TABLE OF CONTENTS

PROGRESS THROUGH KNOWLEDGE

Ex No 1: **Download and Installing Hadoop**

Date:

HADOOP COMMANDS

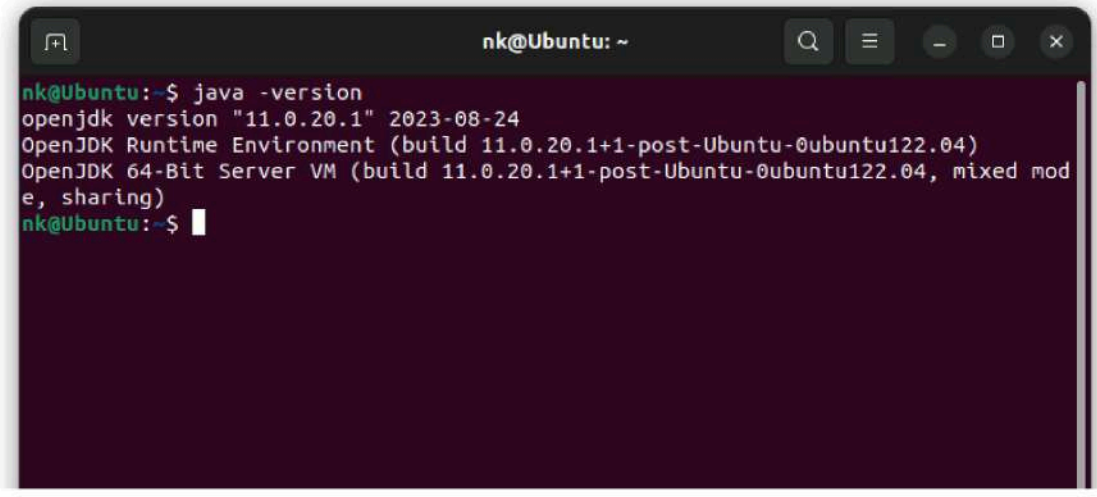
1. Install Java

1.1 Install the latest version of Java.

$ sudo apt install default-jdk default-jre –y

1.2 Verify the installed version of Java.

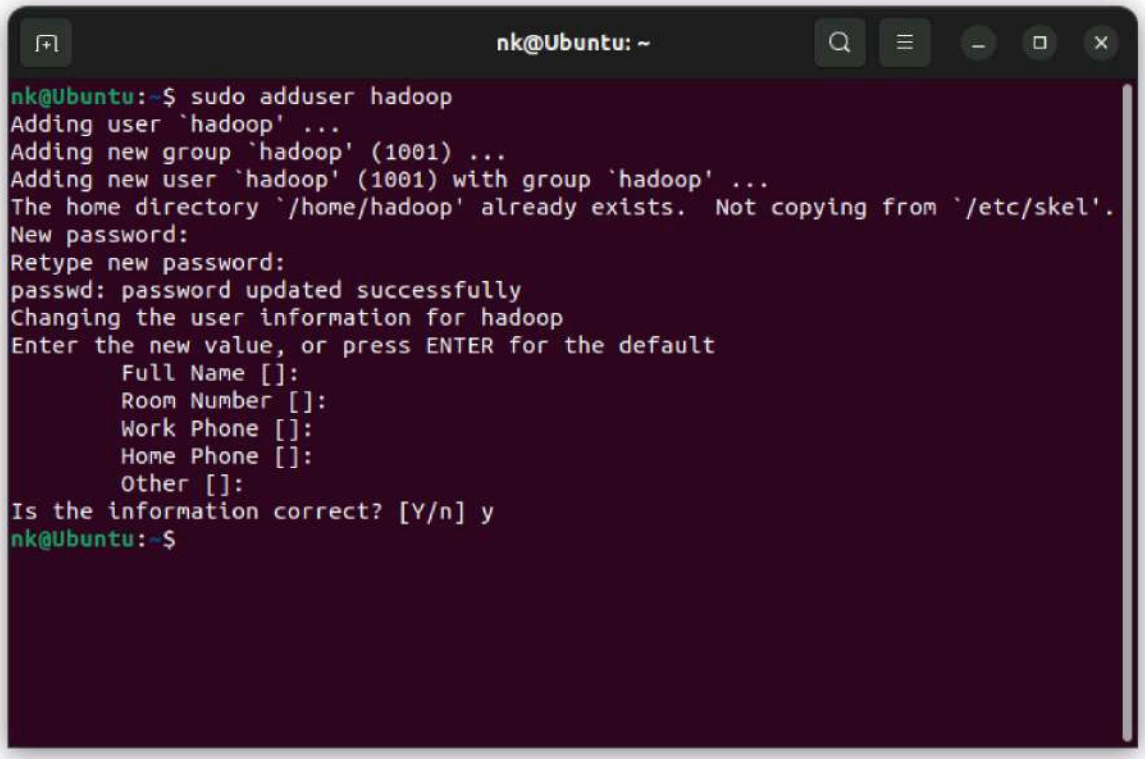
$ java –version



2. Create Hadoop User and Configure Password-less SSH

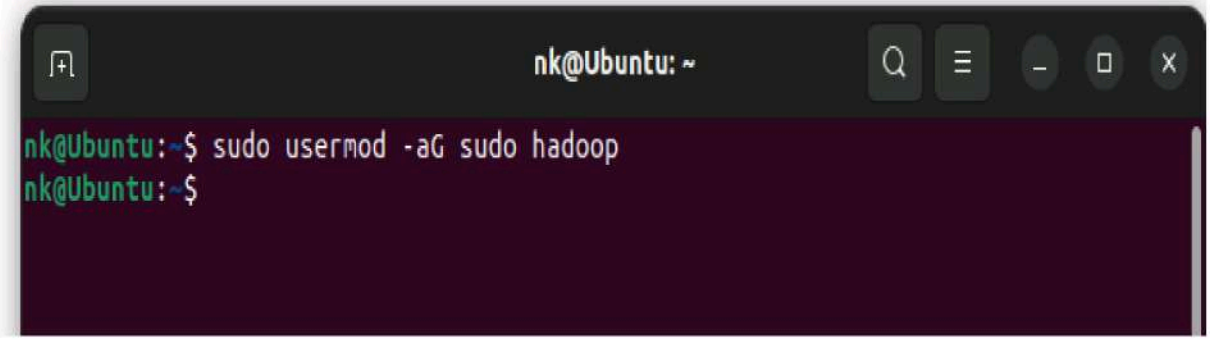
2.1. Add a new user hadoop.

$ sudo adduser hadoop



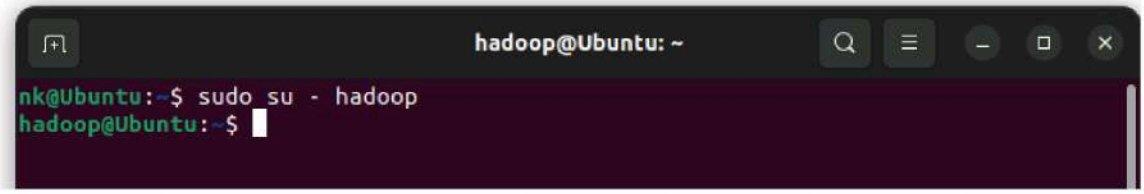
2.2 Add the hadoop user to the sudo group.

$ sudo usermod -aG sudo Hadoop



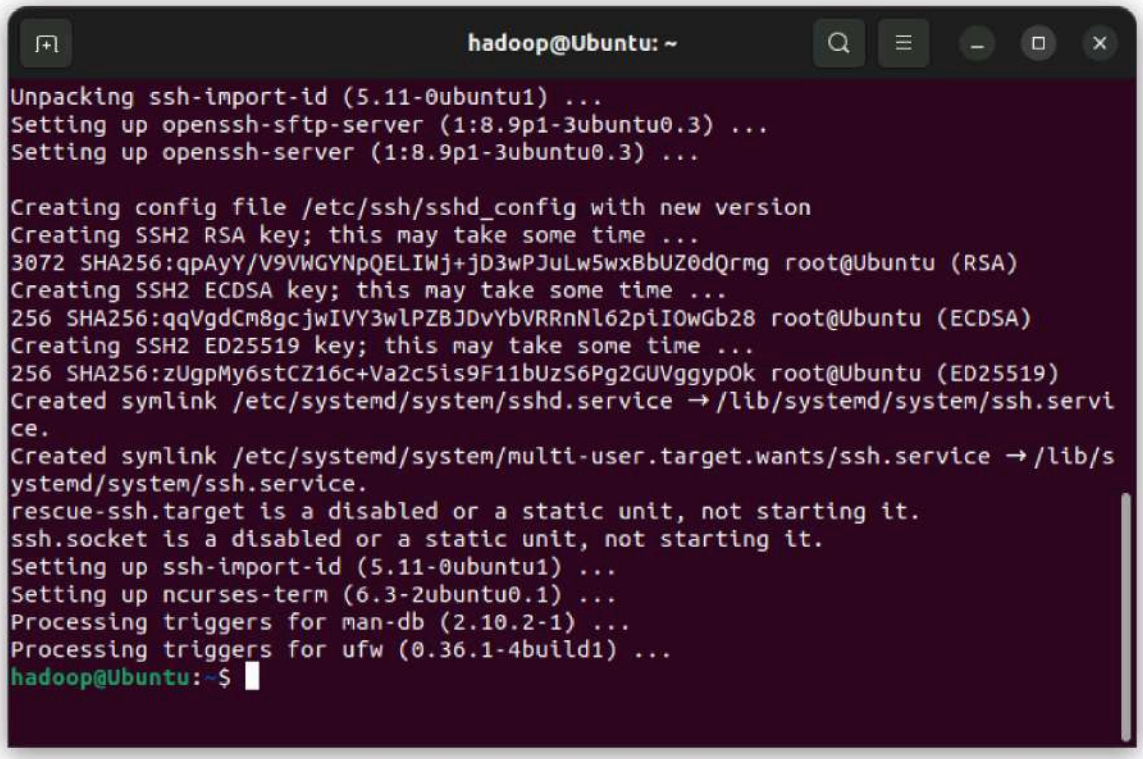
2.2 Switch to the created user.

$ sudo su – hadoop



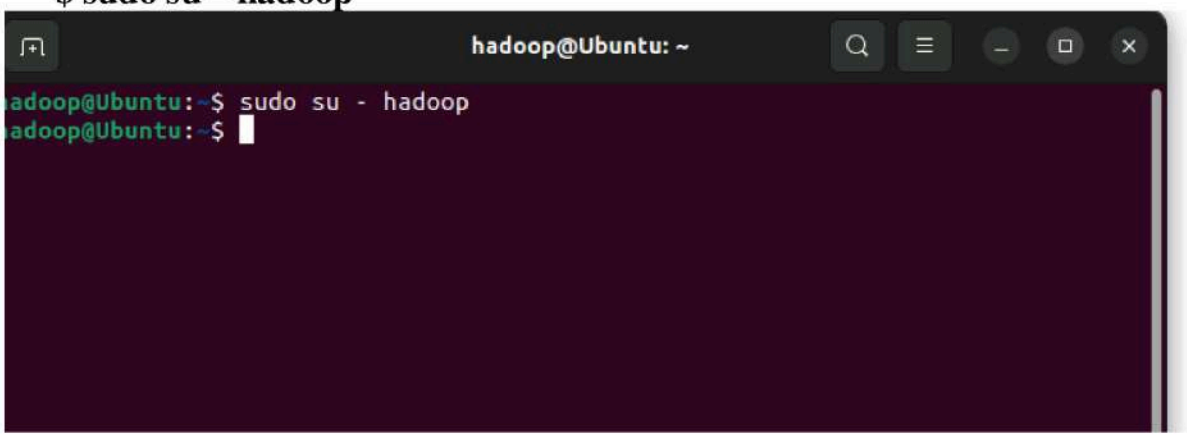
2.3 Install the OpenSSH server and client.

