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1. INSTRUCTIONS FOR LAB (DO'S AND DONT'S)

VNR VIGNANA JYOTHI INSTITUTE OF ENGINEERING & TECHNOLOGY
(An Autonomous Institution)



Department of Computer Science & Engineering
Computer Lab DO's



1. Read and understand how to carry out an experiment / activity thoroughly before coming to the laboratory.
2. Report any broken plugs or exposed electrical wires and any rectification needed, to your faculty/staff immediately.
3. Know the location of the fire extinguisher and the first aid box and have an understanding of how to use them in case of an emergency.
4. Report fires or accidents to your Faculty / Staff immediately.
5. Students have to come in formal wear and wear ID cards.
6. Should bring observation books and lab records for each lab session.



Computer Lab Don'ts

1. Do not open the system unit casing or monitor casing particularly unless you are agreed to do so and under supervision of Faculty / Staff. Some internal components hold electrical voltages of up to 30000 volts, which can be fatal.
2. Avoid stepping on electrical wires or any other computer cables.
3. Do not insert any material and particularly metal objects such as clips, pins and needles into computer casings. They may cause fire / electric shock.
4. Do not touch, connect or disconnect any plug or cable without your Faculty / Staff permission /assistance.
5. Do not remove anything from the computer laboratory without permission.
6. Do not disobey the instructions given and cause problems.
7. Do not eat or drink in the laboratory.
8. Any external storage device for loading / copying can be used only with prior permission from the lab-incharges.
9. Browsing internet during the Academic Schedules is prohibited

2. COURSE OBJECTIVES

1. To introduce visual perception and core skills for visual analysis.
2. To develop skills to both design and critique visualizations.
3. To obtain a Comprehensive knowledge of various tools and techniques for Data Science.
4. To analyze the various methods of data collection.

3. LAB SYLLABUS

1. HDFS (Storage)

A. Hadoop Storage File system

Your first objective is to create a directory structure in HDFS using HDFS commands. Create the local files using Linux commands and move the files to HDFS directory and vice versa.

- I. Write a command to create the directory structure in HDFS.
- II. Write a Command to move file from local unix/linux machine to HDFS.

B. Viewing Data Contents, Files and Directory

Try to perform these simple steps:

- a) Write HDFS command to see the contents of files in HDFS.
- b) Write HDFS command to see contents of files which are present in HDFS.

C. Getting Files data from the HDFS to Local Disk

I. Write a HDFS command to copy the file from HDFS to local file system. To process any data first move the data in HDFS. All files storaged in HDFS can be accessed using HDFS commands. Lab Instructions:

- i. Your objective is to use HDFS commands to move data to HDFS for processing data.
2. Map Reduce Programming (Processing data). Hadoop Map-Reduce framework is developed using Java, but the framework allows you to write programs in other languages as well.

A. Word Count

The word count problem is the most famous using map reduce program. Same thing we can do with java but takes lot of time with huge file, in MR it will process less time 47 even with huge and distributed files. The objective is to count the frequency of words of a large text.

Lab Instructions: i. Develop MapReduce example program in a MapReduce environment to find out the number of occurrences of each word in a text file.

B. Most Frequent Words Count

Use the output from the previous program to list the most frequent words with their counts.

Lab Instructions:

- i. Use the same strategy of breaking the programs in three parts. Copy the files from the previous exercise and use them as a starting point.
- ii. Load the data from the output by using third filter to load the files.

3. Data Processing Tool – Hive (NOSQL query based language)

Hive command line tool allows you to submit jobs via bash scripts. **Identifying properties of a data set:**

We have a table 'user data' that contains the following fields: data_date:

string user_id:

string properties:

string The properties field is formatted as a series of attribute=value pairs. Ex:
Age=21; state=CA; gender=M;

Lab Instructions:

- i. Create the table in HIVE using hive nosql based query.
- ii. Fill the table with sample data by using some sample data bases.
- iii. Write a program that produces a list of properties with minimum value(min_value), largest value(max_value) and number of unique values. Before you start, execute the prepare step to load the data into HDFS.
- iv. Generate a count per state.

Now that extracted the properties, calculate the number of records per state.

Lab Instructions:

- i. Write a program that lists the states and their count from the data input.

4. Data Processing Tool – Pig (Latin based scripting lang)

Pig command line tool like the Hive allows you to submit jobs via bash scripts.

A. Simple Logs

We have a set of log files and need to create a job that runs every hour and perform some calculations. The log files are delimited by a 'tab' character and have the following fields:

- a) site
- b) hour_of_day
- c) page_views

d) data_date

The log files are located on the prepare folder. Load them in HDFS at data/ pig/simple_logs folder and use them as the input. Important: In order to load tab delimited files use pigStorage ('\u0001').

Lab Instructions:

Create a program to:

- i. Calculate the total views per hour per day.
- ii. Calculate the total views per day.
- iii. Calculate the total counts of each hour across all days.
- iv. We can write word count script by passing text file as input

5. SQOOP

It is used to import and export data from SQL to HDFS and Vice versa. Before processing any data first need to import data into HDFS. As of now seen importing files into HDFS but using sqoop tool we can import SQL table data into hive table.

- I. Create table in HIVE using hive query language.
- II. Import the sql table data into hive using sqoop too.
- III. Export hive table data into local machine and into SQL.

6. Exploring ARIMA model.

4. NEED OF LAB

1. Python is the most popular language worldwide. Everything from microcontrollers to operating systems is written in python since it's very flexible and versatile, allowing maximum control with minimal commands.
2. The most important benefit is that the Python programming language is recognized worldwide and used in a multitude of applications, including advanced scientific calculation.

5. COURSE OUTCOMES

After completion of the course, the student should be able to

1. Explore various HDFS commands on Hadoop file system
2. Illustrate Map Reduce programming framework on large data sets in a distributed environment
3. Demonstrate different Big Data tools such as HIVE, PIG, and SQOOP
4. Extract large data sets to perform visualization and data analysis tasks

6. BIBLIOGRAPHY

TEXTBOOKS:

1. Data Analytics using R, Seema Acharya, McGraw Hill Education, 2019
2. R for Data Science, Import, Tidy, Transform, Visualize, and Model Data, Hadley Wickham, Garrett Grolemund, 2016
3. Hadoop: The Definitive Guide, Tom White, 3rd Edition, O'reilly Media, 2012

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1. Data Analytics with R, Bharti Motwani, 2019
2. Data Science-Theory, Analysis and Applications, Qurban A. Memon, Shakeel Ahmed Khoja, 2019
3. Big Data Glossary, Pete Warden, O'Reilly, 2011.

URL's:

1. <https://www.w3schools.com/python/>
2. <https://www.programiz.com/python-programming/online-compiler/>
3. <https://www.tutorialspoint.com/python/index.htm>

7. LIST OF EXERCISES

Exercise No.	Exercise Name	Pg. no
1	1. HDFS (Storage)	12
2	<p>A. Hadoop Storage File system</p> <p>Your first objective is to create a directory structure in HDFS using HDFS commands. Create the local files using Linux commands and move the files to HDFS directory and vice versa.</p> <p>I. Write a command to create the directory structure in HDFS.</p> <p>II. Write a Command to move file from local unix/linux machine to HDFS.</p>	15
3	<p>B. Viewing Data Contents, Files and Directory</p> <p>Try to perform these simple steps:</p> <p>a) Write HDFS command to see the contents of files in HDFS.</p> <p>b) Write HDFS command to see contents of files which are present in HDFS.</p>	17

4	<p>C. Getting Files data from the HDFS to Local Disk</p> <p>I. Write a HDFS command to copy the file from HDFS to local file system. To process any data first move the data in HDFS. All files storaged in HDFS can be accessed using HDFS commands.</p> <p>Lab Instructions:</p> <ul style="list-style-type: none"> i. Your objective is to use HDFS commands to move data to HDFS for processing data. <p>2. Map Reduce Programming (Processing data). Hadoop Map-Reduce framework is developed using Java, but the framework allows you to write programs in other languages as well.</p>	19
5	<p>A. Word Count</p> <p>The word count problem is the most famous using map reduce program. Same thing we can do with java but takes lot of time with huge file, in MR it will process less time 47 even with huge and distributed files. The objective is to count the frequency of words of a large text.</p> <p>Lab Instructions:</p> <ul style="list-style-type: none"> i. Develop MapReduce example program in a MapReduce environment to find out the number of occurrences of each word in a text file. 	21

6	<p>B. Most Frequent Words Count</p> <p>Use the output from the previous program to list the most frequent words with their counts.</p> <p>Lab Instructions:</p> <ul style="list-style-type: none"> iii. Use the same strategy of breaking the programs in three parts. Copy the files from the previous exercise and use them as a starting point. iv. Load the data from the output by using third filter to load the files. 	23
7	<p>3. Data Processing Tool – Hive (NOSQL query based language)</p> <p>Hive command line tool allows you to submit jobs via bash scripts. Identifying properties of a data set:</p> <p>We have a table 'user data' that contains the following fields: data_date: string user_id: string properties: string The properties field is formatted as a series of attribute=value pairs. Ex: Age=21; state=CA; gender=M;</p> <p>Lab Instructions:</p> <ul style="list-style-type: none"> v. Create the table in HIVE using hive nosql based query. vi. Fill the table with sample data by using some sample data bases. vii. Write a program that produces a list of properties with minimum 	25

	<p>value(min_value), largest value(max_value) and number of unique values. Before you start, execute the prepare step to load the data into HDFS.</p> <p>viii. Generate a count per state.</p> <p>Now that extracted the properties, calculate the number of records per state.</p>	
8.	<p>Data Processing Tool – Pig (Latin based scripting lang)</p> <p>Pig command line tool like the Hive allows you to submit jobs via bash scripts.</p> <p>B. Simple Logs</p> <p>We have a set of log files and need to create a job that runs every hour and perform some calculations. The log files are delimited by a 'tab' character and have the following fields:</p> <ul style="list-style-type: none"> a) site b) hour_of_day c) page_views d) data_date <p>The log files are located on the prepare folder. Load them in HDFS at data/ pig/ simple_logs folder and use them as the input. Important: In order to load tab delimited files use pigStorage ('\u0001').</p> <p>Lab Instructions:</p>	

	<p>Create a program to:</p> <ul style="list-style-type: none"> v. Calculate the total views per hour per day. vi. Calculate the total views per day. vii. Calculate the total counts of each hour across all days. viii. We can write word count script by passing text file as input 	
9.	<p>5. SQOOP</p> <p>It is used to import and export data from SQL to HDFS and Vice versa. Before processing any data first need to import data into HDFS. As of now seen importing files into HDFS but using sqoop tool we can import SQL table data into hive table.</p> <ul style="list-style-type: none"> I. Create table in HIVE using hive query language. II. Import the sql table data into hive using sqoop too. III. Export hive table data into local machine and into SQL. 	

10.	Exploring ARIMA model.	
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8. ASSESSMENT

Internal Assessment (30 M):

Staff should maintain the assessment register and Head of the department should monitor it

Template of internal marks

Day to day evaluation	10
Practical Examinations (1 & 2)	10
Laboratory Record	10
Total	30

External Assessment (70 M):

Exam will be conducted at the end of Lab

One of the examiners will be appointed by controller of examinations in consultation with HOD

1. Installation of Hadoop:

Hadoop software can be installed in three modes of operation:

- **Stand Alone Mode:** Hadoop is a distributed software and is designed to run on a commodity of machines. However, we can install it on a single node in stand-alone mode. In this mode, Hadoop software runs as a single monolithic java process. This mode is extremely useful for debugging purpose. You can first testrun your Map-Reduce application in this mode on small data, before actually executing it on cluster with big data.
- **Pseudo Distributed Mode:** In this mode also, Hadoop software is installed on a Single Node. Various daemons of Hadoop will run on the same machine as separate java processes. Hence all the daemons namely NameNode, DataNode, SecondaryNameNode, JobTracker, TaskTracker run on single machine.
- **Fully Distributed Mode:** In Fully Distributed Mode, the daemons NameNode, JobTracker, SecondaryNameNode (Optional and can be run

on a separate node) run on the Master Node. The daemons DataNode and TaskTracker run on the Slave Node.

Hadoop Installation: Ubuntu Operating System in stand-alone mode

Steps for Installation

- 1.** `sudo apt-get update`
- 2.** In this step, we will install latest version of JDK (1.8) on the machine.

The Oracle JDK is the official JDK; however, it is no longer provided by Oracle as a default installation for Ubuntu. You can still install it using apt-get.

