using Speculative Execution. In simple words, if a particular drive is taking long time to complete a task, Hadoop will create a duplicate task on another disk.  Disk that finish the task first are retained and disks that do not finish first are killed.

#### Question 10:

 Explain what is difference between an Input Split and HDFS Block?

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#### Answer

Logical division of data is known as Split while physical division of data is known as HDFS Block

#### Question 11:

Mention what are the main configuration parameters that user need to specify to run Mapreduce Job ?

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#### Answer

The user of Mapreduce framework needs to specify

Job’s input locations in the distributed file system

Job’s output location in the distributed file system

Input format

Output format

Class containing the map function

Class containing the reduce function

JAR file containing the mapper, reducer and driver classes

#### Question 12:

Explain how JobTracker schedules a task ?

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#### Answer

The task tracker send out heartbeat messages to Jobtracker usually every few minutes to make sure that JobTracker is active and functioning.  The message also informs JobTracker about the number of available slots, so the JobTracker can stay upto date with where in the cluster work can be delegated

#### Question 13:

Explain what is Hadoop?

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#### Answer

It is an open-source software framework for storing data and running applications on clusters of commodity hardware.  It provides enormous processing power and massive storage for any type of data.

#### Question 14:

Mention what is the difference between an RDBMS and Hadoop?

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

#### Answer

|  |  |
| --- | --- |
| RDBMS | Hadoop |
| RDBMS is relational database management system | Hadoop is node based flat structure |
| It used for OLTP processing whereas Hadoop | It is currently used for analytical and for BIG DATA processing |
| In RDBMS, the database cluster uses the same data files stored in shared storage | In Hadoop, the storage data can be stored independently in each processing node. |
| You need to pre-process data before storing it | you don’t need to pre-process data before storing it |

#### Question 15:

Mention Hadoop core components?

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#### Answer

Hadoop core components include,

HDFS

MapReduce

YARN

#### Question 16:

What is the DataNode in Hadoop?

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#### Answer

In HDFS, a DataNode stores data. Normally having more than one DataNode, with data replicated across them.

The DataNodes connect to the NameNode. It responds to requests from the NameNode for file system operations.

#### Question 17:

When Namenode is down what happens to job tracker?

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#### Answer

Namenode is the single point of failure in HDFS so when Namenode is down your cluster will set off.

#### Question 18:

Explain how indexing in HDFS is done?

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#### Answer

Hadoop has a unique way of indexing. Once the data is stored as per the block size, the HDFS will keep on storing the last part of the data which say where the next part of the data will be.

#### Question 19:

Explain is it possible to search for files using wildcards?

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#### Answer

Yes, it is possible to search for files using wildcards.

#### Question 20:

List out Hadoop’s three configuration files?

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#### Answer

The three configuration files are

core-site.xml

mapred-site.xml

hdfs-site.xml

#### Question 21:

Mention what is rack awareness?

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#### Answer

Rack awareness is the way in which the namenode determines on how to place blocks based on the rack definitions.

#### Question 22:

Explain what is a Task Tracker in Hadoop?

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#### Answer

A Task Tracker in Hadoop is a slave node daemon in the cluster that accepts tasks from a JobTracker. It also sends out the heartbeat messages to the JobTracker, every few minutes, to confirm that the JobTracker is still alive.

#### Question 23:

Mention what daemons run on a master node and slave nodes?

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#### Answer

Daemons that run on Master nodes are "NameNode", “Secondary Name Node”, “Job Tracker”

Daemons that run on each Slave nodes are “Task Tracker” and "Data"

#### Question 24:

Explain what is storage and compute nodes?

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#### Answer

The storage node is the machine or computer where your file system resides to store the processing data

The compute node is the computer or machine where your actual business logic will be executed.

#### Question 25:

Mention what is the best way to copy files between HDFS clusters?

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#### Answer

The best way to copy files between HDFS clusters is by using multiple nodes and the distcp command, so the workload is shared.

#### Question 26:

Mention what are the three modes in which Hadoop can be run?

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#### Answer

The three modes in which Hadoop can be run are

Pseudo distributed mode

Standalone (local) mode

Fully distributed mode

#### Question 27:

Mention how many InputSplits is made by a Hadoop Framework?

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#### Answer

Hadoop will make 5 splits

1 split for 64K files

2 split for 65mb files

2 splits for 127mb files

#### Question 28:

Mention what is distributed cache in Hadoop?

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#### Answer

Distributed cache in Hadoop is a facility provided by MapReduce framework.  At the time of execution of the job, it is used to cache file.  The Framework copies the necessary files to the slave node before the execution of any task at that node.

#### Question 29:

Explain what is “map” and what is "reducer" in Hadoop?

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#### Answer

In Hadoop, a map is a phase in HDFS query solving.  A map reads data from an input location, and outputs a key value pair according to the input type.

In Hadoop, a reducer collects the output generated by the mapper, processes it, and creates a final output of its own.

# Summary

You should now be able to navigate the HDFS, transfer bulk data into it and have a thorough understanding of the Hadoop core and the daemon processes that support the application.