$ sudo apt install openssh-server openssh-client –y



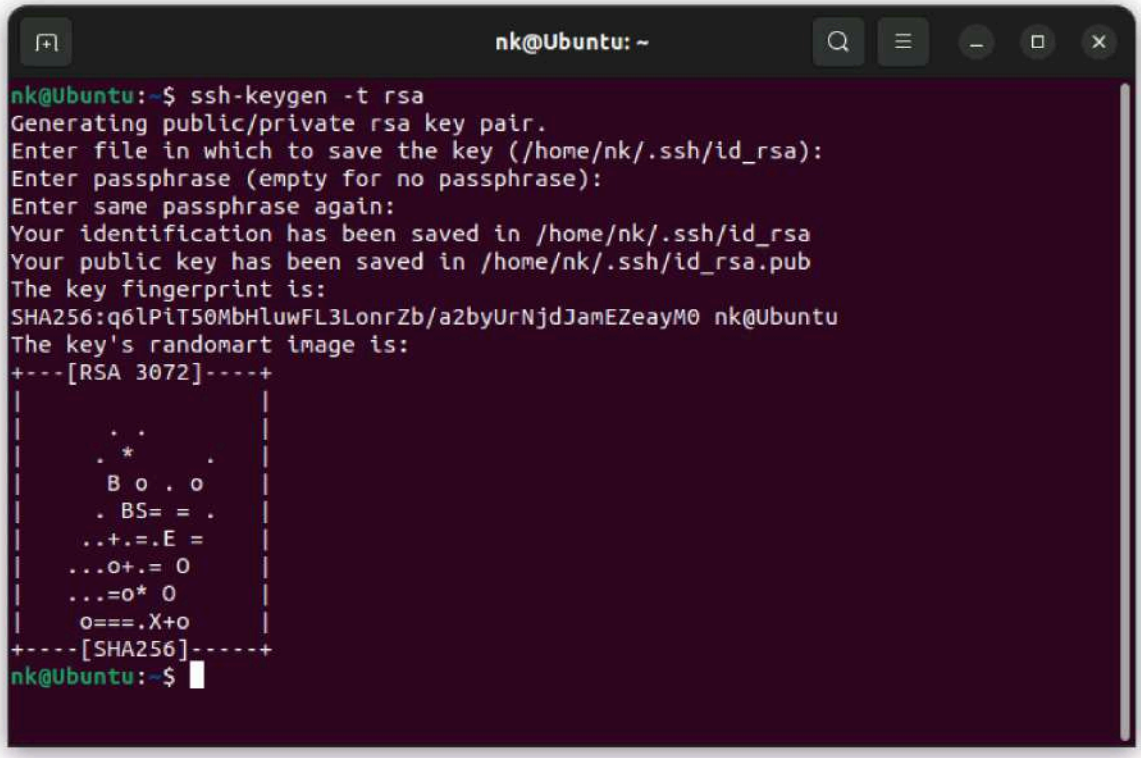
2.4 Switch to the created user.

$ sudo su – hadoop



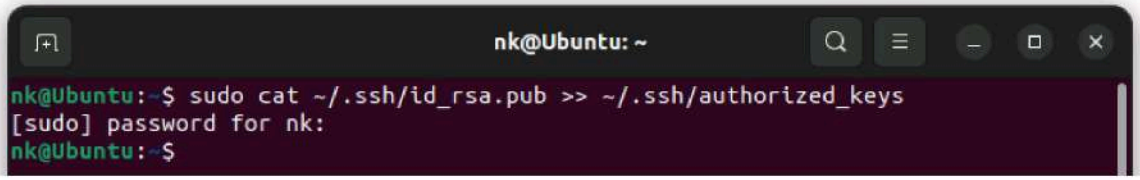
2.5 Generate public and private key pairs.

$ ssh-keygen -t rsa



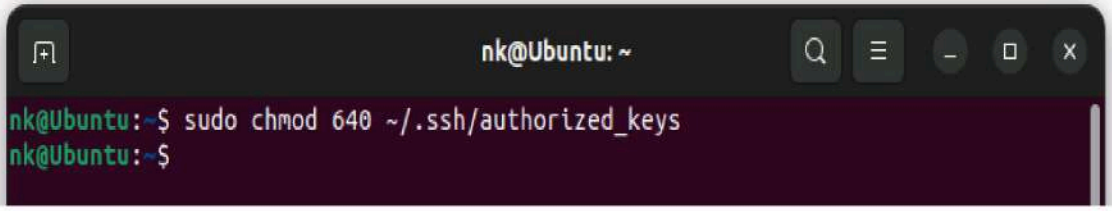
2.6 Add the generated public key from id_rsa.pub to authorized_keys.

$ sudo cat ~/.ssh/id_rsa.pub >> ~/.ssh/authorized_keys



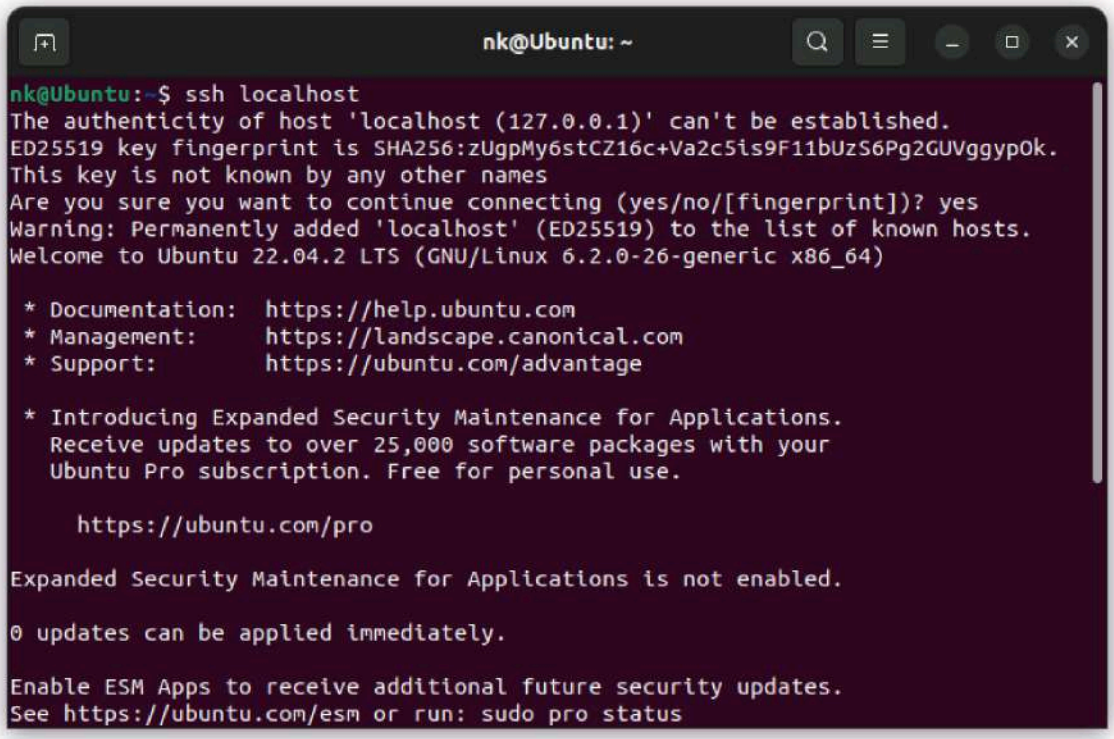
2.7 Change the permissions of the authorized_keys file.

$ sudo chmod 640 ~/.ssh/authorized_keys



2.8 Verify if Password less SSH is functional

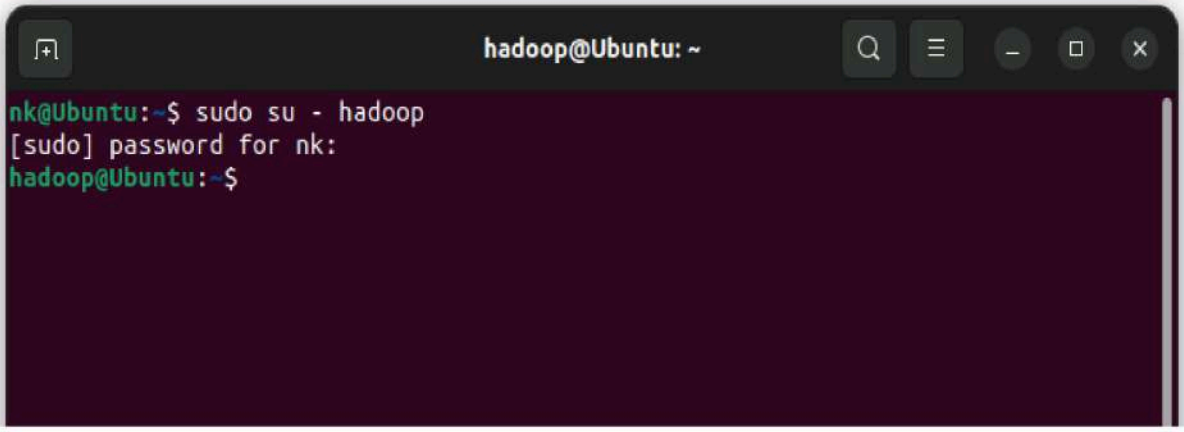
$ ssh localhost



3. Install Apache Hadoop

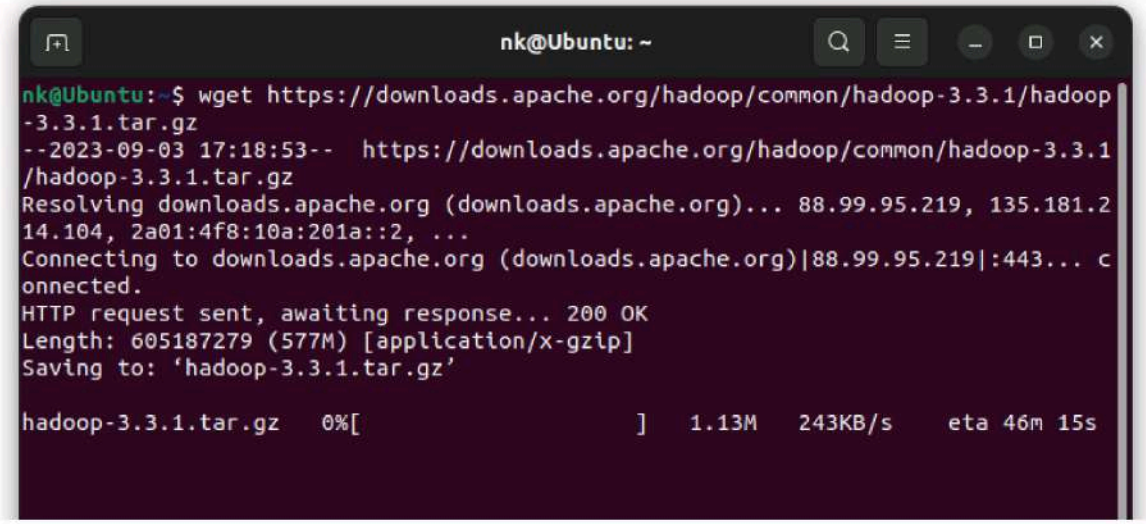
3.1 Log in with hadoop user.