To install any version, first execute the following commands:

- a.** `sudo apt-get install python-software-properties`
- b.** `sudo add-apt-repository ppa:webupd8team/java`
- c.** `sudo apt-get update`

Then, depending on the version you want to install, execute one of the following commands:

Oracle JDK 7: `sudo apt-get install oracle-java7-installer`

Oracle JDK 8: `sudo apt-get install oracle-java8-installer`

3. Now, let us setup a new user account for Hadoop installation. This step is optional, but recommended because it gives you flexibility to have a separate account for Hadoop installation by separating this installation from other software installation

a. `sudo adduser hadoop_dev` (Upon executing this command, you will prompted to enter the new password for this user. Please enter the password and enter other details. Don't forget to save the details at the end)

b. `su - hadoop_dev` (Switches the user from current user to the new user created i.e Hadoop_dev)

4. Download the latest Hadoop distribution.

a. Visit this [URL](#) and choose one of the mirror sites. You can copy the download link and also use “wget” to download it from command prompt:

```
Wget http://apache.mirrors.lucidnetworks.net/hadoop/common/hadoop-2.7.0/hadoop-2.7.0.tar.gz
```

5. Untar the file :

```
tar xvzf hadoop-2.7.0.tar.gz
```

6. Rename the folder to hadoop2

```
mv hadoop-2.7.0 hadoop2
```

7. Edit configuration file /home/hadoop_dev/hadoop2/etc/hadoop/hadoop-env.sh and set JAVA_HOME in that file.

a. `vim /home/hadoop_dev/hadoop2/etc/hadoop/hadoop-env.sh`

b. uncomment JAVA_HOME and update it following line:

```
export JAVA_HOME=/usr/lib/jvm/java-8-oracle ( Please check for your relevant java installation and set this value accordingly. Latest 22 versions of Hadoop require > JDK1.7)
```

8. Let us verify if the installation is successful or not(change to home directory `cd /home/hadoop_dev/hadoop2/`):

a. `bin/hadoop` (running this command should prompt you with various options)

9. This finishes the Hadoop setup in stand-alone mode.

10. Let us run a sample hadoop programs that is provided to you in the download package:

`$ mkdir input` (create the input directory)

`$ cp etc/hadoop/*.*xml`
`input` (copy over all the xml files to input folder)

`$ bin/hadoop jar share/hadoop/mapreduce/hadoop-mapreduce-examples-2.7.0.jar grep input output 'dfs[a-z.]+'` (grep/find all the files matching the pattern ‘dfs[a-z.]+' and copy those files to output directory)

`$ cat output/*` (look for the output in the output directory that Hadoop creates for you).

Steps for Installation

1. Edit the file /home/Hadoop_dev/hadoop2/etc/hadoop/core-site.xml as below:

```
<configuration>
  <property>
    <name>fs.defaultFS</name>
    <value>hdfs://localhost:9000</value>
  </property>
</configuration>
```

Note: This change sets the namenode ip and

port.

2. Edit the file /home/Hadoop_dev/hadoop2/etc/hadoop/hdfs-site.xml as below:

```
<configuration>
  <property>
    <name>dfs.replication</name>
    <value>1</value>
  </property>
</configuration>
```

Note: This change sets the default replication count for blocks used by HDFS.

3. We need to setup password less login so that the master will be able to do a password-less ssh to start the daemons on all the slaves.

Check if ssh server is running on your host or not:

- a. `ssh localhost` (enter your password and if you are able to login then ssh server is running)
- b. In step a. if you are unable to login, then install ssh as follows:

```
sudo apt-get install ssh
```

- c. Setup password less login as below:

- i. `ssh-keygen -t dsa -P '' -f ~/.ssh/id_dsa`
- ii. `cat ~/.ssh/id_dsa.pub >> ~/.ssh/authorized_keys`

4. We can run Hadoop jobs locally or on YARN in this mode. In this Post, we will focus on running the jobs **locally**.

5. Format the file system. When we format namenode it formats the meta-data related to data-

nodes. By doing that, all the information on the datanodes are lost and they can be reused for new data:

a. `bin/hdfs namenode -format`

6. Start the daemons

a. `sbin/start-dfs.sh` (Starts NameNode and DataNode)

You can check If NameNode has started successfully or not by using the following web interface: <http://0.0.0.0:50070> . If you are unable to see this, try to check the logs in the /home/hadoop_dev/hadoop2/logs folder.

7. You can check whether the daemons are running or not by issuing Jps command.

8. This finishes the installation of Hadoop in pseudo distributed mode.

9. Let us run the same example we can in the previous blog post:

i) Create a new directory on the hdfs

```
bin/hdfs dfs -mkdir -p /user/hadoop_dev
```

ii) Copy the input files for the program to hdfs:

```
bin/hdfs dfs -put etc/hadoop input
```

iii) Run the program:

```
bin/hadoop jar share/hadoop/mapreduce/  
hadoop-mapreduce-examples-2.6.0.jar grep  
input output 'dfs[a-z.]+'
```

iv) View the output on hdfs:

```
bin/hdfs dfs -cat output/*
```

10. Stop the daemons when you are done executing the jobs, with the below command:

```
sbin/stop-dfs.sh
```

Hadoop Installation – PsuedoDistributed Mode(YARN)

Steps for Installation

1. Edit the file /home/hadoop_dev/hadoop2/etc/hadoop/mapred-site.xml as below:

```
<configuration>  
  
<property>  
  
<name>mapreduce.framework.name</name>
```

```
<value>yarn</value>  
</property>  
</configuration>
```

2. Edit the file /home/hadoop_dev/hadoop2/etc/hadoop/yarn-site.xml as below:

```
<configuration>  
<property>  
<name>yarn.nodemanager.aux-services</name>  
<value>mapreduce_shuffle</value>  
</property>  
</configuration>
```

Note: This particular configuration tells

MapReduce how to do its shuffle. In this case it uses the mapreduce_shuffle.

3. Format the NameNode:

```
bin/hdfs namenode -format
```

4. Start the daemons using the command:

```
sbin/start-yarn.sh
```

This starts the daemons ResourceManager and NodeManager.

Once this command is run, you can check if ResourceManager is running or not by visiting the following URL on browser : <http://0.0.0.0:8088> . If you are unable to see this, check for the logs in the directory: /home/hadoop_dev/hadoop2/logs

5. To check whether the services are running, issue a jps command. The following shows all the services necessary to run YARN on a single server:

\$ jps

15933 Jps

15567 ResourceManager

15785 NodeManager

6. Let us run the same example as we ran before:

i) Create a new directory on the hdfs

```
bin/hdfs dfs -mkdir -p /user/hadoop_dev
```

ii) Copy the input files for the program to hdfs:

```
bin/hdfs dfs -put etc/hadoop input
```

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iii) Run the program:

```
bin/yarn jar share/hadoop/mapreduce/
hadoop-mapreduce-examples-2.6.0.jar grep
input output 'dfs[a-z.]+'
```

iv) View the output on hdfs:

```
bin/hdfs dfs -cat output/*
```

7. Stop the daemons when you are done executing the jobs, with the below command:

```
sbin/stop-yarn.sh
```

This completes the installation part of Hadoop.

2.File Management tasks in Hadoop

1. Create a directory in HDFS at given path(s).

Usage :

```
hadoop fs -mkdir <paths>
```

Example :

```
hadoop fs -mkdir /user/saurzcode/dir1 /user/saurzcode/dir2
```

2. List the contents of a directory.

Usage :

```
hadoop fs -ls <args>
```

Example :

```
hadoop fs -ls /user/saurzcode
```

3. Upload and download a file in HDFS.

Upload:

hadoop fs -put:

Copy single src file, or multiple src files from local file system to the Hadoop data file system

Usage:

```
hadoop fs -put <localsrc> ... <HDFS_dest_Path>
```

Example:

```
hadoop fs -put /home/saurzcode/Samplefile.txt /user/saurzcode/dir3/
```

Download:

hadoop fs -get:

Copies/Downloads files to the local file system

Usage:

```
hadoop fs -get <hdfs_src> <localdst>
```

Example:

```
hadoop fs -get /user/saurzcode/dir3/Samplefile.txt /home/
```

4. See contents of a file

Same as unix cat command:

Usage:

```
hadoop fs -cat <path[filename]>
```

Example:

```
hadoop fs -cat /user/saurzcode/dir1/abc.txt
```

5. Copy a file from source to destination

This command allows multiple sources as well in which case the destination must be a directory.

Usage:

```
hadoop fs -cp <source> <dest>
```

Example:

```
hadoop fs -cp /user/saurzcode/dir1/abc.txt /user/saurzcode/
dir2
```

6. Copy a file from/To Local filesystem to HDFS

copyFromLocal

Usage:

```
hadoop fs -copyFromLocal <localsrc> URI
```

Example:

```
hadoop fs -copyFromLocal /home/saurzcode/abc.txt /user/
saurzcode/abc.txt
```

Similar to put command, except that the source is restricted to a local file reference.

copyToLocal

Usage:

```
hadoop fs -copyToLocal [-ignorecrc] [-crc] URI <localdst>
```

Similar to get command, except that the destination is restricted to a local file reference.

7. Move file from source to destination.

Note:- Moving files across filesystem is not permitted.

Usage :

```
hadoop fs -mv <src> <dest>
```

Example:

```
hadoop fs -mv /user/saurzcode/dir1/abc.txt /user/saurzcode/  
dir2
```

8. Remove a file or directory inHDFS.

Remove files specified as argument. Deletes directory onlywhen it is empty

Usage :

```
hadoop fs -rm <arg>
```

Example:

```
hadoop fs -rm /user/saurzcode/dir1/abc.txt
```

Recursive version of delete.

Usage :

```
hadoop fs -rmr <arg>
```

Example:

```
hadoop fs -rmr /user/saurzcode/
```

9. Display last few lines of a file.

Similar to tail command in Unix.

Usage :

```
hadoop fs -tail <path[filename]>
```

Example:

```
hadoop fs -tail /user/saurzcode/dir1/abc.txt
```

10. Display the aggregate lengthof a file.

Usage :

```
hadoop fs -du <path>
```

Example:

```
hadoop fs -du /user/saurzcode/dir1/abc.txt
```

3. Word Count Map Reduce program to understand Map Reduce Paradigm

Source code:

```
import java.io.IOException;
import java.util.StringTokenizer;
import org.apache.hadoop.io.IntWritable;
import org.apache.hadoop.io.LongWritable;
import org.apache.hadoop.io.Text;
import org.apache.hadoop.mapreduce.Mapper;
import org.apache.hadoop.mapreduce.Reducer;
import org.apache.hadoop.conf.Configuration;
import org.apache.hadoop.mapreduce.Job;
import org.apache.hadoop.mapreduce.lib.input.TextInputFormat;
import org.apache.hadoop.mapreduce.lib.output.TextOutputFormat;
import org.apache.hadoop.mapreduce.lib.input.FileInputFormat;
import org.apache.hadoop.mapreduce.lib.output.FileOutputFormat;
import org.apache.hadoop.fs.Path;

public class WordCount
{
    public static class Map extends Mapper<LongWritable, Text, Text, IntWritable> {
        public void map(LongWritable key, Text value, Context context) throws
IOException, InterruptedException {
            String line = value.toString();
            StringTokenizer tokenizer = new StringTokenizer(line);
            while (tokenizer.hasMoreTokens()) {
                value.set(tokenizer.nextToken());
                context.write(value, new IntWritable(1));
            }
        }
    }

    public static class Reduce extends Reducer<Text, IntWritable, Text, IntWritable> {
        public void reduce(Text key, Iterable<IntWritable> values, Context context)
throws IOException, InterruptedException {
            int sum=0;
```

```

for(IntWritable x: values)
{
sum+=x.get();
}
context.write(key, new IntWritable(sum));
}

public static void main(String[] args) throws Exception {
Configuration conf= new Configuration();
Job job = new Job(conf, "My Word Count Program");
job.setJarByClass(WordCount.class);
job.setMapperClass(Map.class);
job.setReducerClass(Reduce.class);
job.setOutputKeyClass(Text.class);
job.setOutputValueClass(IntWritable.class);
job.setInputFormatClass(TextInputFormat.class);
job.setOutputFormatClass(TextOutputFormat.class);
Path outputPath = new Path(args[1]);
//Configuring the input/output path from the filesystem into the job
FileInputFormat.addInputPath(job, new Path(args[0]));
FileOutputFormat.setOutputPath(job, new Path(args[1]));
//deleting the output path automatically from hdfs so that we don't have to
delete it explicitly
outputPath.getFileSystem(conf).delete(outputPath);
//exiting the job only if the flag value becomes false
System.exit(job.waitForCompletion(true) ? 0 : 1);
}
}

```

The entire MapReduce program can be fundamentally divided into three parts:

- Mapper Phase Code
- Reducer Phase Code
- Driver Code

We will understand the code for each of these three partssequentially.