$ sudo su – hadoop



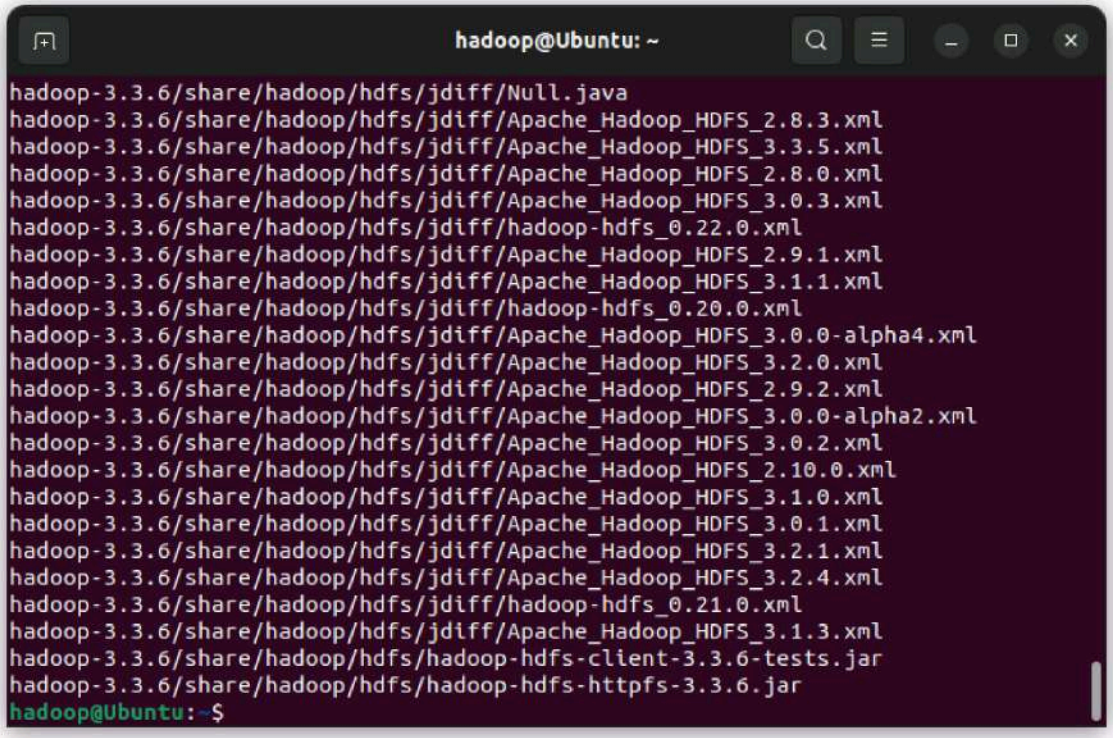
3.2 Download the latest stable version of Hadoop.

$ wget https://downloads.apache.org/hadoop/common/hadoop-3.3.1/hadoop-3.3.1.tar.gz



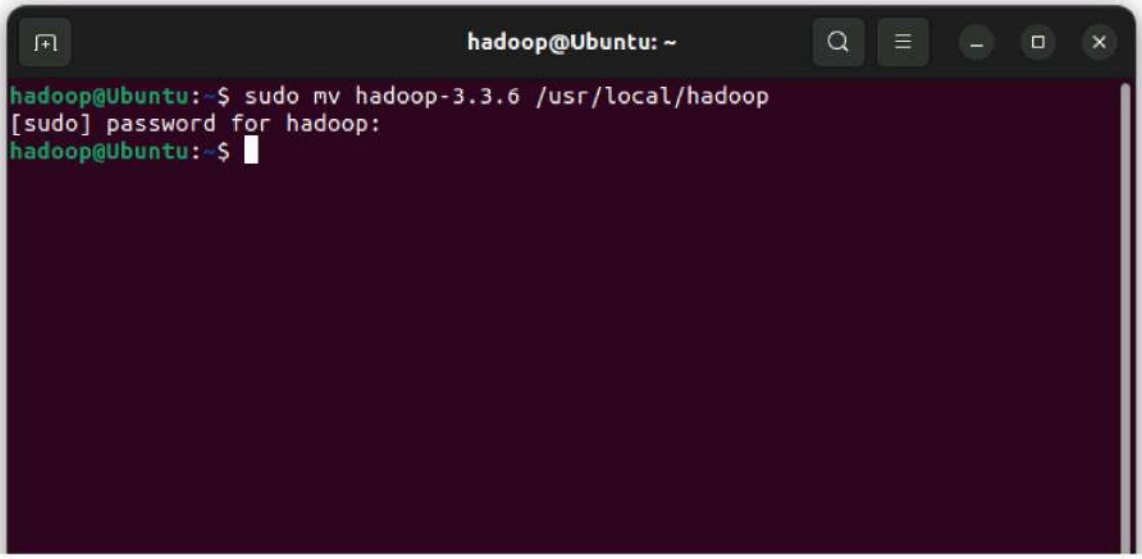
3.3 Extract the downloaded file.

$ tar -xvzf hadoop-3.3.1.tar.gz



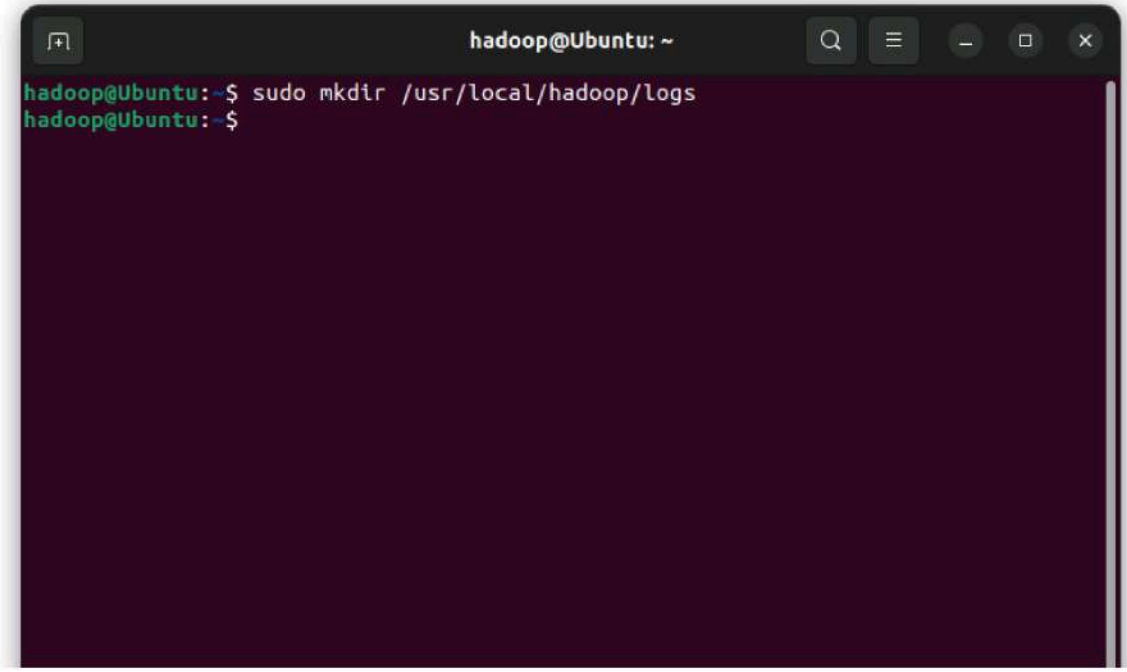
3.4 Move the extracted directory to the /usr/local/ directory.

$ sudo mv hadoop-3.3.1 /usr/local/hadoop



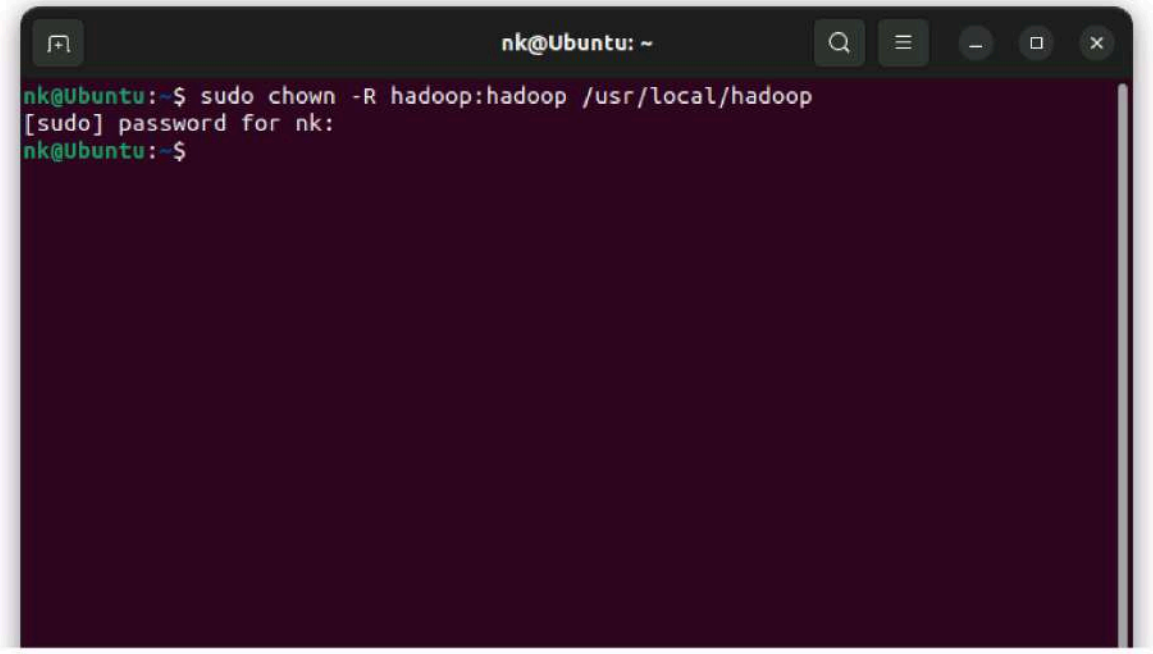
3.5 Create a directory to store system logs.

$ sudo mkdir /usr/local/hadoop/logs



3.6 Change the ownership of the hadoop directory.

$ sudo chown -R hadoop:hadoop /usr/local/hadoop

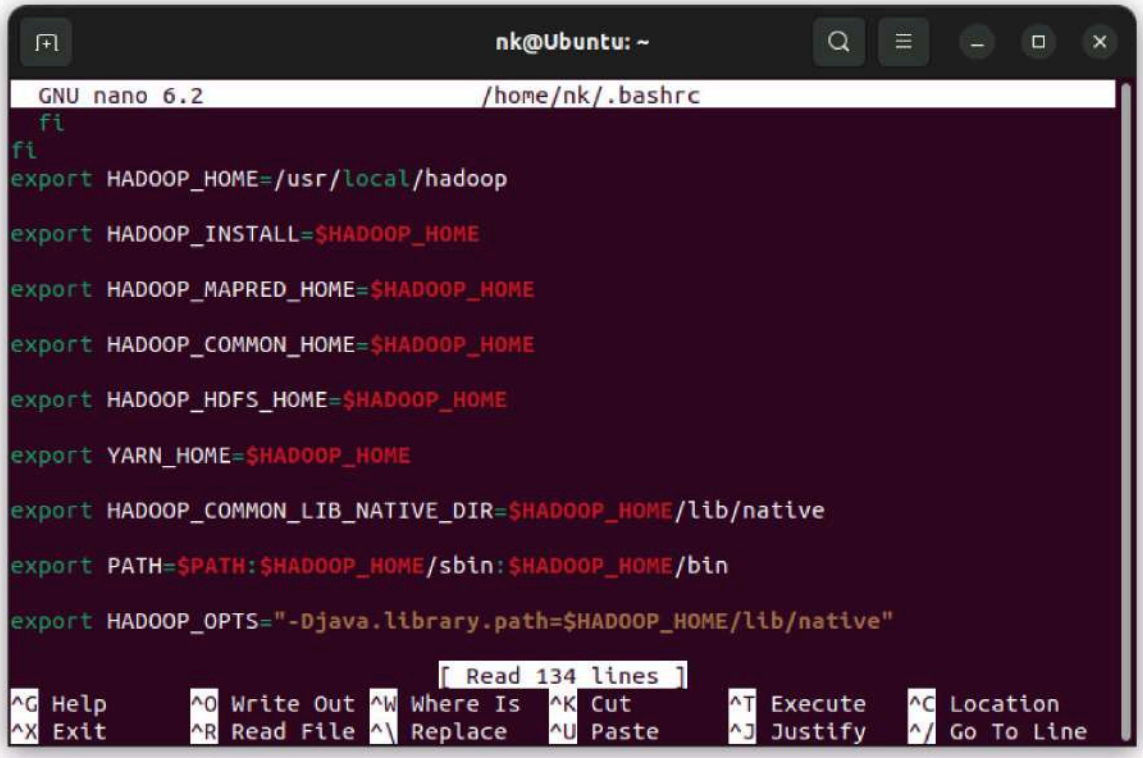


4 Configure Hadoop

4.1 Edit file ~/.bashrc to configure the Hadoop environment variables.
$ sudo nano ~/.bashrc

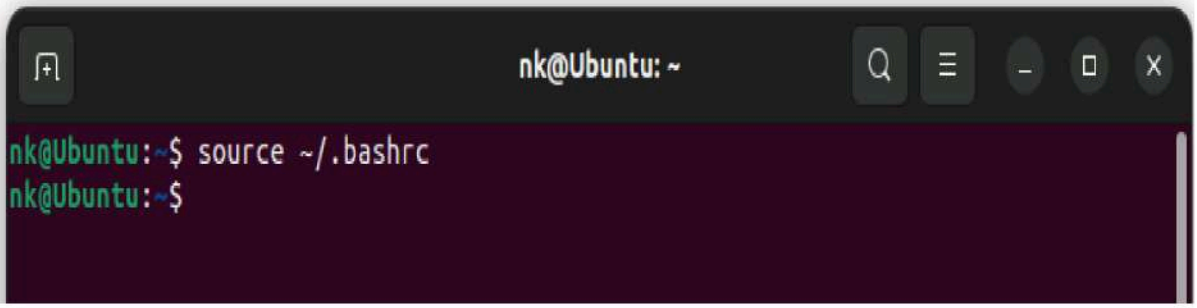
Add the following lines to the file. Save and close the

file.export HADOOP_HOME=/usr/local/hadoop
export HADOOP_INSTALL=$HADOOP_HOME
export
HADOOP_MAPRED_HOME=$HADOOP_HOME
export
HADOOP_COMMON_HOME=$HADOOP_HOME
export
HADOOP_HDFS_HOME=$HADOOP_HOME
export YARN_HOME=$HADOOP_HOME
export
HADOOP_COMMON_LIB_NATIVE_DIR=$HADOOP_HOME/lib/
nat
iveexport
PATH=$PATH:$HADOOP_HOME/sbin:$HADOOP_HOME/bin
export HADOOP_OPTS="-Djava.library.path=$HADOOP_HOME/lib/native"



Activate the environment variables.

$ source ~/.bashrc

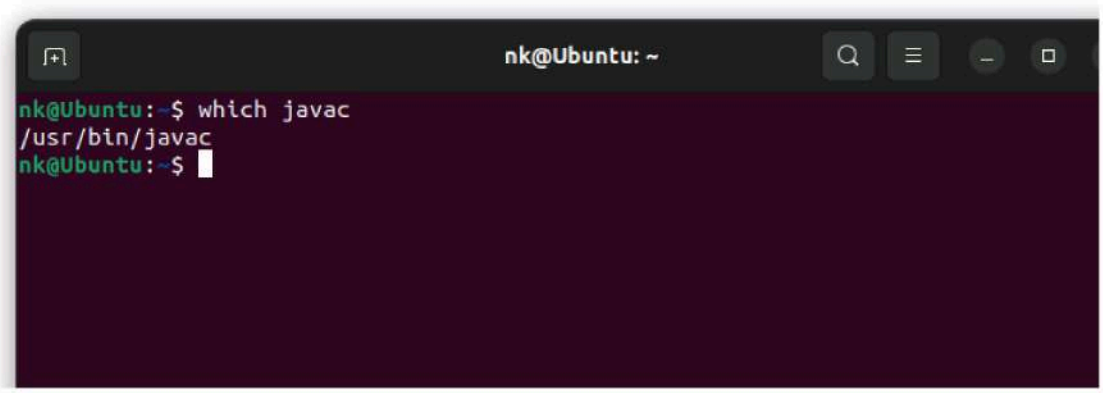


5 Configure Java Environment Variables

Hadoop has a lot of components that enable it to perform its core functions. To configure these components such as YARN, HDFS, MapReduce, and Hadoop-related project settings, you need to define Java environment variables in hadoop-env.sh configuration file.

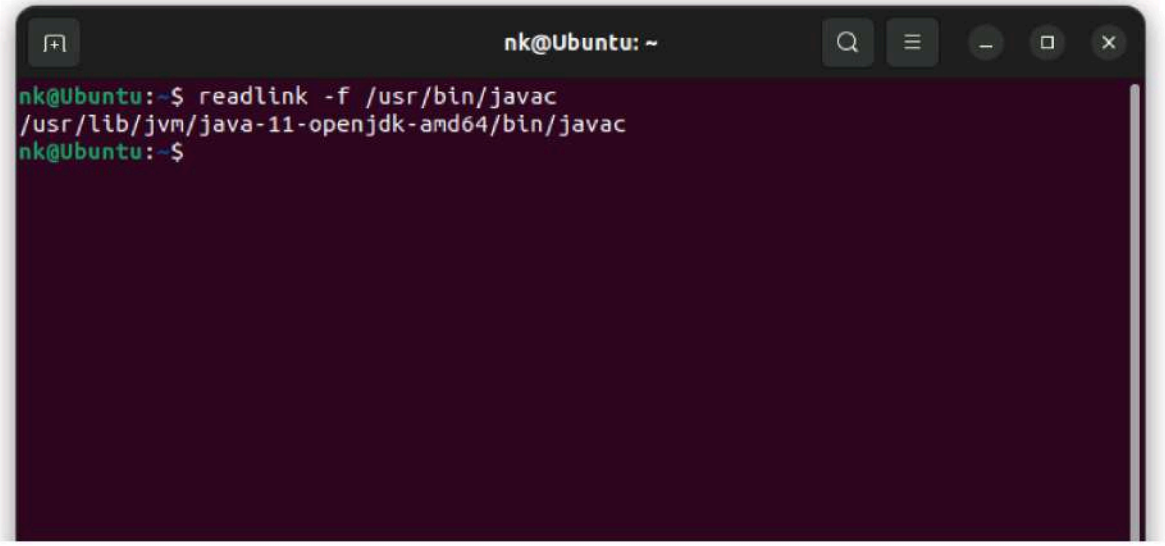
5.1 Find the Java path.

$ which javac



5.2 Find the OpenJDK directory.

$ readlink -f /usr/bin/javac

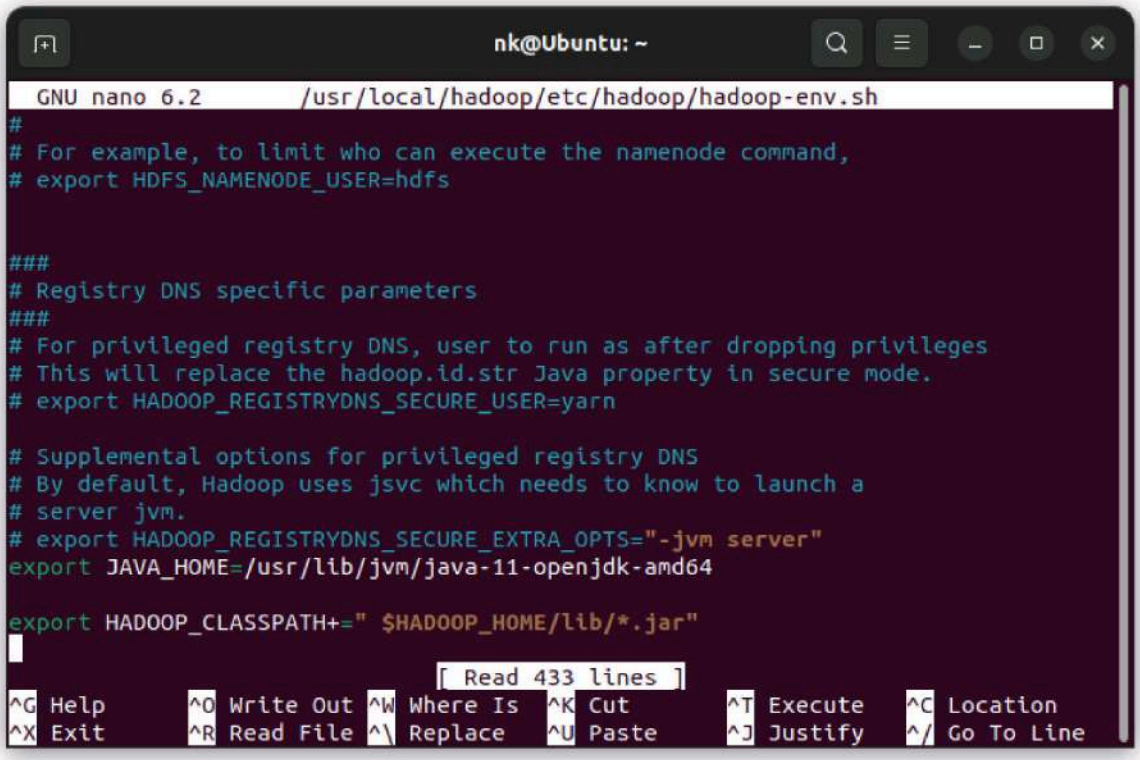


5.3 Edit the hadoop-env.sh file.

$ sudo nano $HADOOP_HOME/etc/hadoop/hadoop-env.sh

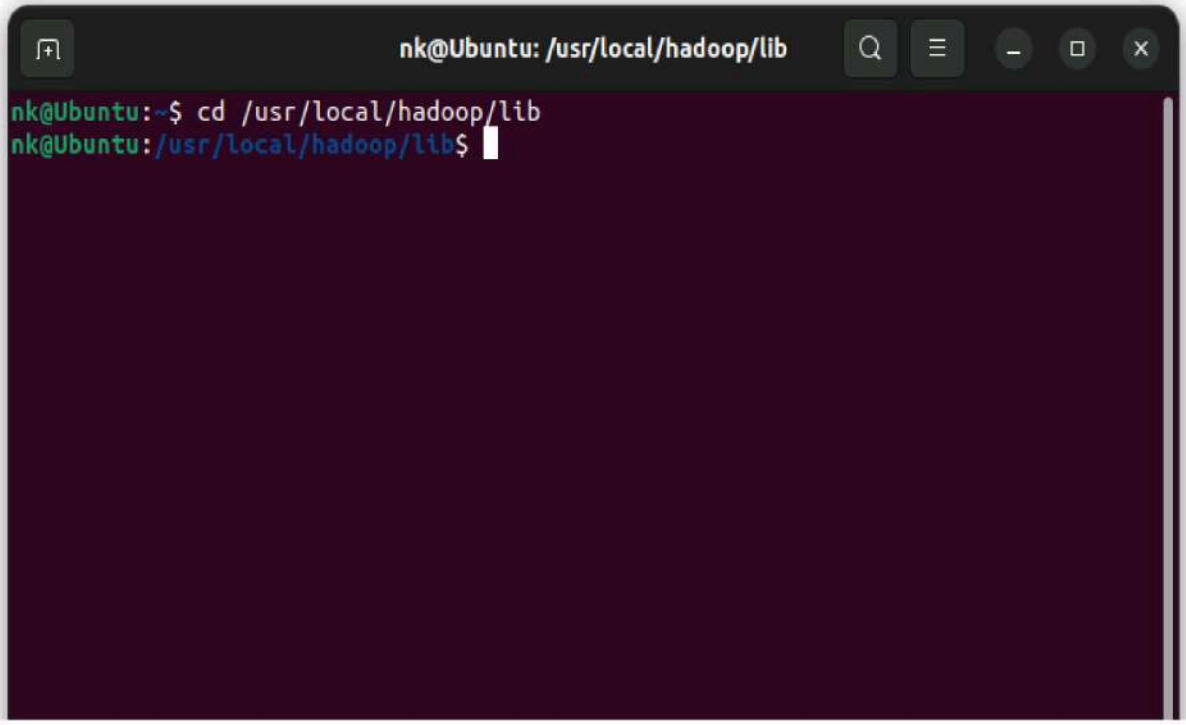
Add the following lines to the file. Then, close and save the file.