Mapper code:

```
public static class Map extends  
Mapper<LongWritable,Text,Text,IntWritable> {  
  
    public void map(LongWritable key, Text value, Context context) throws  
    IOException,InterruptedException {  
  
        String line = value.toString();  
        StringTokenizer tokenizer = new StringTokenizer(line);  
        while (tokenizer.hasMoreTokens()) {  
            value.set(tokenizer.nextToken());  
            context.write(value, new IntWritable(1));  
        }  
    }  
}
```

- We have created a class Map that extends the class Mapper which is already defined in the MapReduce Framework.
- We define the data types of input and output key/value pair after the class declaration using angle brackets.
- Both the input and output of the Mapper is a key/value pair.
- Input:
 - The key is nothing but the offset of each line in the text file:LongWritable
 - The value is each individual line (as shown in the figure at the right): Text

- Output:
 - The key is the tokenized words: Text
 - We have the hardcoded value in our case which is 1: IntWritable
 - Example – Dear 1, Bear 1, etc.
- We have written a java code where we have tokenized each word and assigned them a hardcoded value equal to 1.

Reducer Code:

```
public static class Reduce extends
Reducer<Text, IntWritable, Text, IntWritable> {

    public void reduce(Text key, Iterable<IntWritable> values, Context
context)
    throws IOException, InterruptedException {

        int sum=0;
        for(IntWritable x: values)
        {
            sum+=x.get();
        }
        context.write(key, new IntWritable(sum));
    }
}
```

- We have created a class Reduce which extends class Reducer like that of Mapper.
- We define the data types of input and output key/value pair after the class declaration using angle brackets as done for Mapper.

- Both the input and the output of the Reducer is a key-value pair.
- Input:
 - The key nothing but those unique words which have been generated after the sorting and shuffling phase: Text
 - The value is a list of integers corresponding to each key: IntWritable
 - Example – Bear, [1, 1], etc.
- Output:
 - The key is all the unique words present in the input text file: Text
 - The value is the number of occurrences of each of the unique words: IntWritable
 - Example – Bear, 2; Car, 3, etc.
- We have aggregated the values present in each of the list corresponding to each key and produced the final answer.
- In general, a single reducer is created for each of the unique words, but, you can specify the number of reducer in mapred-site.xml.

Driver Code:

```
Configuration conf= new Configuration();
Job job = new Job(conf,"My Word Count Program");
job.setJarByClass(WordCount.class);
job.setMapperClass(Map.class);
job.setReducerClass(Reduce.class);
job.setOutputKeyClass(Text.class);

job.setOutputValueClass(IntWritable.class);
job.setInputFormatClass(TextInputFormat.class);
job.setOutputFormatClass(TextOutputFormat.class);
Path outputPath = new Path(args[1]);

//Configuring the input/output path from the filesystem into the job
FileInputFormat.addInputPath(job, new Path(args[0]));
FileOutputFormat.setOutputPath(job, new Path(args[1]));
```

- In the driver class, we set the configuration of our MapReduce job to run in Hadoop.
- We specify the name of the job , the data type of input/ output of the mapper and reducer.
- We also specify the names of the mapper and reducer classes.
- The path of the input and output folder is also specified.
- The method setInputFormatClass () is used for specifying that how a Mapper will read the input data or what will be the unit of work. Here, we have chosen TextInputFormat so that single line is read by the mapper at a time from the input text file.

- The main () method is the entry point for the driver. In this method, we instantiate a new Configuration object for the job.

Run the MapReduce code:

The command for running a MapReduce code is:

```
hadoop jar hadoop-mapreduce-example.jar WordCount /  
sample/input /sample/output
```

- 4.** Weather Report POC-Map Reduce Program to analyse time-temperaturestatistics and generate report with max/min temperature.

Problem Statement:

1. The system receives temperatures of various cities(Austin, Boston,etc) of USA captured at regular intervals of time on each day in an input file.
2. System will process the input data file and generates a report with Maximum and Minimum temperatures of each day along with time.
3. Generates a separate output report for each city.

Ex: Austin-r-00000

Boston-r-00000

Newjersy-r-00000

Baltimore-r-00000

California-r-00000

Newyork-r-00000

Expected output:- In each output file record should be like this:

25-Jan-2014 Time: 12:34:542 MinTemp: -22.3 Time: 05:12:345 MaxTemp: 35.7

First **download input file** which contains temperature statistics with time for multiple cities. Schema of record set : CA_25-Jan-2014 00:12:345 15.7
01:19:345 23.1 02:34:542 12.3

CA is city code, here it stands for California followed by date. After that each pair of values represent time and temperature.

Mapper class and map method:-

The very first thing which is required for any map reduce problem is to understand what will be the type of keyIn, ValueIn, KeyOut, ValueOut for the given Mapper class and followed by type of map method parameters.

- public class WhetherForcastMapper extends Mapper<Object, Text, Text, Text>
- Object (keyIn) - Offset for each line, line number 1, 2...
- Text (ValueIn) - Whole string for each line (CA_25-Jan-2014 00:12:345))

- Text (KeyOut) - City information with date information as string
- Text (ValueOut) - Temperature and time information which need to be passed to reducer as string.
- public void map(Object keyOffset, Text dayReport, Context con) {}
- *KeyOffset* is like line number for each line in input file.
- *dayreport* is input to map method - whole string present in one line of input file.
- *con* is context where we write mapper output and it is used by reducer.

Reducer class and reducer method:-

Similarly,we have to decide what will be the type of keyIn, ValueIn, KeyOut,ValueOut for the given Reducer class and followed by type of reducer method parameters.

- public class WhetherForcastReducer extends Reducer<Text, Text, Text, Text>
- Text(keyIn) - it is same as keyOut of Mapper.
- Text(ValueIn)- it is same as valueOut of Mapper.
- Text(KeyOut)- date as string
- text(ValueOut) - reducer writes max and min temperature with time as string
- public void reduce(Text key, Iterable<Text> values, Context context)
- Text key is value of mapper output. i.e:- City & date information
- Iterable<Text> values - values stores multiple temperature values for a given city and date.
- context object is where reducer write it's processed outcome and finally written in file.

MultipleOutputs :- In general, reducer generates output file(i.e: part_r_0000), however in this use case we want to generate multiple output files. In order to deal with such scenario we need to use MultipleOutputs of "org.apache.hadoop.mapreduce.lib.output.MultipleOutputs" which provides a way to write multiple file depending on reducer outcome. See below reducer class for more details. For each reducer task multipleoutput object is created and key/result is written to appropriate file.

Lets **create a Map/Reduce project in eclipse** and create a class file name it as CalculateMaxAndMinTemeratureWithTime. For simplicity,here we have written mapper and reducer class as inner static class. Copy following code lines and paste in newly created class file.

```
/**
```

```

* Question:- To find Max and Min temperature from
record set stored in
*           text file. Schema of record set :- tab
separated (\t) CA_25-Jan-2014
*           00:12:345 15.7 01:19:345 23.1 02:34:542
12.3 03:12:187 16 04:00:093
*           -14 05:12:345 35.7 06:19:345 23.1 07:34:542
12.3 08:12:187 16
*           09:00:093 -7 10:12:345 15.7 11:19:345 23.1
12:34:542 -22.3 13:12:187
*           16 14:00:093 -7 15:12:345 15.7 16:19:345
23.1 19:34:542 12.3
*           20:12:187 16 22:00:093 -7
* Expected output:- Creates files for each city and
store maximum & minimum
*                           temperature for each day along
with time.
*/

```

```

import java.io.IOException;
import java.util.StringTokenizer;

import org.apache.hadoop.io.Text;
import org.apache.hadoop.mapreduce.Mapper;
import org.apache.hadoop.mapreduce.Reducer;
import
org.apache.hadoop.mapreduce.lib.output.MultipleOutput
s;
import org.apache.hadoop.conf.Configuration;
import org.apache.hadoop.fs.Path;
import org.apache.hadoop.mapreduce.Job;
import
org.apache.hadoop.mapreduce.lib.input.FileInputFormat
;

```

```

import org.apache.hadoop.mapreduce.lib.output.FileOutputFormat;
import org.apache.hadoop.mapreduce.lib.output.TextOutputFormat;

/**
 * @author devinline
 */

public class CalculateMaxAndMinTemeratureWithTime {
    public static String calOutputName =
        "California";
    public static String nyOutputName = "Newyork";
    public static String njOutputName = "Newjersy";
    public static String ausOutputName = "Austin";
    public static String bosOutputName = "Boston";
    public static String balOutputName =
        "Baltimore";

    public static class WhetherForcastMapper extends
        Mapper<Object, Text, Text, Text> {

        public void map(Object keyOffset, Text dayReport, Context con)
            throws IOException, InterruptedException {
            StringTokenizer strTokens = new
                StringTokenizer(
                    dayReport.toString(), "\t");
            int counter = 0;
            Float currnetTemp = null;
            Float minTemp = Float.MAX_VALUE;
            Float maxTemp = Float.MIN_VALUE;
            String date = null;

```

```

String currentTime = null;
String minTempANDTime = null;
String maxTempANDTime = null;

while (strTokens.hasMoreElements()) {
    if (counter == 0) {
        date = strTokens.nextToken();
    } else {
        if (counter % 2 == 1) {
            currentTime = strTokens.nextToken();
        } else {
            currnetTemp =
Float.parseFloat(strTokens.nextToken());
            if (minTemp > currnetTemp) {
                minTemp = currnetTemp;
                minTempANDTime = minTemp + "AND" +
currentTime;
            }
            if (maxTemp < currnetTemp) {
                maxTemp = currnetTemp;
                maxTempANDTime = maxTemp + "AND" +
currentTime;
            }
        }
        counter++;
    }
    // Write to context - MinTemp, MaxTemp and
corresponding time
    Text temp = new Text();
    temp.set(maxTempANDTime);
    Text dateText = new Text();
    dateText.set(date);
}

```

```
try {
    con.write(dateText, temp);
} catch (Exception e) {
    e.printStackTrace();
}

temp.set(minTempANDTime);
dateText.set(date);
con.write(dateText, temp);

}

public static class WhetherForcastReducer extends
    Reducer<Text, Text, Text, Text> {
    MultipleOutputs<Text, Text> mos;

    public void setup(Context context) {
        mos = new MultipleOutputs<Text,
Text>(context);
    }

    public void reduce(Text key, Iterable<Text>
values, Context context)
        throws IOException, InterruptedException {
        int counter = 0;
        String reducerInputStr[] = null;
        String f1Time = "";
        String f2Time = "";
        String f1 = "", f2 = "";
        Text result = new Text();
        for (Text value : values) {
```

```

    if (counter == 0) {
        reducerInputStr =
value.toString().split("AND");
        f1 = reducerInputStr[0];
        f1Time = reducerInputStr[1];
    }

else {
    reducerInputStr =
value.toString().split("AND");
    f2 = reducerInputStr[0];
    f2Time = reducerInputStr[1];
}

counter = counter + 1;
}

if (Float.parseFloat(f1) >
Float.parseFloat(f2)) {

    result = new Text("Time: " + f2Time + "
MinTemp: " + f2 + "\t"
    + "Time: " + f1Time + " MaxTemp: " + f1);
} else {

    result = new Text("Time: " + f1Time + "
MinTemp: " + f1 + "\t"
    + "Time: " + f2Time + " MaxTemp: " + f2);
}

String fileName = '';
if (key.toString().substring(0, 2).equals("CA")) {

    fileName =
CalculateMaxAndMinTemeratureTime.calOutputName;
}

```

```

    } else if (key.toString().substring(0,
2).equals("NY")) {
    fileName =
CalculateMaxAndMinTemeratureTime.nyOutputName;
} else if (key.toString().substring(0,
2).equals("NJ")) {
    fileName =
CalculateMaxAndMinTemeratureTime.njOutputName;
} else if (key.toString().substring(0,
3).equals("AUS")) {
    fileName =
CalculateMaxAndMinTemeratureTime.ausOutputName;
} else if (key.toString().substring(0,
3).equals("BOS")) {
    fileName =
CalculateMaxAndMinTemeratureTime.bosOutputName;
} else if (key.toString().substring(0,
3).equals("BAL")) {
    fileName =
CalculateMaxAndMinTemeratureTime.balOutputName;
}
String strArr[] = key.toString().split("_");
key.set(strArr[1]); //Key is date value
mos.write(fileName, key, result);
}

```

```

@Override
public void cleanup(Context context) throws
IOException,
    InterruptedException {
    mos.close();
}
}

```

```
public static void main(String[] args) throws  
IOException,  
    ClassNotFoundException,  
InterruptedException {  
    Configuration conf = new Configuration();  
    Job job = Job.getInstance(conf, "Wheather  
Statistics of USA");  
  
    job.setJarByClass(CalculateMaxAndMinTemeratureW  
ithTime.class);  
  
    job.setMapperClass(WhetherForcastMapper.class);  
  
    job.setReducerClass(WhetherForcastReducer.class)  
;  
  
    job.setMapOutputKeyClass(Text.class);  
    job.setMapOutputValueClass(Text.class);  
  
    job.setOutputKeyClass(Text.class);  
    job.setOutputValueClass(Text.class);  
  
    MultipleOutputs.addNamedOutput(job,  
calOutputName,  
        TextOutputFormat.class, Text.class,  
Text.class);  
    MultipleOutputs.addNamedOutput(job,  
nyOutputName,  
        TextOutputFormat.class, Text.class,  
Text.class);  
    MultipleOutputs.addNamedOutput(job,  
njOutputName,
```

```

    TextOutputFormat.class, Text.class,
Text.class);
    MultipleOutputs.addNamedOutput(job,
bosOutputName,
    TextOutputFormat.class, Text.class,
Text.class);
    MultipleOutputs.addNamedOutput(job,
ausOutputName,
    TextOutputFormat.class, Text.class,
Text.class);
    MultipleOutputs.addNamedOutput(job,
balOutputName,
    TextOutputFormat.class, Text.class,
Text.class);

// FileInputFormat.addInputPath(job, new
Path(args[0]));
// FileOutputFormat.setOutputPath(job, new
Path(args[1]));
Path pathInput = new Path(
  "hdfs://192.168.213.133:54310/weatherInputData/
input_temp.txt");
Path pathOutputDir = new Path(
  "hdfs://192.168.213.133:54310/user/hduser1/
testfs/output_mapred3");
FileInputFormat.addInputPath(job, pathInput);
FileOutputFormat.setOutputPath(job,
pathOutputDir);

try {
  System.exit(job.waitForCompletion(true) ? 0 :
1);
} catch (Exception e) {

```

```

    // TODO Auto-generated catch block
    e.printStackTrace();
}
}

}

```

Explanation:-

In **map method**, we are parsing each input line and maintains a counter for extracting date and each temperature & time information. For a given input line, first extract date(counter ==0) and followed by alternatively extract time(counter%2==1) since time is on odd number position like (1,3,5...) and get temperature otherwise. Compare for max & min temperature and store it accordingly. Once while loop terminates for a given input line, write maxTempTime and minTempTime with date.