export JAVA_HOME=/usr/lib/jvm/java-11-openjdk-amd64
export HADOOP_CLASSPATH+="
$HADOOP_HOME/lib/*.jar"



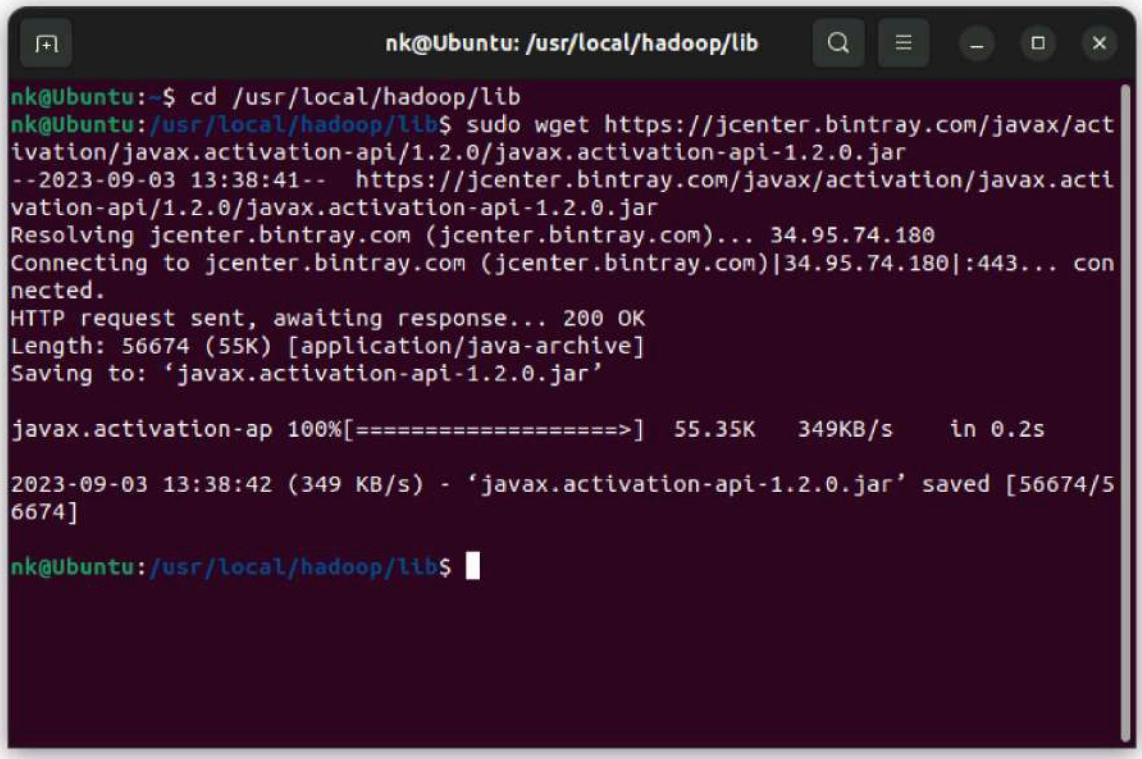
5.4 Browse to the hadoop lib directory.

$ cd /usr/local/hadoop/lib



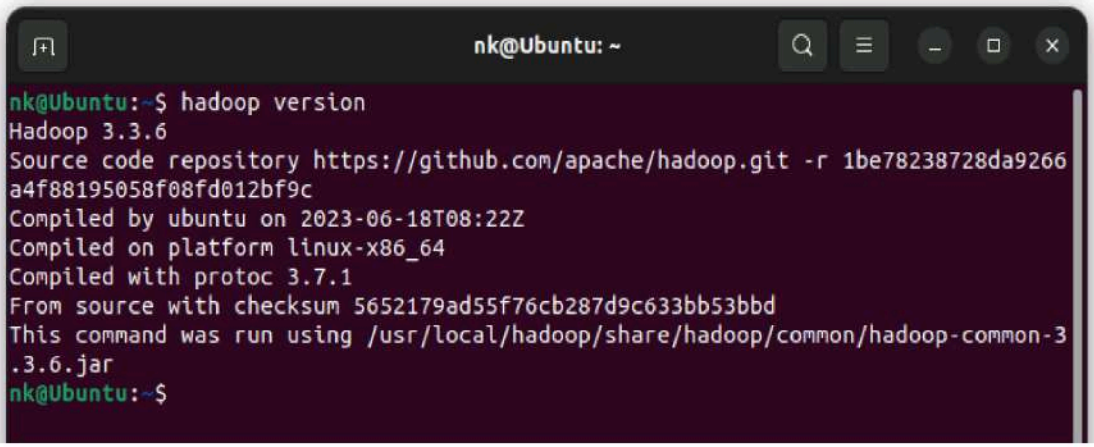
5.5 Download the Javax activation file.

$ sudo wget https://jcenter.bintray.com/javax/activation/javax.activation-api/1.2.0/javax.activation-api-1.2.0.jar



5.6 6 Verify the Hadoop version.

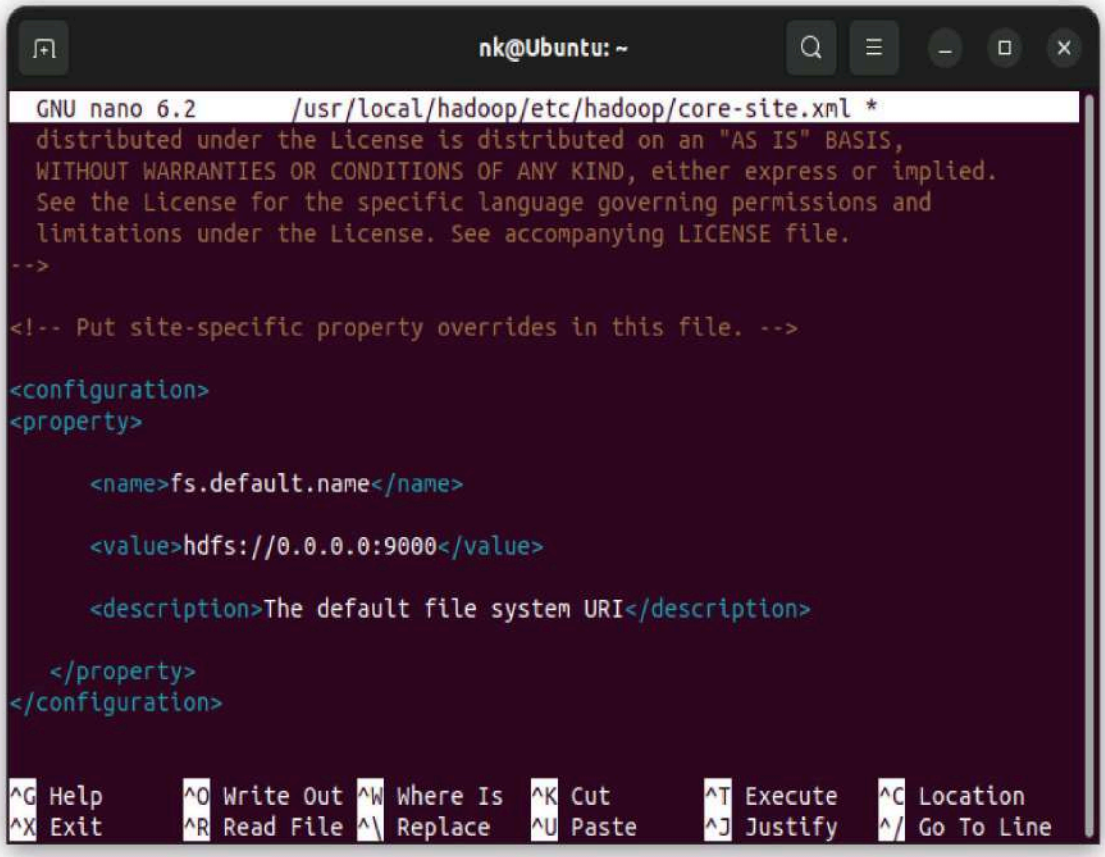
$ hadoop version



5.7 Edit the core-site.xml configuration file to specify the URL for your NameNode. Add thefollowing lines. Save and close the file.

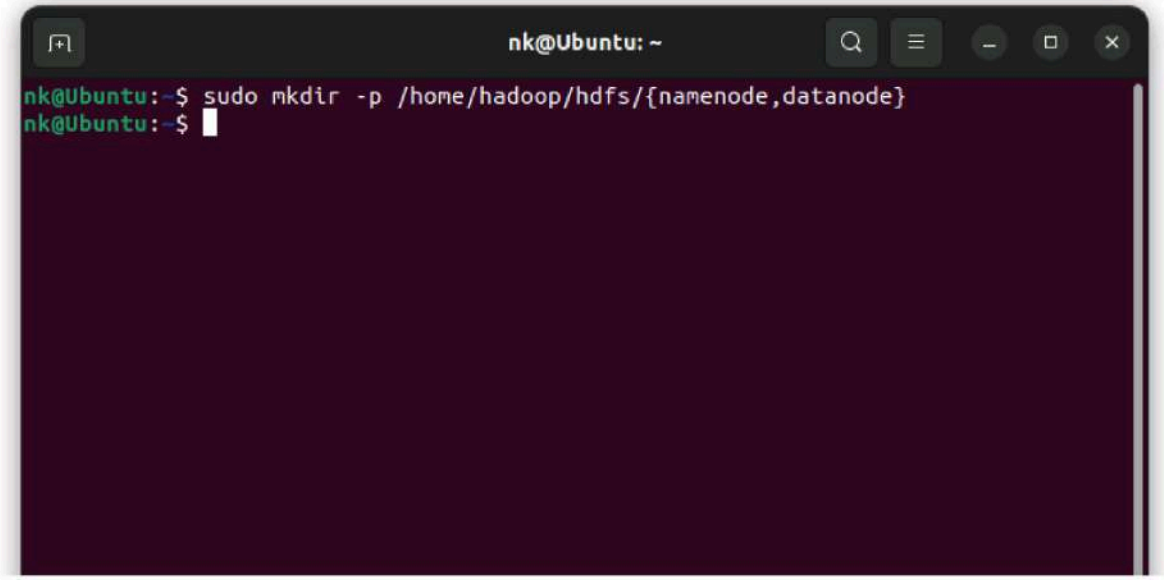
```
<configuration>
  <property>
    <name>fs.default.name</name>
    <value>hdfs://0.0.0.0:9000</value>
    <description>The default file system URI</description>
  </property>
</configuration>
```