In **reduce method**, for each reducer task, setup method is executed and create MultipleOutput object. For a given key, we have two entry (maxtempANDTime and mintempANDTime). Iterate values list , split value and get temperature & time value. Compare temperature value and create actual value sting which reducer write in appropriate file.

In **main method**, a instance of Job is created with Configuration object. Job is configured with mapper, reducer class and along with input and output format. MultipleOutputs information added to Job to indicate file name to be used with input format. For this sample program, we are using input file("/weatherInputData/input_temp.txt") placed on HDFS and output directory (/user/hduser1/testfs/output_mapred5) will be also created on HDFS. Refer below command to copy downloaded input file from local file system to HDFS and give write permission to client who is executing this program unit so that output directory can be created.

Copy a input file form local file system to HDFS

```
hduser1@ubuntu:/usr/local/hadoop2.6.1/bin$ ./hadoop
fs -put /home/zytham/input_temp.txt /
weatherInputData/
```

Give write permission to all user for creating output directory

```
hduser1@ubuntu:/usr/local/hadoop2.6.1/bin$ ./hadoop
fs -chmod -R 777 /user/hduser1/testfs/
```

Before executing above program unit make sure hadoop services are running(to start all service execute ./start-all.sh from <hadoop_home>/sbin).

Now execute above sample program. Run -> Run as hadoop. Wait for a moment and check whether output directory is in place on HDFS. Execute following command to verify the same.

```
hduser1@ubuntu:/usr/local/hadoop2.6.1/bin$ ./hadoop
fs -ls /user/hduser1/testfs/output_mapred3
Found 8 items
-rw-r--r-- 3 zytham supergroup          438
2015-12-11 19:21 /user/hduser1/testfs/output_mapred3/
Austin-r-00000
-rw-r--r-- 3 zytham supergroup          219
2015-12-11 19:21 /user/hduser1/testfs/output_mapred3/
Baltimore-r-00000
-rw-r--r-- 3 zytham supergroup          219
2015-12-11 19:21 /user/hduser1/testfs/output_mapred3/
Boston-r-00000
-rw-r--r-- 3 zytham supergroup          511
2015-12-11 19:21 /user/hduser1/testfs/output_mapred3/
California-r-00000
-rw-r--r-- 3 zytham supergroup          146
2015-12-11 19:21 /user/hduser1/testfs/output_mapred3/
Newjersy-r-00000
-rw-r--r-- 3 zytham supergroup          219
2015-12-11 19:21 /user/hduser1/testfs/output_mapred3/
Newyork-r-00000
-rw-r--r-- 3 zytham supergroup          0
2015-12-11 19:21 /user/hduser1/testfs/output_mapred3/
_SUCCESS
-rw-r--r-- 3 zytham supergroup          0
2015-12-11 19:21 /user/hduser1/testfs/output_mapred3/
part-r-00000
```

Open one of the file and verify expected output schema, execute following command for the same.

```
hduser1@ubuntu:/usr/local/hadoop2.6.1/bin$ ./hadoop
fs -cat /user/hduser1/testfs/output_mapred3/
Austin-r-00000
25-Jan-2014 Time: 12:34:542 MinTemp: -22.3 Time:      54
05:12:345 MaxTemp: 35.7
```

```
26-Jan-2014 Time: 22:00:093 MinTemp: -27.0 Time:  
05:12:345 MaxTemp: 55.7  
27-Jan-2014 Time: 02:34:542 MinTemp: -22.3 Time:  
05:12:345 MaxTemp: 55.7  
29-Jan-2014 Time: 14:00:093 MinTemp: -17.0 Time:  
02:34:542 MaxTemp: 62.9  
30-Jan-2014 Time: 22:00:093 MinTemp: -27.0 Time:  
05:12:345 MaxTemp: 49.2  
31-Jan-2014 Time: 14:00:093 MinTemp: -17.0 Time:  
03:12:187 MaxTemp: 56.0
```

Note:-

- In order to reference input file from local file system instead of HDFS, uncomment below lines in main method and comment below added addInputPath and setOutputPath lines. Here Path(args[0]) and Path(args[1]) **read input and output location path from program arguments**. OR create path object with sting input of input file and output location.
`// FileInputFormat.addInputPath(job, new Path(args[0]));
// FileOutputFormat.setOutputPath(job, new Path(args[1]));`

Execute WeatherReportPOC.jar on single node cluster

We can create jar file out of this project and run on single node cluster too. **Download WeatherReportPOC jar** and place at some convenient location. Start hadoop services(./start-all.sh from <hadoop_home>/sbin). I have placed jar at "/home/zytham/Downloads/WeatherReportPOC.jar". Execute following command to submit job with input file HDFS location is "/wheatherInputData/input_temp.txt" and output directory location is "/user/hduser1/testfs/output_mapred7"

```
hduser1@ubuntu:/usr/local/hadoop2.6.1/bin$ ./hadoop  
jar /home/zytham/Downloads/  
WeatherReportPOC.jar
```

CalculateMaxAndMinTemeratureWithTime /

**wheatherInputData/input_temp.txt /user/hduser1/
testfs/output_mapred7**

```
15/12/11 22:16:12 INFO Configuration.deprecation: 55  
session.id is deprecated. Instead, use  
dfs.metrics.session-id
```

```
15/12/11 22:16:12 INFO jvm.JvmMetrics: Initializing
JVM Metrics with processName=JobTracker, sessionId=
15/12/11 22:16:14 WARN mapreduce.JobResourceUploader:
Hadoop command-line option parsing not performed.
Implement the Tool interface and execute your
application with ToolRunner to remedy this.
.....
15/12/11 22:16:26 INFO output.FileOutputCommitter:
Saved output of task
'attempt_local1563851561_0001_r_000000_0' to hdfs://
hostname:54310/user/hduser1/testfs/output_mapred7/
_temporary/0/task_local1563851561_0001_r_000000
15/12/11 22:16:26 INFO mapred.LocalJobRunner: reduce
> reduce
15/12/11 22:16:26 INFO mapred.Task: Task
'attempt_local1563851561_0001_r_000000_0' done.
15/12/11 22:16:26 INFO mapred.LocalJobRunner:
Finishing task:
attempt_local1563851561_0001_r_000000_0
15/12/11 22:16:26 INFO mapred.LocalJobRunner: reduce
task executor complete.
15/12/11 22:16:26 INFO mapreduce.Job: map 100%
reduce 100%
15/12/11 22:16:27 INFO mapreduce.Job: Job
job_local1563851561_0001 completed successfully
15/12/11 22:16:27 INFO mapreduce.Job: Counters: 38
.....
```

5. Implementing Matrix Multiplication with Hadoop Map Reduce

```
import java.io.IOException;
import java.util.*;
import java.util.AbstractMap.SimpleEntry;
import java.util.Map.Entry;

import org.apache.hadoop.fs.Path;
import org.apache.hadoop.conf.*;
import org.apache.hadoop.io.*;
import org.apache.hadoop.mapreduce.*;
import org.apache.hadoop.mapreduce.lib.input.FileInputFormat;
import org.apache.hadoop.mapreduce.lib.input.TextInputFormat;
import org.apache.hadoop.mapreduce.lib.output.FileOutputFormat;
import org.apache.hadoop.mapreduce.lib.output.TextOutputFormat;

public class TwoStepMatrixMultiplication {

    public static class Map extends Mapper<LongWritable, Text,
Text, Text> {
        public void map(LongWritable key, Text value, Context
context) throws IOException, InterruptedException {
            String line = value.toString();
            String[] indicesAndValue = line.split(",");
            Text outputKey = new Text();
            Text outputValue = new Text();
            if (indicesAndValue[0].equals("A")) {
                outputKey.set(indicesAndValue[2]);
                outputValue.set("A," + indicesAndValue[1] + "," +
indicesAndValue[3]);
                context.write(outputKey, outputValue);
            } else {
                outputKey.set(indicesAndValue[1]);
                outputValue.set("B," + indicesAndValue[2] + "," +
indicesAndValue[3]);
                context.write(outputKey, outputValue);
            }
        }
    }

    public static class Reduce extends Reducer<Text, Text, Text,
Text> {
        public void reduce(Text key, Iterable<Text> values,
Context context) throws IOException, InterruptedException {
            String[] value;
            ArrayList<Entry<Integer, Float>> listA = new
ArrayList<Entry<Integer, Float>>();
```

```

        ArrayList<Entry<Integer, Float>> listB = new
ArrayList<Entry<Integer, Float>>();
        for (Text val : values) {
            value = val.toString().split(",");
            if (value[0].equals("A")) {
                listA.add(new SimpleEntry<Integer,
Float>(Integer.parseInt(value[1]), Float.parseFloat(value[2])));
            } else {
                listB.add(new SimpleEntry<Integer,
Float>(Integer.parseInt(value[1]), Float.parseFloat(value[2])));
            }
        }
        String i;
        float a_ij;
        String k;
        float b_jk;
        Text outputValue = new Text();
        for (Entry<Integer, Float> a : listA) {
            i = Integer.toString(a.getKey());
            a_ij = a.getValue();
            for (Entry<Integer, Float> b : listB) {
                k = Integer.toString(b.getKey());
                b_jk = b.getValue();
                outputValue.set(i + "," + k + "," +
Float.toString(a_ij*b_jk));
                context.write(null, outputValue);
            }
        }
    }

public static void main(String[] args) throws Exception {
    Configuration conf = new Configuration();

    Job job = new Job(conf,
"MatrixMatrixMultiplicationTwoSteps");
    job.setJarByClass(TwoStepMatrixMultiplication.class);
    job.setOutputKeyClass(Text.class);
    job.setOutputValueClass(Text.class);

    job.setMapperClass(Map.class);
    job.setReducerClass(Reduce.class);

    job.setInputFormatClass(TextInputFormat.class);
    job.setOutputFormatClass(TextOutputFormat.class);

    FileInputFormat.addInputPath(job, new Path("hdfs://
127.0.0.1:9000/matrixin"));
    FileOutputFormat.setOutputPath(job, new Path("hdfs:// 58
127.0.0.1:9000/matrixout"));

    job.waitForCompletion(true);
}

```

```
    }  
}
```

6. Pig Latin scripts to sort,group,join,project, and filter your data.

ORDER BY

Sorts a relation based on one or more fields.

Syntax

```
alias = ORDER alias BY { * [ASC|DESC] | field_alias [ASC|DESC] [,  
field_alias [ASC|DESC] ...] } [PARALLEL n];
```

Terms

alias	The name of a relation.
*	The designator for a tuple.
field_alias	A field in the relation. The field must be a simple type.
ASC	Sort in ascending order.
DESC	Sort in descending order.
PARALLEL n	Increase the parallelism of a job by specifying the number of reduce tasks, n. For more information, see Use the Parallel Features .

Usage

Note: ORDER BY is NOT stable; if multiple records have the same ORDER BY key, the order in which these records are returned is not defined and is not guaranteed to be the same from one run to the next.

In Pig, relations are unordered (see [Relations, Bags, Tuples, Fields](#)):

- If you order relation A to produce relation X (X = ORDER A BY * DESC;) relations A and X still contain the same data.
- If you retrieve relation X (DUMP X;) the data is guaranteed to be in the order you specified (descending).

- However, if you further process relation X (`Y = FILTER X BY $0 > 1;`) there is no guarantee that the data will be processed in the order you originally specified (descending).

Pig currently supports ordering on fields with simple types or by tuple designator (*). You cannot order on fields with complex types or by expressions.

```
A = LOAD 'mydata' AS (x: int, y: map[]);
B = ORDER A BY x; -- this is allowed because x is a simple
type
B = ORDER A BY y; -- this is not allowed because y is a
complex type
B = ORDER A BY y#'id'; -- this is not allowed because y#'id'
is an expression
```

Examples

Suppose we have relation A.

```
A = LOAD 'data' AS (a1:int,a2:int,a3:int);

DUMP A;
(1,2,3)
(4,2,1)
(8,3,4)
(4,3,3)
(7,2,5)
(8,4,3)
```

In this example relation A is sorted by the third field, f3 in descending order. Note that the order of the three tuples ending in 3 can vary.

```
X = ORDER A BY a3 DESC;

DUMP X;
(7,2,5)
(8,3,4)
(1,2,3)
(4,3,3)
(8,4,3)
(4,2,1)
```

RANK

Returns each tuple with the rank within a relation.

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Syntax

```
alias = RANK alias [ BY { * [ASC|DESC] | field_alias [ASC|DESC] [,  
field_alias [ASC|DESC] ...] } [DENSE] ];
```

Terms

alias	The name of a relation.
*	The designator for a tuple.
field_alias	A field in the relation. The field must be a simple type.
ASC	Sort in ascending order.
DESC	Sort in descending order.
DENSE	No gap in the ranking values.

Usage

When specifying no field to sort on, the RANK operator simply prepends a sequential value to each tuple.

Otherwise, the RANK operator uses each field (or set of fields) to sort the relation. The rank of a tuple is one plus the number of different rank values preceding it. If two or more tuples tie on the sorting field values, they will receive the same rank.

NOTE: When using the option **DENSE**, ties do not cause gaps in ranking values.

Examples

Suppose we have relation A.

```
A = load 'data' AS (f1:chararray,f2:int,f3:chararray);  
  
DUMP A;  
(David,1,N)  
(Tete,2,N)  
(Ranjit,3,M)  
(Ranjit,3,P)  
(David,4,Q)  
(David,4,Q)  
(Jillian,8,Q)  
(JaePak,7,Q)  
(Michael,8,T)  
(Jillian,8,Q)  
(Jose,10,V)
```

In this example, the RANK operator does not change the order of the relation and simply prepends to each tuple a sequential value.

```
B = rank A;
```

```
dump B;
(1,David,1,N)
(2,Tete,2,N)
(3,Ranjit,3,M)
(4,Ranjit,3,P)
(5,David,4,Q)
(6,David,4,Q)
(7,Jillian,8,Q)
(8,JaePak,7,Q)
(9,Michael,8,T)
(10,Jillian,8,Q)
(11,Jose,10,V)
```

In this example, the RANK operator works with f1 and f2 fields, and each one with different sorting order. RANK sorts the relation on these fields and prepends the rank value to each tuple. Otherwise, the RANK operator uses each field (or set of fields) to sort the relation. The rank of a tuple is one plus the number of different rank values preceding it. If two or more tuples tie on the sorting field values, they will receive the same rank.

```
C = rank A by f1 DESC, f2 ASC;
```

```
dump C;
(1,Tete,2,N)
(2,Ranjit,3,M)
(2,Ranjit,3,P)
(4,Michael,8,T)
(5,Jose,10,V)
(6,Jillian,8,Q)
(6,Jillian,8,Q)
(8,JaePak,7,Q)
(9,David,1,N)
(10,David,4,Q)
(10,David,4,Q)
```

Same example as previous, but DENSE. In this case there are no gaps in ranking values.

```
C = rank A by f1 DESC, f2 ASC DENSE;
```

```
dump C;
(1,Tete,2,N)
(2,Ranjit,3,M)
(2,Ranjit,3,P)
(3,Michael,8,T)
```

```
(4,Jose,10,V)
(5,Jillian,8,Q)
(5,Jillian,8,Q)
(6,JaePak,7,Q)
(7,David,1,N)
(8,David,4,Q)
(8,David,4,Q)
```

7. Hive Databases,Tables,Views,Functions and Indexes

Databases in Hive

The Hive concept of a database is essentially just

a *catalog* or *namespace* of tables. However, they are very useful for larger clusters with multiple teams and users, as a way of avoiding table name collisions. It's also common to use databases to organize production tables into logical groups.

If you don't specify a database, the `default` database is used.

The simplest syntax for creating a database is shown in the following example:

```
hive> CREATE DATABASE financials;
```

Hive will throw an error if `financials` already exists. You can suppress these warnings with this variation:

```
hive> CREATE DATABASE IF NOT EXISTS financials;
```

While normally you might like to be warned if a database of the same name already exists, the `IF NOT EXISTS` clause is useful for scripts that should create a database on-the-fly, if necessary, before proceeding.

You can also use the keyword `SCHEMA` instead of `DATABASE` in all the database-related commands.

At any time, you can see the databases that already exist as follows:

```
hive> SHOW DATABASES;
```

```
default
```

```
financials
```

```
hive> CREATE DATABASE human_resources;
```

```
hive> SHOW DATABASES;
```

```
default
```

```
financials
```

```
human_resources
```

If you have a lot of databases, you can restrict the ones listed using

a *regular expression*, a concept we'll explain in `LIKE` and `RLIKE`, if it is new to you. The following example lists only those databases that start with the letter `h` and end with any other characters (the `.*` part):

```
hive> SHOW DATABASES LIKE 'h.*';
```

```
human_resources
```

```
hive> ...
```

Hive will create a directory for each database. Tables in that

database will be stored in subdirectories of the database

directory. The exception is tables in the `default` database, which doesn't have its own directory.

The database directory is created under a top-level directory specified by the property `hive.metastore.warehouse.dir`, which we discussed in Local Mode Configuration and Distributed and Pseudodistributed Mode Configuration. Assuming you are using the default value for this property, `/user/hive/warehouse`, when the `financials` database is created, Hive will create the directory `/user/hive/warehouse/financials.db`. Note the `.db` extension.

You can override this default location for the new directory as shown in this example:

```
hive> CREATE DATABASE financials  
> LOCATION '/my/preferred/directory';
```

You can add a descriptive comment to the database, which will be shown by the `DESCRIBE DATABASE <database>` command.

```
hive> CREATE DATABASE financials  
> COMMENT 'Holds all financial tables';
```

```
hive> DESCRIBE DATABASE financials;  
financials    Holds all financial tables  
    hdfs://master-server/user/hive/warehouse/financials.db
```

Note that `DESCRIBE DATABASE` also shows the directory location for the database. In this example, the *URI scheme* is `hdfs`. For a MapR installation, it would be `maprfs`. For an Amazon Elastic MapReduce (EMR) cluster, it would also be `hdfs`, but you could set `hive.metastore.warehouse.dir` to use Amazon S3

explicitly (i.e., by specifying `s3n://bucketname/`...as the property value). You could use `s3` as the scheme, but the newer `s3n` is preferred.

In the output of `DESCRIBE DATABASE`, we're showing `master-server` to indicate the URI *authority*, in this case a DNS name and optional port number (i.e., `server:port`) for the “master node” of the filesystem (i.e., where the `NameNode` service is running for HDFS). If you are running in *pseudo-distributed* mode, then the master server will be `localhost`. For *local* mode, the path will be a local path, `file:///user/hive/warehouse/financials.db`.

If the authority is omitted, Hive uses the `master-server` name and port defined by the property `fs.default.name` in the Hadoop configuration files, found in the `$HADOOP_HOME/conf` directory.

To be clear, `hdfs:///user/hive/warehouse/financials.db` is equivalent to `hdfs://master-server/user/hive/warehouse/financials.db`, where `master-server` is your master node's DNS name and optional port.

For completeness, when you specify a *relative path* (e.g., `some/relative/path`), Hive will put this under your home directory in the distributed filesystem (e.g., `hdfs:///user/<user-name>`) for HDFS. However, if you are running in *local mode*, your current working directory is used as the parent of `some/relative/path`.

For script portability, it's typical to omit the authority, only specifying it when referring to another distributed filesystem instance (including S3 buckets).

Lastly, you can associate key-value properties with the database, although their only function currently is to provide a way of adding information to the output of `DESCRIBE DATABASE EXTENDED`

<database>:

```
hive> CREATE DATABASE financials
      > WITH DBPROPERTIES ('creator' = 'Mark Moneybags', 'date'
= '2012-01-02');

hive> DESCRIBE DATABASE financials;
financials    hdfs://master-server/user/hive/warehouse/
financials.db

hive> DESCRIBE DATABASE EXTENDED financials;
financials    hdfs://master-server/user/hive/warehouse/
financials.db

{date=2012-01-02, creator=Mark Moneybags};
```

The `USE` command sets a database as your working database, analogous to changing working directories in a filesystem:

```
hive> USE financials;
```

Now, commands such as `SHOW TABLES;` will list the tables in this database.

Unfortunately, there is no command to show you which database is your current working database!

Fortunately, it's always safe to repeat the `USE ...` command; there is no concept in Hive of nesting of databases.

Recall that we pointed out a useful trick in Variables and Properties for setting a property to print the current database aspart of the prompt (Hive v0.8.0 and later):

```
hive> set hive.cli.print.current.db=true;

hive (financials)> USE default;

hive (default)> set hive.cli.print.current.db=false;

hive> ...
```

Finally, you can drop a database:

```
hive> DROP DATABASE IF EXISTS financials;
```

The IF EXISTS is optional and suppresses warnings if financials doesn't exist.

By default, Hive won't permit you to drop a database if it contains tables. You can either drop the tables first or append

the CASCADE keyword to the command, which will cause the Hive to drop the tables in the database first:

```
hive> DROP DATABASE IF EXISTS financials CASCADE;
```

Using the RESTRICT keyword instead of CASCADE is equivalent to the default behavior, where existing tables must be dropped before dropping the database.

When a database is dropped, its directory is also deleted.

Alter Database

You can set key-value pairs in the DBPROPERTIES associated with a database using the ALTER DATABASE command. No other metadata about the database can be changed, including its name and directory location:

```
hive> ALTER DATABASE financials SET DBPROPERTIES ('edited-by' = 'Joe Dba');
```

There is no way to delete or “unset” a DBPROPERTY.

Creating Tables

The CREATE TABLE statement follows SQL conventions, but Hive’s version offers significant extensions to support a wide range of flexibility where the data files for tables are stored, the formats used, etc. We discussed many of these options in Text File Encoding of Data Values and we’ll return to more advanced options later

in Chapter 15. In this section, we describe the other options available for the CREATE TABLE statement, adapting

the employees table declaration we used previously in Collection Data Types:

```
CREATE TABLE IF NOT EXISTS mydb.employees (
    name          STRING COMMENT 'Employee name',
    salary        FLOAT   COMMENT 'Employee salary',
    subordinates ARRAY<STRING> COMMENT 'Names of subordinates',
    deductions    MAP<STRING, FLOAT>
                    COMMENT 'Keys are deductions names, values are'
```

```

address      STRUCT<street:STRING, city:STRING,
state:STRING, zip:INT>
              COMMENT 'Home address')

COMMENT 'Description of the table'
TBLPROPERTIES ('creator'='me', 'created_at'='2012-01-02
10:00:00', ...)
LOCATION '/user/hive/warehouse/mydb.db/employees';

```

First, note that you can prefix a database name, `mydb` in this case, if you're not currently working in the target database.

If you add the option `IF NOT EXISTS`, Hive will silently ignore the statement if the table already exists. This is useful in scripts that should create a table the first time they run.

However, the clause has a gotcha you should know. If the schema specified differs from the schema in the table that already exists, Hive won't warn you. If your intention is for this table to have the new schema, you'll have to drop the old table, losing your data, and then re-create it. Consider if you should use one or more `ALTER TABLE` statements to change the existing table schema instead.

See `Alter Table` for details.

WARNING

If you use `IF NOT EXISTS` and the existing table has a different schema than the schema in the `CREATE TABLE` statement, Hive will ignore the discrepancy.

You can add a comment to any column, after the type. Like databases, you can attach a comment to the table itself and you can define one or more table *properties*. In most cases, the primary benefit of `TBLPROPERTIES` is to add additional documentation in a key-value format. However, when we examine Hive's integration

with databases such as DynamoDB (see [DynamoDB](#)), we'll see that the `TBLPROPERTIES` can be used to express essential metadata about the database connection.

Hive automatically adds two table

properties: `last_modified_by` holds the username of the last user to modify the table, and `last_modified_time` holds the epoch time in seconds of that modification.

NOTE

A planned enhancement for Hive v0.10.0 is to add a `SHOW TBLPROPERTIES table_name` command that will list just the `TBLPROPERTIES` for a table.