$ sudo nano $HADOOP_HOME/etc/hadoop/core-site.xml

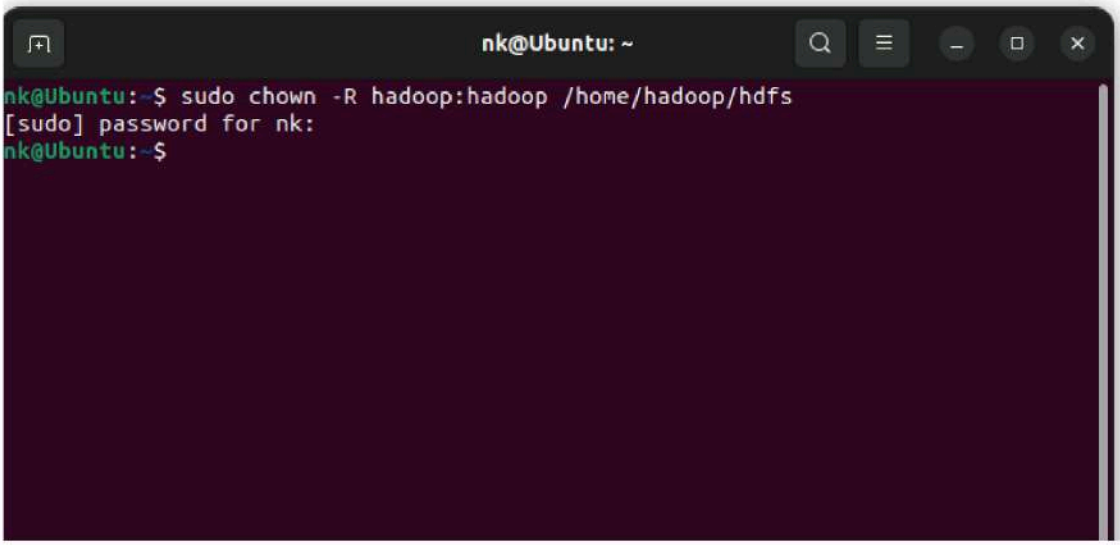


5.8 Create a directory for storing node metadata and change the ownership to hadoop.

a) **$ sudo mkdir -p /home/hadoop/hdfs/{namenode,datanode}**



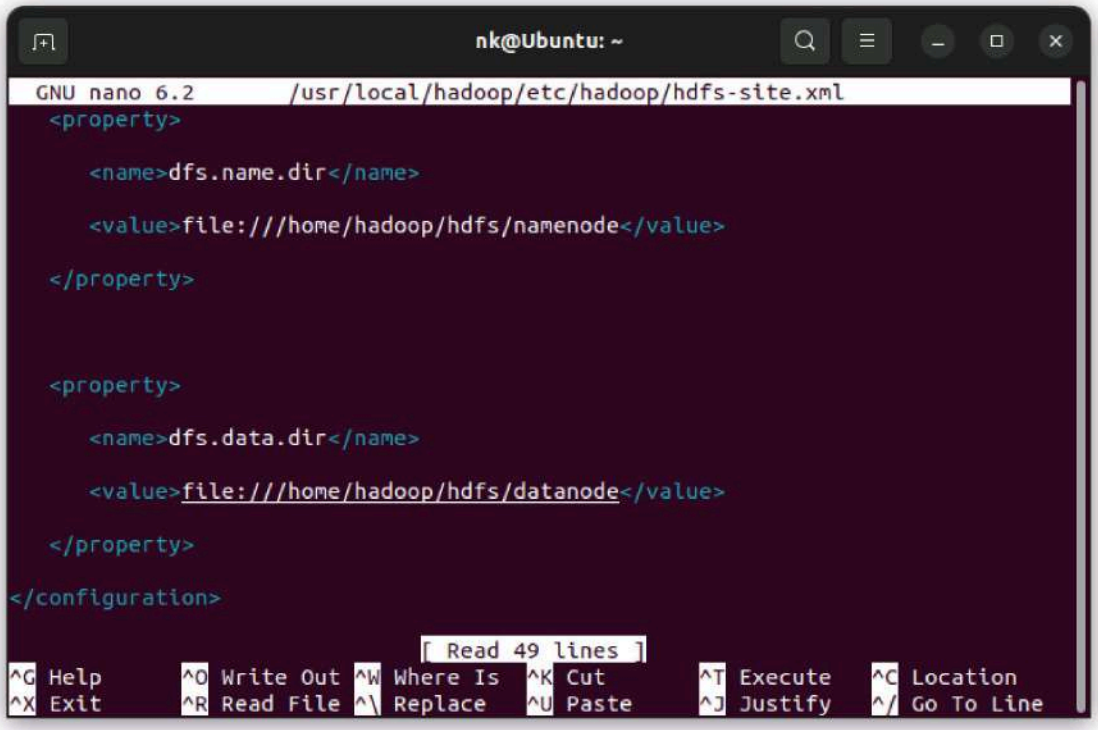
b) **$ sudo chown -R hadoop:hadoop /home/hadoop/hdfs**



5.9 Edit hdfs-site.xml configuration file to define the location for storing node metadata, fs-image file. Add the following lines. Close and save the file.

```
<configuration>

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

  <property>
    <name>dfs.name.dir</name>
    <value>file:///home/hadoop/hdfs/namenode</value>
  </property>

  <property>
    <name>dfs.data.dir</name>
    <value>file:///home/hadoop/hdfs/datanode</value>
  </property>

</configuration>
```

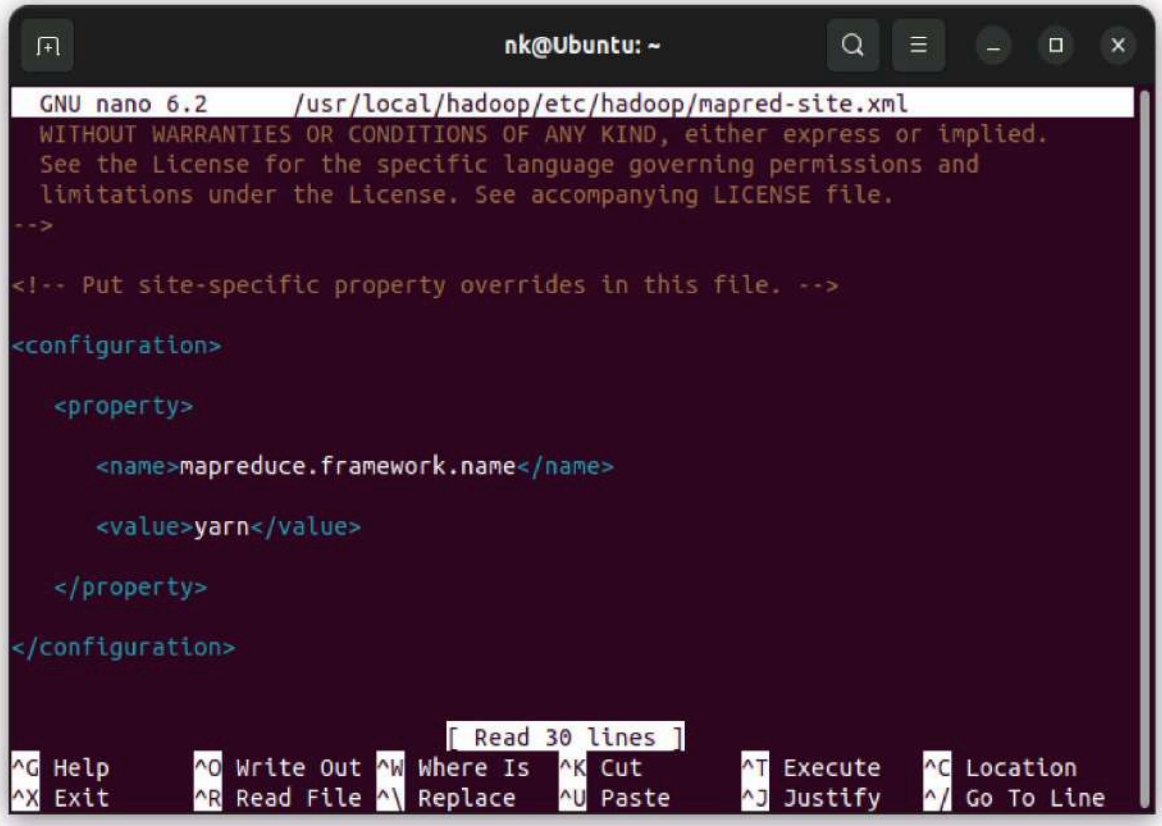
$ sudo nano $HADOOP_HOME/etc/hadoop/hdfs-site.xml



5.10 Edit mapred-site.xml configuration file to define MapReduce values.Add thefollowing lines. Save and close the file.

```
<configuration>

  <property>

    <name>mapreduce.framework.name</name>

    <value>yarn</value>

  </property>

</configuration>
```

$ sudo nano $HADOOP_HOME/etc/hadoop/mapred-site.xml



5.11 Edit the yarn-site.xml configuration file and define YARN-related settings. Add thefollowing lines. Save and close the file.

<configuration>

<property>

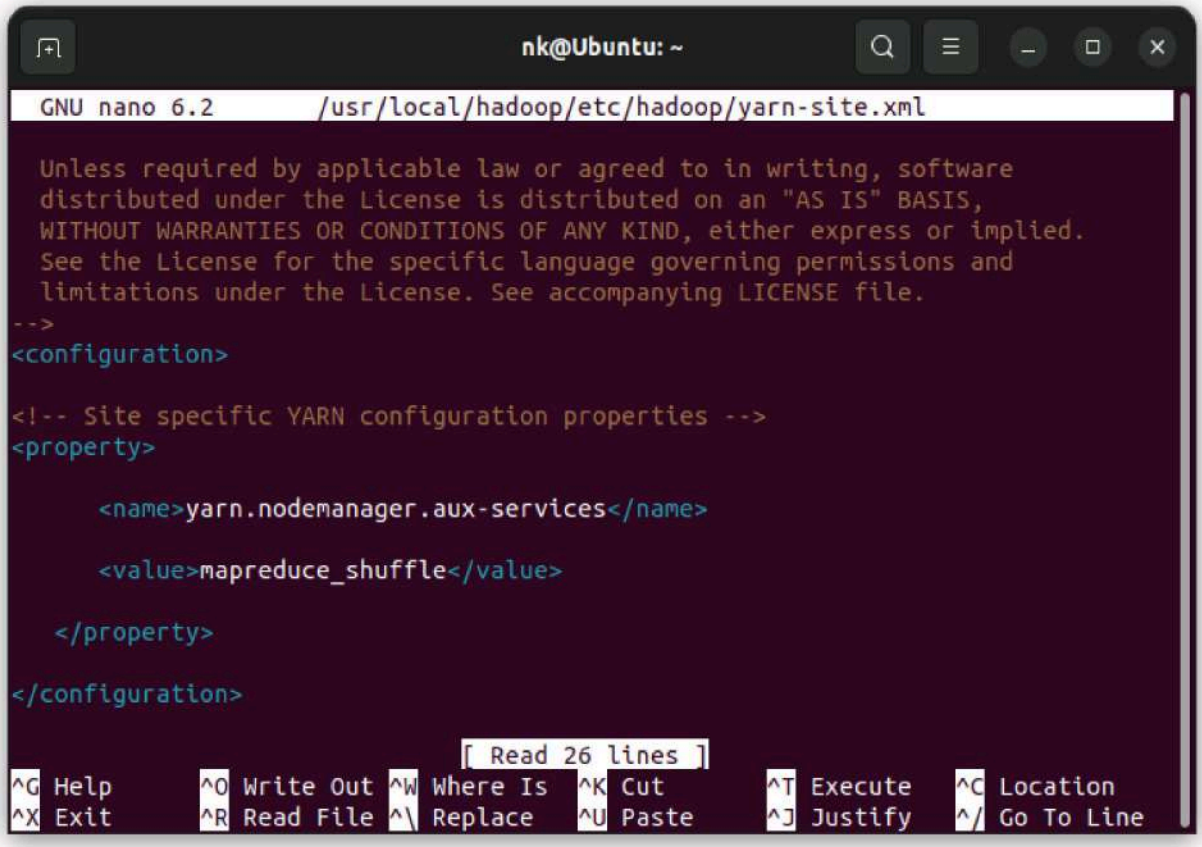
<name>yarn.nodemanager.aux-services</name>

<value>mapreduce_shuffle</value>

</property>

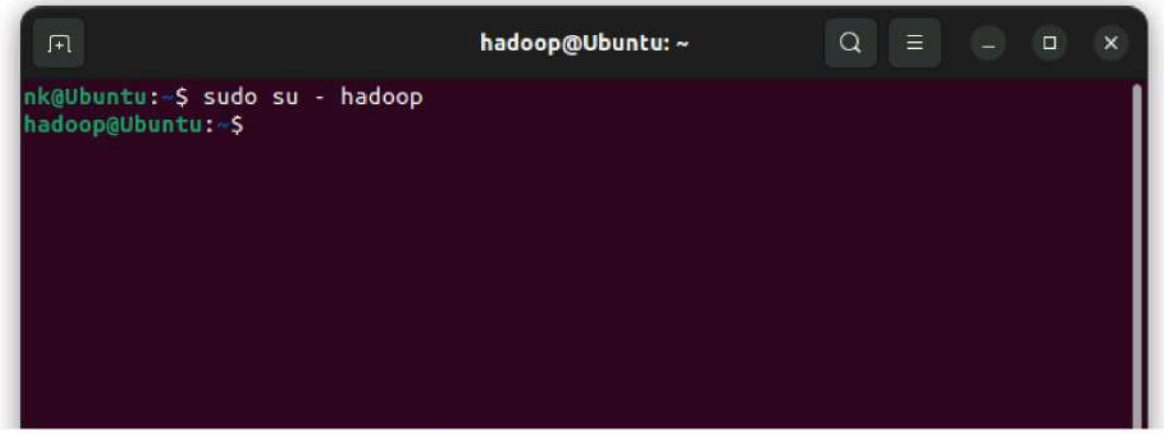
</configuration>

$ sudo nano $HADOOP_HOME/etc/hadoop/yarn-site.xml



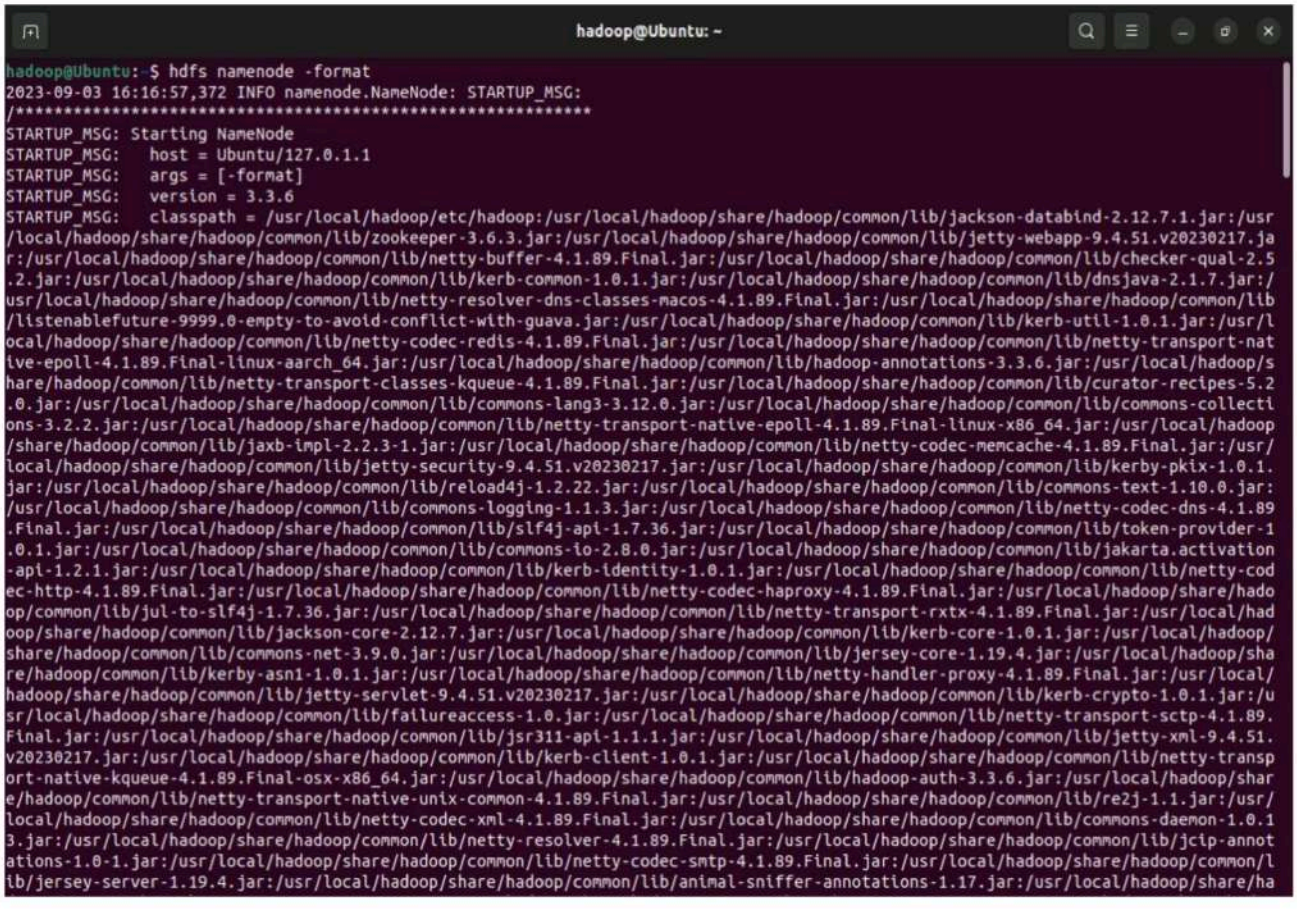
5.12 Log in with hadoop user.

$ sudo su - hadoop



5.13 Validate the Hadoop configuration and format the HDFS NameNode.

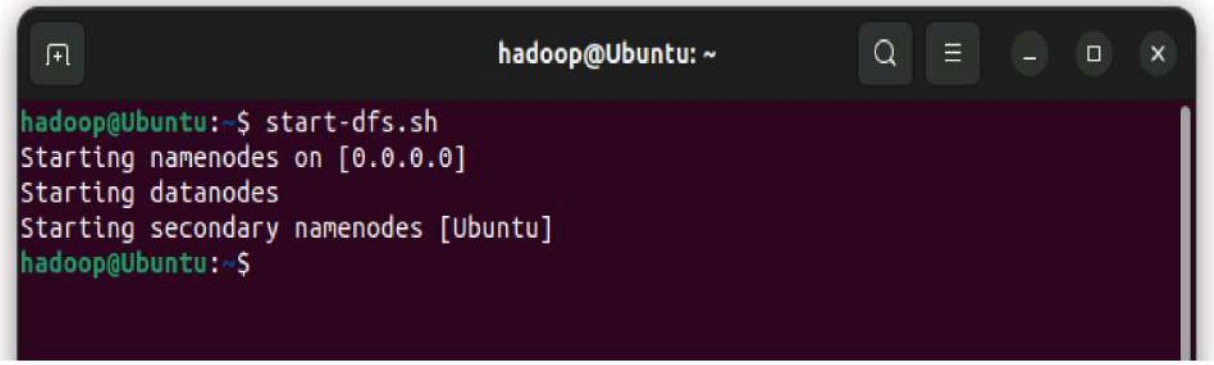
$ hdfs namenode –format



6. Start the Apache Hadoop Cluster

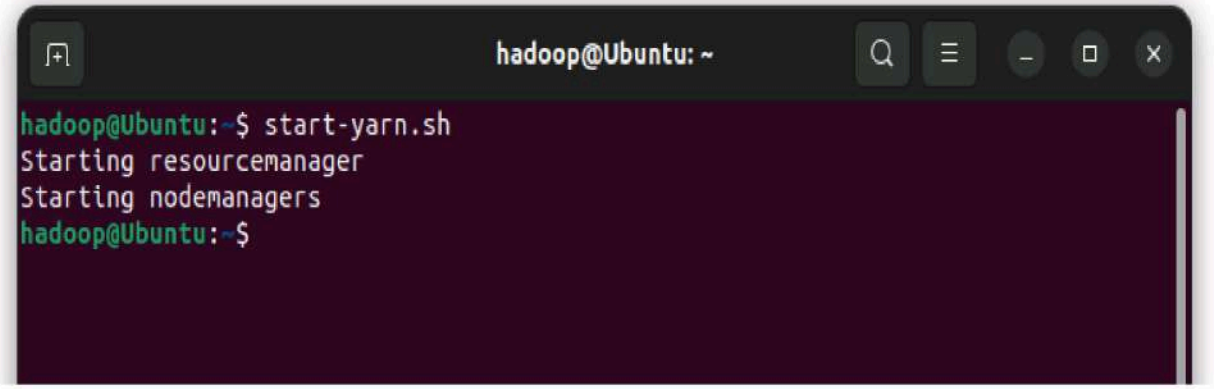
6.1 Start the NameNode and DataNode.

$ start-dfs.sh



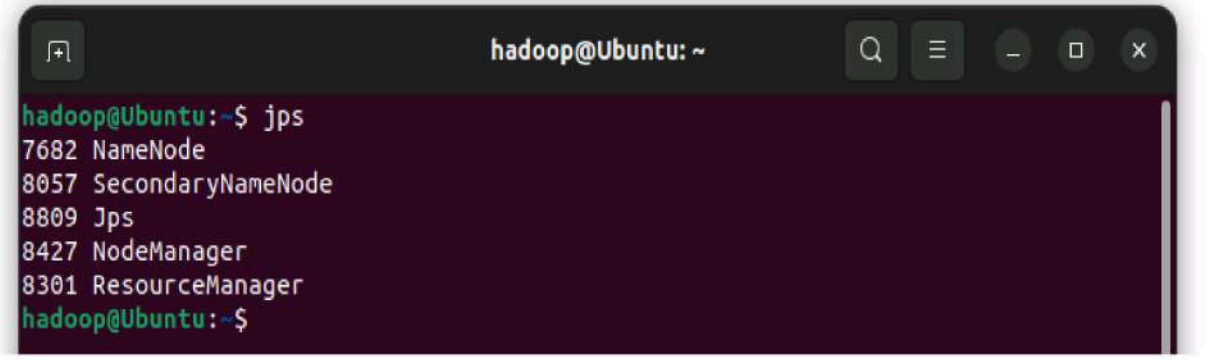
6.2 Start the YARN resource and node managers.

$ start-yarn.sh



Verify all the running components.