Finally, you can optionally specify a location for the table data (as opposed to *metadata*, which the *metastore* will always hold). In this example, we are showing the default location that Hive would use, `/user/hive/warehouse/mydb.db/employees`, where `/user/hive/warehouse` is the default “warehouse” location (as discussed previously), `mydb.db` is the database directory, and `employees` is the table directory.

By default, Hive always creates the table's directory under the directory for the enclosing database.

The exception is

the *default* database. It doesn't have a directory under `/user/hive/warehouse`, so a table in the *default* database will have its directory created directly in `/user/hive/warehouse` (unless explicitly overridden).

NOTE

To avoid potential confusion, it's usually better to use an *external* table if you don't want to use the default location table. See [External Tables](#) for details.

You can also copy the schema (but not the data) of an existing table:

```
CREATE TABLE IF NOT EXISTS mydb.employees2
LIKE mydb.employees;
```

This version also accepts the optional `LOCATION` clause, but note that no other properties, including the schema, can be defined; they are determined from the original table.

The `SHOW TABLES` command lists the tables. With no additional arguments, it shows the tables in the current working database.

Let's assume we have already created a few other tables, `table1` and `table2`, and we did so in the `mydb` database:

```
hive> USE mydb;
hive> SHOW TABLES;
employees
table1
table2
```

If we aren't in the same database, we can still list the tables in that database:

```
hive> USE default;
hive> SHOW TABLES IN mydb;
employees
table1
table2
```

If we have a lot of tables, we can limit the ones listed using a *regular expression*, a concept we'll discuss in detail in LIKE and RLIKE:

```
hive> USE mydb;  
  
hive> SHOW TABLES 'empl.*';  
employees
```

Not all regular expression features are supported. If you know regular expressions, it's better to test a candidate regular expression to make sure it actually works!

The regular expression in the single quote looks for all tables with names starting with empl and ending with any other characters (the . * part).

NOTE

Using the IN database_name clause and a regular expression for the table names together is not supported.

We can also use the DESCRIBE EXTENDED

mydb.employees command to show details about the table. (We can drop the mydb. prefix if we're currently using the mydb database.) We have reformatted the output for easier reading and we have suppressed many details to focus on the items that interest us now:

```
hive> DESCRIBE EXTENDED mydb.employees;  
name      string   Employee name  
salary    float    Employee salary  
subordinates  array<string>  Names of subordinates  
deductions   map<string, float> Keys are deductions names,  
values are percentages
```

```
address struct<street:string,city:string,state:string,zip:int>
Home address
```

```
Detailed Table Information          Table(tableName:employees,
dbName:mydb, owner:me,
...
location:hdfs://master-server/user/hive/warehouse/mydb.db/
employees,
parameters:{creator=me, created_at='2012-01-02 10:00:00',
               last_modified_user=me,
last_modified_time=1337544510,
               comment:Description of the table, ...}, ...)
```

Replacing EXTENDEDwith FORMATTEDprovides more readable butalso more verbose output.

The first section shows the output

of DESCRIBE without EXTENDED or FORMATTED(i.e., the schema including the comments for each column).

If you only want to see the schema for a particular column, append the column to the table name. Here, EXTENDEDadds no additionaloutput:

```
hive> DESCRIBE mydb.employees.salary;
salary float Employee salary
```

Returning to the extended output, note the line in the description

that starts with location:. It shows the full URI path in HDFS tothe directory where Hive will keep all the data for this table, as we discussed above.

WARNING

We said that the `last_modified_by` and `last_modified_time` table properties are automatically created. However, they are only *shown* in the Detailed Table Information *if* a user-specified table property has also been defined!

Managed Tables

The tables we have created so far are called *managed* tables or sometimes called *internal* tables, because Hive controls the lifecycle of their data (more or less). As we've seen, Hive stores the data for these tables in a subdirectory under the directory defined

by `hive.metastore.warehouse.dir` (e.g.,`/user/hive/warehouse`), by default.

When we drop a managed table (see Dropping Tables), Hive deletes the data in the table.

However, managed tables are less convenient for sharing with other tools. For example, suppose we have data that is created and used primarily by *Pig* or other tools, but we want to run some queries against it, but not give Hive *ownership* of the data. We can define an *external* table that points to that data, but doesn't take ownership of it.

External Tables

Suppose we are analyzing data from the stock markets. Periodically, we ingest the data for NASDAQ and the NYSE from a source like Infochimps (<http://infochimps.com/datasets>) and we want to study this data with many tools. (See the data sets

named `infochimps_dataset_4777_download_16185` and `infochimps_dataset_4778_download_16677`, respectively, which are actually sourced from Yahoo! Finance.) The schema we'll use next matches the schemas of both these data sources. Let's assume the data files are in the distributed filesystem directory `/data/stocks`.

The following table declaration creates an *external* table that can read all the data files for this comma-delimited data in `/data/stocks`:

```
CREATE EXTERNAL TABLE IF NOT EXISTS stocks (
    exchange      STRING,
    symbol        STRING,
    ymd           STRING,
    price_open    FLOAT,
    price_high   FLOAT,
    price_low    FLOAT,
    price_close   FLOAT,
    volume        INT,
    price_adj_close FLOAT)
ROW FORMAT DELIMITED FIELDS TERMINATED BY ','
LOCATION '/data/stocks';
```

The `EXTERNAL` keyword tells Hive this table is external and the `LOCATION` ... clause is required to tell Hive where it's located.

Because it's external, Hive does not assume it *owns* the data. Therefore, dropping the table *does not* delete the data, although the *metadata* for the table will be deleted.

There are a few other small differences between managed and external tables, where some HiveQL constructs are not permitted for external tables. We'll discuss those when we come to them.

However, it's important to note that the differences between managed and external tables are smaller than they appear at first. Even for managed tables, you *know* where they are located, so you can use other tools, hadoop dfs commands, etc., to modify and even delete the files in the directories for managed tables. Hive may technically own these directories and files, but it doesn't have full control over them! Recall, in Schema on Read, we said that Hive really has no control over the integrity of the files used for storage and whether or not their contents are consistent with the table schema. Even managed tables don't give us this control.

Still, a general principle of good software design is to express intent. If the data is shared between tools, then creating an external table makes this ownership explicit.

You can tell whether or not a table is managed or external using the output of DESCRIBE EXTENDED tablename. Near the end of

the Detailed Table Information output, you will see the following for managed tables:

```
... tableType:MANAGED_TABLE)
```

For external tables, you will see the following:

```
... tableType:EXTERNAL_TABLE)
```

As for managed tables, you can also copy the schema (but not the data) of an existing table:

```
CREATE EXTERNAL TABLE IF NOT EXISTS mydb.employees3  
LIKE mydb.employees  
LOCATION '/path/to/data';
```

NOTE

If you omit the EXTERNAL keyword and the original table is external, the new table will also be external. If you omit EXTERNAL and the original table is managed, the new table will also be managed. However, if you include the EXTERNAL keyword and the original table is managed, the new table will be external. Even in this scenario, the LOCATION clause will still be optional.

Partitioned, Managed Tables

The general notion of partitioning data is an old one. It can take many forms, but often it's used for distributing load horizontally, moving data physically closer to its most frequent users, and other purposes.

Hive has the notion of partitioned tables. We'll see that they have important performance benefits, and they can help organize data in a logical fashion, such as hierarchically.

We'll discuss partitioned managed tables first. Let's return to our employees table and imagine that we work for a very large multinational corporation. Our HR people often run queries with WHERE clauses that restrict the results to a particular country or to a particular *first-level subdivision* (e.g., *state* in the United States or *province* in Canada). (First-level subdivision is an actual term, used here, for example: <http://www.commondatahub.com/>)

`state_source.jsp`.) We'll just use the word *state* for simplicity. We have redundant state information in the address field. It is distinct from the state partition. We could remove the `state` element from address. There is no ambiguity in queries, since we have to use `address.state` to project the value inside the address. So, let's partition the data first by country and then by state:

```
CREATE TABLE employees (
    name          STRING,
    salary        FLOAT, RING,  FLOAT>,
    subordinates  ARRAY<STRING>, STRING,  city:STRING,
    state:STRING,  zip:INT>
)
PARTITIONED BY (country STRING, state STRING);
```

Partitioning tables changes how Hive structures the data storage. If we create this table in the `mydb` database, there will still be

an *employees* directory for the table:

```
hdfs://master_server/user/hive/warehouse/mydb.db/employees
```

However, Hive will now create subdirectories reflecting the partitioning structure. For example:

```
...
.../employees/country=CA/state=AB
.../employees/country=CA/state=BC
...
.../employees/country=US/state=AL
.../employees/country=US/state=AK
...
```

Yes, those are the actual directory names. The state directories will contain zero or more files for the employees in those states.

Once created, the partition *keys* (`country` and `state`, in this case) behave like regular columns. There is one known exception, due to a bug (see Aggregate functions). In fact, users of the table don't need to *care* if these "columns" are partitions or not, except when they want to optimize query performance.

For example, the following query selects all employees in the state of Illinois in the United States:

```
SELECT * FROM employees  
WHERE country = 'US' AND state = 'IL';
```

Note that because the `country` and `state` values are encoded in directory names, there is no reason to have this data in the data files themselves. In fact, the data just gets in the way in the files, since you have to account for it in the table schema, and this data wastes space.

Perhaps the most important reason to partition data is for faster queries. In the previous query, which limits the results to employees in Illinois, it is only necessary to scan the contents of *one* directory. Even if we have thousands of country and state directories, all but one can be ignored. For very large data sets, partitioning can dramatically improve query performance, but *only* if the partitioning scheme reflects common *range* filtering (e.g., by locations, timestamp ranges).

When we add predicates to WHERE clauses that filter on partition values, these predicates are called *partition filters*.

Even if you do a query across the entire US, Hive only reads the 65 directories covering the 50 states, 9 territories, and the District of Columbia, and 6 military “states” used by the armed services. You can see the full list here: <http://www.50states.com/abbreviations.htm>.

Of course, if you need to do a query for all employees around the globe, you can still do it. Hive will have to read every directory, but hopefully these broader disk scans will be relatively rare.

However, a query across all partitions could trigger an enormous MapReduce job if the table data and number of partitions are large. A highly suggested safety measure is putting Hive into “strict” mode, which prohibits queries of partitioned tables without

a WHERE clause that filters on partitions. You can set the mode to “nonstrict,” as in the following session:

```
hive> set hive.mapred.mode=strict;

hive> SELECT e.name, e.salary FROM employees e LIMIT 100;
FAILED: Error in semantic analysis: No partition predicate
found for
Alias "e" Table "employees"

hive> set hive.mapred.mode=nonstrict;

hive> SELECT e.name, e.salary FROM employees e LIMIT 100;
John Doe 100000.0
...

```

You can see the partitions that exist with the SHOWPARTITIONS command:

```
hive> SHOW PARTITIONS employees;  
...  
Country=CA/state=AB  
country=CA/state=BC  
...  
country=US/state=AL  
country=US/state=AK  
...
```

If you have a lot of partitions and you want to see if partitions have been defined for particular partition keys, you can further restrict the command with an optional PARTITION clause that specifies one or more of the partitions with specific values:

```
hive> SHOW PARTITIONS employees PARTITION(country='US');  
country=US/state=AL  
country=US/state=AK  
...  
  
hive> SHOW PARTITIONS employees PARTITION(country='US',  
state='AK');  
country=US/state=AK
```

The DESCRIBE EXTENDED employees command shows the partition keys:

```
hive> DESCRIBE EXTENDED employees;  
name          string,  
salary        float,  
...  
address       struct<...>,  
country       string,  
state         string
```

Detailed **Table** Information...

```
partitionKeys:[FieldSchema(name:country, type:string,  
comment:null),
```

```
FieldSchema(name:state, type:string, comment:null) ] ,  
...
```

The schema part of the output lists the country and state with the other columns, because they are columns as far as queries are concerned. The Detailed Table Information includes the country and state as partition keys. The comments for both of these keys are null; we could have added comments just as for regular columns.

You create partitions in managed tables by loading data into them. The following example creates a US and CA (California) partition while loading data into it from a local directory, \${HOME}/california-employees. You must specify a value for each partition column. Notice how we reference the HOME environment variable in HiveQL:

```
LOAD DATA LOCAL INPATH '${env:HOME}/california-employees'  
INTO TABLE employees  
PARTITION (country = 'US', state = 'CA');
```

The directory for this partition, .../employees/country=US/

state=CA, will be created by Hive and all data files in \${HOME}/california-employees will be copied into it. See Loading Data into Managed Tables for more information on populating tables.

External Partitioned Tables

You can use partitioning with external tables. In fact, you may find that this is your most common scenario for managing large production data sets. The combination gives you a way to “share” data with other tools, while still optimizing query performance.

You also have more flexibility in the directory structure used, as you define it yourself. We'll see a particularly useful example in a moment.

Let's consider a new example that fits this scenario well: logfileanalysis. Most organizations use a standard format for log messages, recording a timestamp, severity (e.g., ERROR, WARNING, INFO), perhaps a server name and process ID, and then an arbitrary text message. Suppose our Extract, Transform, and Load (ETL) process ingests and aggregates logfiles in our environment, converting each log message to a tab-delimited record and also decomposing the timestamp into

separate year, month, and day fields, and a combined hms field for the remaining hour, minute, and second parts of the timestamp, for reasons that will become clear in a moment. You could do this parsing of log messages using the string parsing functions built into Hive or Pig, for example. Alternatively, we could use smaller integertypes for some of the timestamp-related fields to conserve space.

Here, we are ignoring subsequent resolution.

Here's how we might define the corresponding Hive table:

```
CREATE EXTERNAL TABLE IF NOT EXISTS log_messages (
    hms          INT,
    severity     STRING,
    server       STRING,
    process_id   INT,
    message      STRING)
PARTITIONED BY (year INT, month INT, day INT)
ROW FORMAT DELIMITED FIELDS TERMINATED BY '\t';
```

We're assuming that a day's worth of log data is about the correct size for a useful partition and finer grain queries over a day's data will be fast enough.

Recall that when we created the nonpartitioned

external `stocks` table, a `LOCATION ...` clause was required. It isn't used for external partitioned tables.

Instead, an `ALTER`

`TABLE` statement is used to add *each* partition separately. It must specify a value for each partition key, the `year`, `month`, and `day`, in this case (see `Alter Table` for more details on this feature). Here is an example, where we add a partition for January 2nd, 2012:

```
ALTER TABLE log_messages ADD PARTITION(year = 2012, month = 1,  
day = 2)  
LOCATION 'hdfs://master_server/data/log_messages/2012/01/02';
```

The directory convention we use is completely up to us. Here, we follow a hierarchical directory structure, because it's a logical way to organize our data, but there is no requirement to do so. We could follow Hive's directory naming convention (e.g., `.../exchange=NASDAQ/symbol=AAPL`), but there is no requirement to do so.

An interesting benefit of this flexibility is that we can archive old data on inexpensive storage, like Amazon's S3, while keeping newer, more "interesting" data in HDFS. For example, each day we might use the following procedure to move data older than a month to S3:

- Copy the data for the partition being moved to S3. For example, you can use the `hadoop distcp` command:

```
hadoop distcp /data/log_messages/2011/12/02  
s3n://ourbucket/logs/2011/12/02
```

- Alter the table to point the partition to the S3 location:
`ALTER TABLE log_messages PARTITION(year = 2011, month = 12, day = 2)`
- `SET LOCATION 's3n://ourbucket/logs/2011/01/02';`
- Remove the HDFS copy of the partition using the `hadoop fs -rmr` command:
`hadoop fs -rmr /data/log_messages/2011/01/02`

You don't have to be an Amazon Elastic MapReduce user to use S3 this way. S3 support is part of the Apache Hadoop distribution. You can *still* query this data, even queries that cross the month-old "boundary," where some data is read from HDFS and some data is read from S3!

By the way, Hive doesn't care if a partition directory doesn't exist for a partition or if it has no files. In both cases, you'll just get no results for a query that filters for the partition. This is convenient when you want to set up partitions before a separate process starts writing data to them. As soon as data is there, queries will return results from that data.

This feature illustrates another benefit: new data can be written to a dedicated directory with a clear distinction from older data in other

directories. Also, whether you move old data to an “archive” location or delete it outright, the risk of tampering with newer data is reduced since the data subsets are in separate directories.

As for nonpartitioned external tables, Hive does not own the data and it does not delete the data if the table is dropped.

As for managed partitioned tables, you can see an external table’s partitions with SHOW PARTITIONS:

```
hive> SHOW PARTITIONS log_messages;  
...  
year=2011/month=12/day=31  
year=2012/month=1/day=1  
year=2012/month=1/day=2  
...
```

Similarly, the DESCRIBE EXTENDED log_messages shows the partition keys both as part of the schema and in the list of partitionKeys:

```
hive> DESCRIBE EXTENDED log_messages;  
...  
message          string,  
year           int,  
month          int,  
day            int
```

Detailed **Table** Information...

```
partitionKeys:[FieldSchema(name:year, type:int, comment:null),  
FieldSchema(name:month, type:int, comment:null),  
FieldSchema(name:day, type:int, comment:null)],  
...
```

This output is missing a useful bit of information, the actual location of the partition data. There is a `location` field, but it only shows Hive's default directory that would be used if the table were a managed table. However, we can get a partition's location as follows:

```
hive> DESCRIBE EXTENDED log_messages PARTITION (year=2012,  
month=1, day=2);  
...  
location:s3n://ourbucket/logs/2011/01/02,  
...
```

We frequently use external partitioned tables because of the many benefits they provide, such as logical data management, performance queries, etc.

`ALTER TABLE ... ADD PARTITION` is not limited to external tables. You can use it with managed tables, too, when you have (or will have) data for partitions in directories created outside of the `LOAD` and `INSERT` options we discussed above. You'll need to remember that not all of the table's data will be under the usual Hive "warehouse" directory, and this data *won't* be deleted when you drop the managed table! Hence, from a "sanity" perspective, it's questionable whether you should dare to use this feature with managed tables.

Customizing Table Storage Formats

In Text File Encoding of Data Values, we discussed that Hive defaults to a text file format, which is indicated by the optional clause `STORED AS TEXTFILE`, and you can overload the default

values for the various delimiters when creating the table. Here we repeat the definition of the employees table we used in that discussion:

```
CREATE TABLE employees (
    name          STRING,
    salary        FLOAT,
    subordinates ARRAY<STRING>,
    deductions   MAP<STRING, FLOAT>,
    address       STRUCT<street:STRING, city:STRING,
state:STRING, zip:INT>
)
ROW FORMAT DELIMITED
FIELDS TERMINATED BY '\001'
COLLECTION ITEMS TERMINATED BY '\002'
MAP KEYS TERMINATED BY '\003'
LINES TERMINATED BY '\n'
STORED AS TEXTFILE;
```

TEXTFILE implies that all fields are encoded using alphanumeric characters, including those from international character sets, although we observed that Hive uses non-printing characters as “terminators” (delimiters), by default. When TEXTFILE is used, each line is considered a separate record.

You can replace TEXTFILE with one of the other built-in file formats supported by Hive, including SEQUENCEFILE and RCFILE, both of which optimize disk space usage and I/O bandwidth performance using binary encoding and optional compression. Hive draws a distinction between how records are encoded into files and how columns are encoded into records. You customize these behaviors separately.

The record encoding is handled by an *input format* object (e.g., the Java code behind TEXTFILE.) Hive uses a Java *class* (compiled module) named `org.apache.hadoop.mapred.TextInputForm` at. If you are unfamiliar with Java, the dotted name syntax indicates a hierarchical namespace tree of *packages* that actually corresponds to the directory structure for the Java code. The `lastname`, `TextInputFormat`, is a *class* in the lowest-level package `mapred`.

The record parsing is handled by a *serializer*/

deserializer or *SerDe* for short. For TEXTFILE and the encoding we described in Chapter 3 and repeated in the example above, the SerDe Hive uses is another Java class called `org.apache.hadoop.hive.serde2.lazy.LazySimpleSerDe`.

For completeness, there is also an *output format* that Hive uses for writing the output of queries to files and to the console.

For TEXTFILE, the Java

class named `org.apache.hadoop.hive.ql.io.HiveIgnoreKeyTextOutputFormat` is used for output.

NOTE

Hive uses an *input format* to split input streams into *records*, an *output format* to format records into output streams (i.e., the output of queries), and a *SerDe* to parse *records* into *columns*, when reading, and encodes *columns* into *records*, when writing. We'll explore these distinctions in greater depth in Chapter 15.

Third-party input and output formats and SerDes can be specified, a feature which permits users to customize Hive for a wide range of file formats not supported natively.

Here is a complete example that uses a custom SerDe, input format, and output format for files accessible through the *Avro* protocol, which we will discuss in detail in Avro Hive SerDe:

```
CREATE TABLE kst
PARTITIONED BY (ds string)
ROW FORMAT SERDE 'com.linkedin.haivvreo.AvroSerDe'
WITH SERDEPROPERTIES ('schema.url'='http://schema_provider/
kst.avsc')
STORED AS
INPUTFORMAT 'com.linkedin.haivvreo.AvroContainerInputFormat'
OUTPUTFORMAT
'com.linkedin.haivvreo.AvroContainerOutputFormat';
```

The `ROW FORMAT SERDE` ... specifies the SerDe to use. Hive provides the `WITH SERDEPROPERTIES` feature that allows users to pass configuration information to the SerDe. Hive knows nothing about the meaning of these properties. It's up to the SerDe to decide their meaning. Note that the name and value of each property must be a quoted string.

Finally, the `STORED AS INPUTFORMAT ... OUTPUTFORMAT` ... clause specifies the Java classes to use for the input and output formats, respectively. If you specify one of these formats, you are required to specify both of them.

Note that the `DESCRIBE EXTENDED table` command lists the input and output formats, the SerDe, and any SerDe properties in

the DETAILED TABLE INFORMATION. For our example, we would see the following:

```
hive> DESCRIBE EXTENDED kst
...
inputFormat:com.linkedin.haivvreo.AvroContainerInputFormat,
outputFormat:com.linkedin.haivvreo.AvroContainerOutputFormat,
...
serdeInfo:SerDeInfo(name:null,
serializationLib:com.linkedin.haivvreo.AvroSerDe,
parameters:{schema.url=http://schema_provider/kst.avsc})
...
```

Finally, there are a few additional CREATE TABLE clauses that describe more details about how the data is supposed to be stored. Let's extend our previous stocks table example from External Tables:

```
CREATE EXTERNAL TABLE IF NOT EXISTS stocks (
    exchange      STRING,
    symbol        STRING,
    ymd           STRING,
    price_open    FLOAT,
    price_high   FLOAT,
    price_low    FLOAT,
    price_close   FLOAT,
    volume        INT,
    price_adj_close FLOAT)
CLUSTERED BY (exchange, symbol)
SORTED BY (ymd ASC)
INTO 96 BUCKETS
ROW FORMAT DELIMITED FIELDS TERMINATED BY ','
LOCATION '/data/stocks';
```

The CLUSTERED BY ... INTO ... BUCKETS clause, with an optional SORTED BY ... clause is used to optimize certain kinds of queries, which we discuss in detail in Bucketing Table Data Storage.

Dropping Tables

The familiar DROP TABLE command from SQL is supported:

```
DROP TABLE IF EXISTS employees;
```

The IF EXISTS keywords are optional. If not used and the table doesn't exist, Hive returns an error.

For *managed* tables, the table metadata *and* data are deleted.

NOTE

Actually, if you enable the Hadoop Trash feature, which is *not* on by default, the data is moved to the *.Trash* directory in the distributed filesystem for the user, which in HDFS is */user/\$USER/.Trash*. To enable this feature, set the property `fs.trash.interval` to a reasonable positive number. It's the number of minutes between "trash checkpoints"; 1,440 would be 24 hours. While it's not guaranteed to work for all versions of all distributed filesystems, if you accidentally drop a managed table with important data, you may be able to re-create the table, re-create any partitions, and then move the files from *.Trash* to the correct directories (using the filesystem commands) to restore the data.

For *external* tables, the metadata is deleted *but* the data is not.

Alter Table

Most table properties can be altered with ALTER

TABLE statements, which change *metadata* about the table but not the data itself. These statements can be used to fix mistakes in

schema, move partition locations (as we saw in External PartitionedTables), and do other operations.

WARNING

ALTER TABLE modifies table metadata *only*. The data for the table is untouched. It's up to you to ensure that any modifications are consistent with the actual data.

Renaming a Table

Use this statement to rename the table log_messages to logmsgs:

```
ALTER TABLE log_messages RENAME TO logmsgs;
```

Adding, Modifying, and Dropping a Table Partition

As we saw previously, ALTER TABLE table ADD PARTITION ... is used to add a new partition to a table (usually an *external* table). Here we repeat the same command shown previously with the additional options available:

```
ALTER TABLE log messages ADD IF NOT EXISTS
PARTITION (year = 2011, month = 1, day = 1) LOCATION '/logs/
2011/01/01'
PARTITION (year = 2011, month = 1, day = 2) LOCATION '/logs/
2011/01/02'
PARTITION (year = 2011, month = 1, day = 3) LOCATION '/logs/
2011/01/03'
...;
```

Multiple partitions can be added in the same query when using Hivev0.8.0 and later. As always, IF NOT EXISTS is optional and has the usual meaning.

WARNING

Hive v0.7.X allows you to use the syntax with multiple partition specifications, but it actually uses just the *first* partition specification, silently ignoring the others! Instead, use a separate ALTER STATEMENT statement for each partition.

Similarly, you can change a partition location, effectively moving it:

```
ALTER TABLE log_messages PARTITION(year = 2011, month = 12,
day = 2)
SET LOCATION 's3n://ourbucket/logs/2011/01/02';
```

This command does not move the data from the old location, nor does it delete the old data.

Finally, you can drop a partition:

```
ALTER TABLE log_messages DROP IF EXISTS PARTITION(year = 2011,
month = 12, day = 2);
```

The IF EXISTS clause is optional, as usual. For managed tables, the data for the partition is *deleted*, along with the metadata, even if the partition was created using ALTER TABLE ... ADD PARTITION. For external tables, the data is not deleted.

There are a few more ALTER statements that affect partitions discussed later in Alter Storage Properties and Miscellaneous AlterTable Statements.

Changing Columns

You can rename a column, change its position, type, or comment:

```
ALTER TABLE log_messages
CHANGE COLUMN hms hours_minutes_seconds INT
```

```
COMMENT 'The hours, minutes, and seconds part of the  
timestamp'
```

```
AFTER severity;
```

You have to specify the old name, a new name, and the type, even if the name or type is not changing. The keyword COLUMN is optional as is the COMMENT clause. If you aren't moving the column, the AFTER other_column clause is not necessary. In the example shown, we move the column after the severity column. If you want to move the column to the first position, use FIRST instead of AFTER other_column.

As always, this command changes metadata only. If you are moving columns, the data must already match the new schema or you must change it to match by some other means.

Adding Columns

You can add new columns to the end of the existing columns, before any partition columns.

```
ALTER TABLE log_messages ADD COLUMNS (  
    app name STRING COMMENT 'Application name',  
    session id LONG COMMENT 'The current session id');
```

The COMMENT clauses are optional, as usual. If any of the new columns are in the wrong position, use an ALTER COLUMN table CHANGE COLUMN statement for each one to move it to the correct position.

Deleting or Replacing Columns

The following example removes *all* the existing columns and replaces them with the new columns specified:

```
ALTER TABLE log messages REPLACE COLUMNS (
    hours_mins_secs INT COMMENT 'hour, minute, seconds from
timestamp',
    severity         STRING COMMENT 'The message severity'
    message          STRING COMMENT 'The rest of the message');
```

This statement effectively renames the original `hms` column and removes the `server` and `process_id` columns from the original schema definition. As for all ALTER statements, only the table metadata is changed.

The REPLACE statement can only be used with tables that use one of the native SerDe modules: DynamicSerDe or MetadataTypedColumnsetSerDe. Recall that the SerDe determines how records are parsed into columns (deserialization) and how a record's columns are written to storage (serialization). See Chapter 15 for more detail on SerDes.

Alter Table Properties

You can add additional table properties or modify existing properties, but not remove them:

```
ALTER TABLE log_messages SET TBLPROPERTIES (
    'notes' = 'The process id is no longer captured; this column
is always NULL');
```

Alter Storage Properties

There are several ALTER TABLE statements for modifying format and SerDe properties.

The following statement changes the storage format for a partition to be SEQUENCEFILE, as we discussed in Creating

Tables (see Sequence Files and Chapter 15 for more information):

```
ALTER TABLE log_messages
PARTITION (year = 2012, month = 1, day = 1)
SET FILEFORMAT SEQUENCEFILE;
```

The PARTITION clause is required if the table is partitioned.

You can specify a new SerDe along with SerDe properties or change the properties for the existing SerDe.

The following example specifies that a table will use a Java class

named com.example.JSONSerDe to process a file of JSON-encoded records:

```
ALTER TABLE table_using_JSON_storage
SET SERDE 'com.example.JSONSerDe'
WITH SERDEPROPERTIES (
  'prop1' = 'value1',
  'prop2' = 'value2');
```

The SERDEPROPERTIES are passed to the SerDe module (the Java class com.example.JSONSerDe, in this case). Note that both the property names (e.g., prop1) and the values (e.g., value1) must be quoted strings.

The SERDEPROPERTIES feature is a convenient mechanism that SerDe implementations can exploit to permit user customization.

We'll see a real-world example of a JSON SerDe and how it uses SERDEPROPERTIES in JSON SerDe.

The following example demonstrates how to add new SERDEPROPERTIES for the current SerDe:

```
ALTER TABLE table_using_JSON_storage
SET SERDEPROPERTIES (
  'prop3' = 'value3',
  'prop4' = 'value4');
```

You can alter the storage properties that we discussed in CreatingTables:

```
ALTER TABLE stocks
CLUSTERED BY (exchange, symbol)
SORTED BY (symbol)
INTO 48 BUCKETS;
```

The SORTED BY clause is optional, but the CLUSTER BY and INTO ... BUCKETS are required. (See also Bucketing Table DataStorage for information on the use of data bucketing.)

Miscellaneous Alter Table Statements

In Execution Hooks, we'll discuss a technique for adding execution "hooks" for various operations. The ALTER TABLE ...

TOUCH statement is used to trigger these hooks:

```
ALTER TABLE log_messages TOUCH
PARTITION(year = 2012, month = 1, day = 1);
```

The PARTITION clause is required for partitioned tables. A typical scenario for this statement is to trigger execution of the hooks when table storage files have been modified outside of Hive. For example,

a script that has just written new files for the 2012/01/01 partition for `log_message` can make the following call to the Hive CLI:

```
hive -e 'ALTER TABLE log_messages TOUCH PARTITION(year = 2012,  
month = 1, day = 1);'
```

This statement won't create the table or partition if it doesn't already exist. Use the appropriate creation commands in that case.

The `ALTER TABLE ... ARCHIVE PARTITION` statement captures the partition files into a Hadoop archive (HAR) file. This only reduces the number of files in the filesystem, reducing the load on the *NameNode*, but doesn't provide any space savings (e.g., through compression):

```
ALTER TABLE log_messages ARCHIVE  
PARTITION(year = 2012, month = 1, day = 1);
```

To reverse the operation, substitute `UNARCHIVE` for `ARCHIVE`. This feature is only available for individual partitions of partitioned tables.

Finally, various protections are available. The following statements prevent the partition from being dropped and queried:

```
ALTER TABLE log_messages  
PARTITION(year = 2012, month = 1, day = 1) ENABLE NO_DROP;
```

```
ALTER TABLE log_messages  
PARTITION(year = 2012, month = 1, day = 1) ENABLE OFFLINE;
```

To reverse either operation, replace `ENABLE` with `DISABLE`. These operations also can't be used with nonpartitioned tables.

What is a View?

Views are similar to tables, which are generated based on the requirements.

- We can save any result set data as a view in Hive
- Usage is similar to as views used in SQL
- All type of DML operations can be performed on a view

Creation of View:

Syntax:

Create VIEW < VIEWNAME> AS SELECT

Example:

```
Hive>Create VIEW Sample_ViewAS SELECT * FROM  
employees WHERE salary>25000
```

In this example, we are creating view Sample_View where it will display all the row values with salary field greater than 25000.

What is Index?

Indexes are pointers to particular column name of a table.

- The user has to manually define the index
- Wherever we are creating index, it means that we are creating pointer to particular column name of table
- Any Changes made to the column present in tables are stored using the index value created on the column name.

Syntax:

```
Create INDEX < INDEX_NAME> ON TABLE <  
TABLE_NAME(column names)>
```

Example:

```
Create INDEX sample_Index ON TABLE  
guruhive_internaltable(id)
```

Here we are creating index on table guruhive_internaltable for column name id.

HIVE FUNCTIONS

Functions are built for a specific purpose to perform operations like Mathematical, arithmetic, logical and relational on the operands of table column names.

Built-in functions

These are functions that already available in Hive. First, we have to check the application requirement, and then we can use this built in functions in our applications. We can call these functions directly in our application.

The syntax and types are mentioned in the following section.

Types of Built-in Functions in HIVE

- Collection Functions
- Date Functions
- Mathematical Functions
- Conditional Functions
- String Functions
- Misc. Functions

Collection Functions:

These functions are used for collections. Collections mean the grouping of elements and returning single or array of elements depends on return type mentioned in function name.

R e t u r n T y p e	Function Name	Description
IN T	size(Map<K.V>)	It will fetch and give the components number in the map type
IN T	size(Array<T>)	It will fetch and give the elements number in the array type
Ar ra y < K >	Map_keys(Map <K.V>)	It will fetch and gives an array containing the keys of the input map. Here array is in unordered
Ar ra y < V >	Map_values(Map<K.V>)	It will fetch and gives an array containing the values of the input map. Here array is in unordered

Ar ra y <t >	Sort_array(Array y<T>)	sorts the input array in ascending order of array and elements and returns it
--------------------------	---------------------------	--

Date Functions:

These are used to perform Date Manipulations and Conversion of Date types from one type to another type:

Function Name	Return Type	Description

Unix_Timestamp()	BigInt	We will get current Unix timestamp in seconds
To_date(string timestamp)	string	It will fetch and give the date part of a timestamp string:
year(string date)	INT	It will fetch and give the year part of a date or a timestamp string
quarter(date/timestamp/string)	INT	It will fetch and give the quarter of the year for a date, timestamp, or string in the range 1 to 4
month(string date)	INT	It will give the month part of a date or a timestamp string
hour(string date)	INT	It will fetch and gives the hour of the timestamp
minute(string date)	INT	It will fetch and gives the minute of the timestamp
Date_sub(string starting date, int days)	string	It will fetch and gives Subtraction of number of days to starting date
Current_date	date	It will fetch and gives the current date at the start of query evaluation
LAST_day(string date)	string	It will fetch and gives the last day of the month which the date belongs to

trunc(string date, string format)	string	<p>It will fetch and gives date truncated to the unit specified by the format.</p> <p>Supported formats in this :</p> <p>MONTH/MON/MM, YEAR/YYYY/YY.</p>
-----------------------------------	--------	---

Mathematical Functions:

These functions are used for Mathematical Operations. Instead of creating UDFs , we have some inbuilt mathematical functions in Hive.

Function Name	Return Type	Description
round(DOUBLE X)	DOUBLE	It will fetch and returns the rounded BIGINT value of X
round(DOUBLE X, INT d)	DOUBLE	It will fetch and returns X rounded to d decimal places
round(DOUBLE X)	DOUBLE	It will fetch and returns the rounded BIGINT value of X using HALF_EVEN rounding mode
floor(DOUBLE X)	BIGINT	It will fetch and returns the maximum BIGINT value that is equal to or less than X value

ceil(DOUBLE a), ceiling(DOUBLE a)	BIGINT	It will fetch and returns the minimum BIGINT value that is equal to or greater than X value
rand(), rand(INT seed)	DOUBLE	It will fetch and returns a random number that is distributed uniformly from 0 to 1

Conditional Functions:

These functions used for conditional values checks.

Function Name	Return Type	Description
if(Boolean testCondition, T valueTrue, T valueFalseOrNull)	T	It will fetch and gives value True when Test Condition is of true, gives value False Or Null otherwise.
ISNULL(X)	Boolean	It will fetch and gives true if X isNULL and false otherwise.
ISNOTNULL(X)	Boolean	It will fetch and gives true if X isnot NULL and false otherwise.

String Functions:

String manipulations and string operations these functions can¹⁰ be called.

Function Name	Return Type	Description
reverse(string X)	string	It will give the reversed string of X
rpad(stringstr, int length, string pad)	string	It will fetch and gives str, which is right-padded with pad to a length of length(integer value)
rtrim(stringX)	string	It will fetch and returns the string resulting from trimming spaces from the end (right hand side) of X For example , rtrim(' results ') results in ' results'
space(INTn)	string	It will fetch and gives a string of n spaces.
split(STRING str, STRING pat)	array	Splits str around pat (pat is a regular expression).
Str_to_map(text[, delimiter1, delimiter2])	map<String ,String>	It will split text into key-value pairs using two delimiters.

UDFs (User Defined Functions):

In Hive, the users can define own functions to meet certain client requirements. These are known as UDFs in Hive. User Defined Functions written in [Java](#) for specific modules.

Some of UDFs are specifically designed for the reusability of code in application frameworks. The developer will develop these functions in Java and integrate those UDFs with the Hive.

During the Query execution, the developer can directly use the code, and UDFs will return outputs according to the user defined tasks. It will provide high performance in terms of coding and execution.

For example, for string stemming we don't have any predefined function in Hive, for this we can write stem UDF in Java.

Wherever we require Stem functionality, we can directly call this Stem UDF in Hive.

Here stem functionality means deriving words from its root words. It is like stemming algorithm reduces the words "wishing", "wished", and "wishes" to the root word "fish." For performing this type functionality, we can write UDF in java and integrate with Hive.

Depending on the use cases the UDFs can be written, it will accept and produce different numbers of input and output values.

The general type of UDF will accept single input value and produce a single output value. If the UDF used in the query, then UDF will be called once for each row in the result data set.

In the other way, it can accept a group of values as input and return single output value as well.