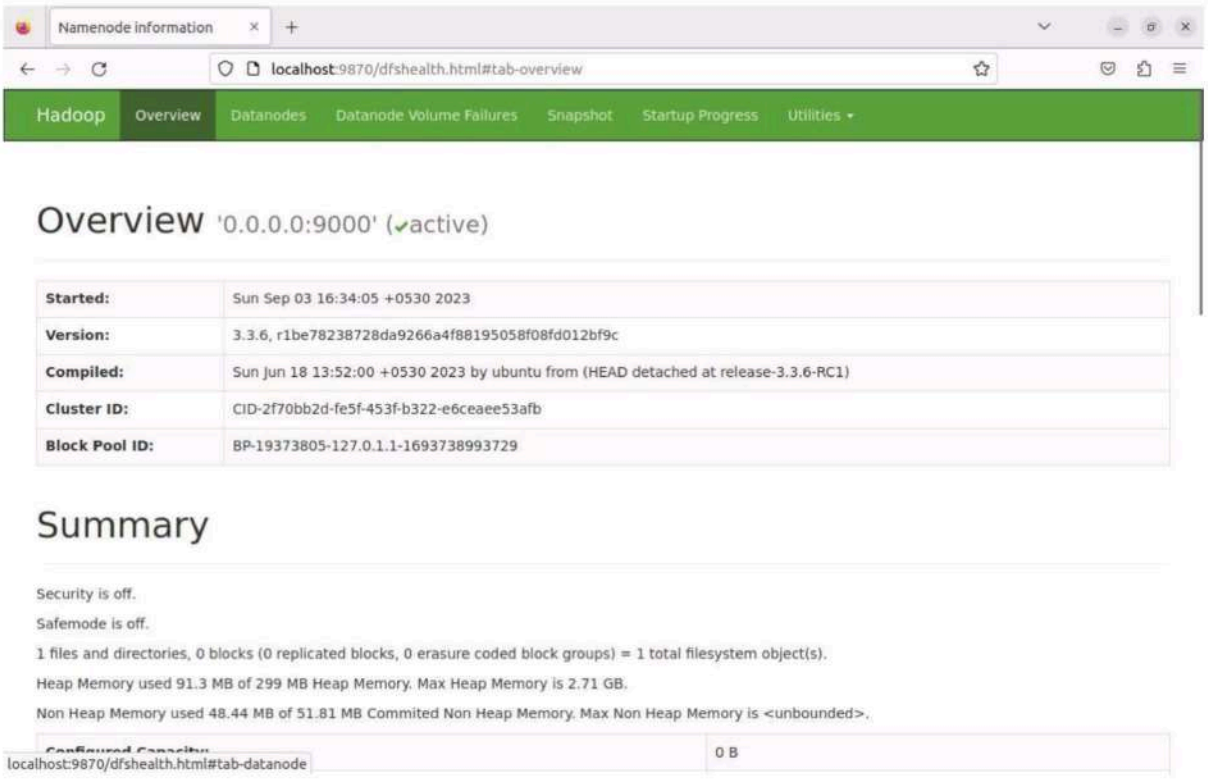
$ jps



7. Access Apache Hadoop Web Interface

You can access the Hadoop NameNode on your browser via http://server-IP:9870
For example:

http://127.0.0.2:9870



RESULT

Thus the program has been executed successfully.

Ex No: 2 **Hadoop Implementation of File Management Task**

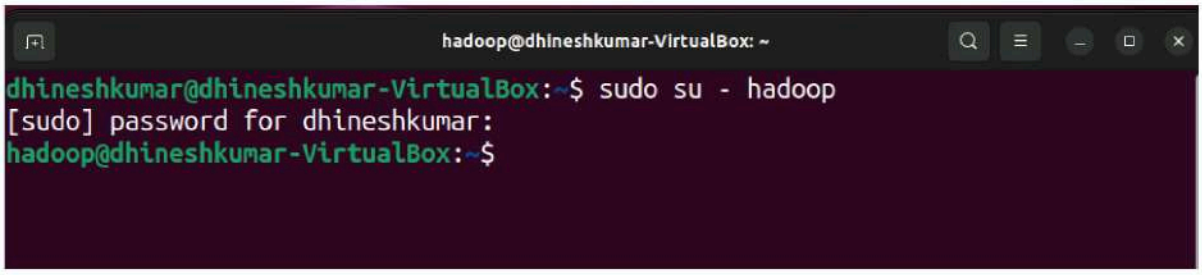
Date:

COMMANDS

1. Starting Hadoop Environment

- After successful installation of Hadoop, log in into the created account from terminal.

$ sudo su – hadoop

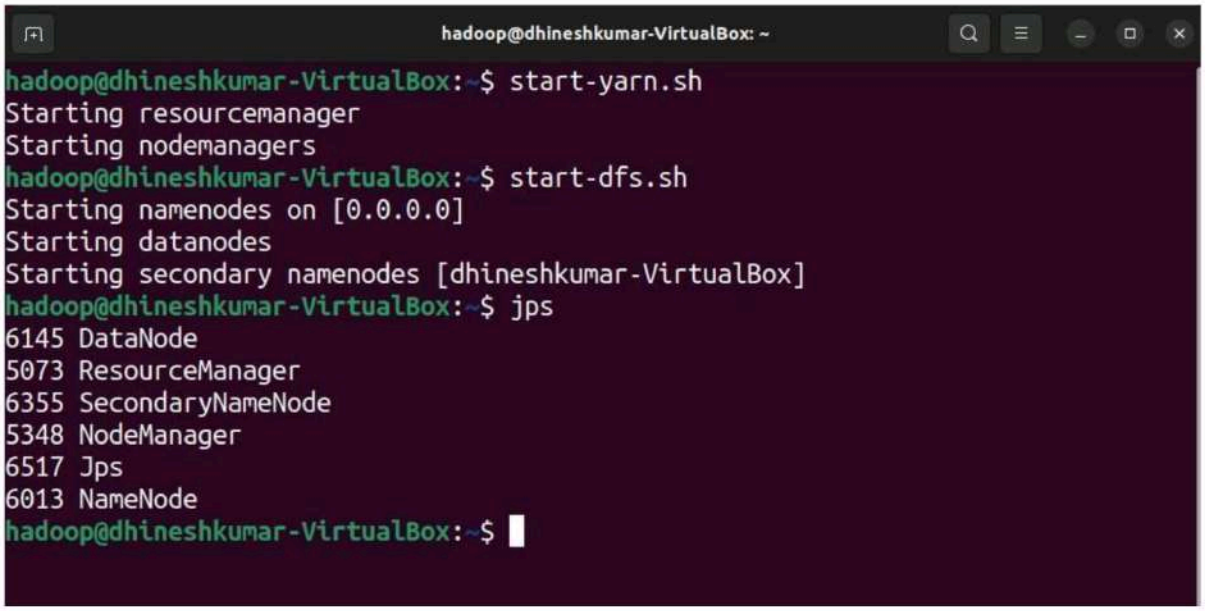


- Start yarn and dfs by using the following commands.

$ start-yarn.sh

$ start-dfs.sh

Check all the running components by using **$ jps** command.

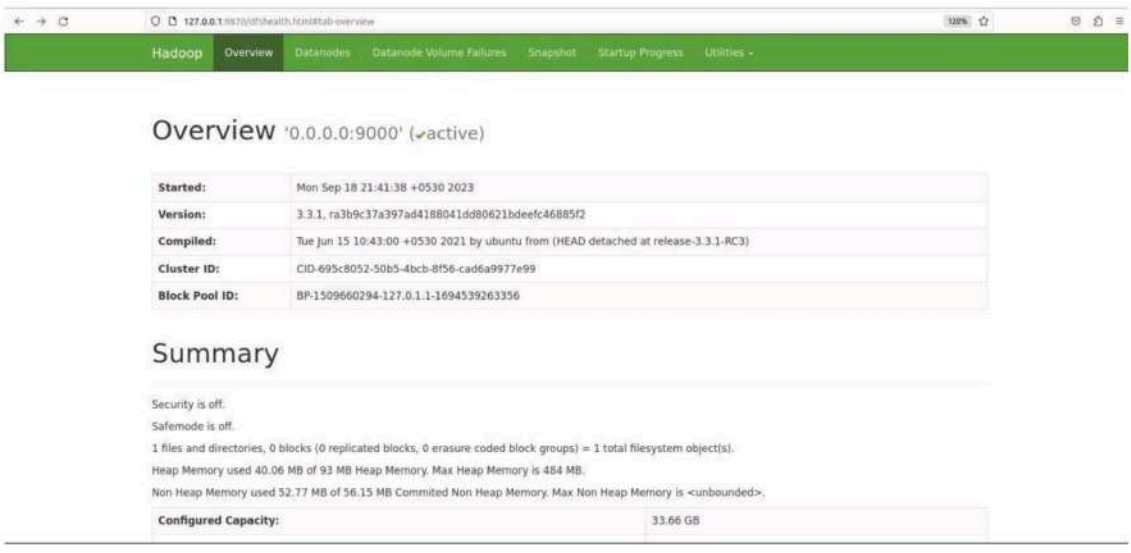


- Find the IP address of the local machine to open the Hadoop environment in a browser.

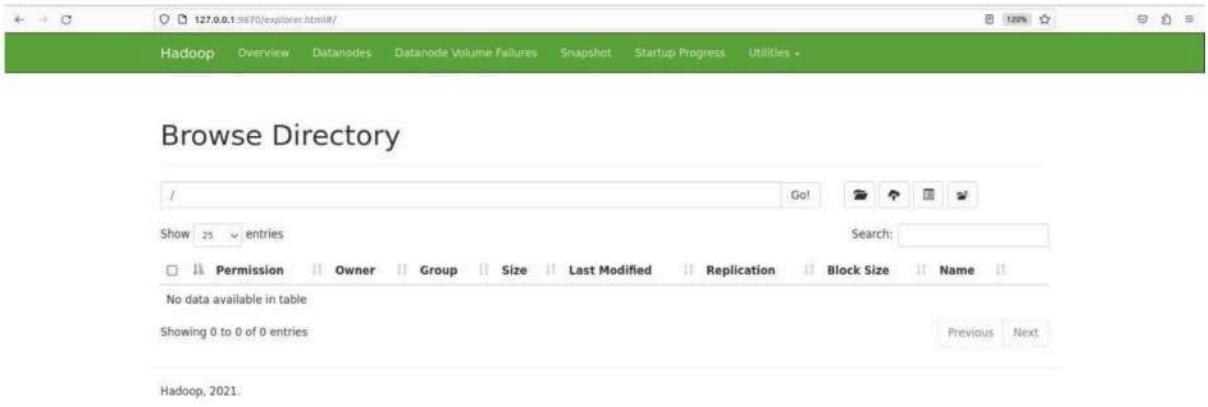
$ ifconfig

```
hadoop@dhineshkumar-VirtualBox: ~
hadoop@dhineshkumar-VirtualBox:~$ ifconfig
enp0s3: flags=4163<UP,BROADCAST,RUNNING,MULTICAST>  mtu 1500
        inet 10.0.2.15  netmask 255.255.255.0  broadcast 10.0.2.255
        inet6 fe80::2a16:ddb:5361:4f0c  prefixlen 64  scopeid 0x20<link>
        ether 08:00:27:e4:cd:91  txqueuelen 1000  (Ethernet)
        RX packets 485239  bytes 727343459 (727.3 MB)
        RX errors 0  dropped 0  overruns 0  frame 0
        TX packets 26501  bytes 1676557 (1.6 MB)
        TX errors 0  dropped 0 overruns 0  carrier 0  collisions 0

lo: flags=73<UP,LOOPBACK,RUNNING>  mtu 65536
        inet 127.0.0.1  netmask 255.0.0.0
        inet6 ::1  prefixlen 128  scopeid 0x10<host>
        loop  txqueuelen 1000  (Local Loopback)
        RX packets 1763  bytes 268343 (268.3 KB)
        RX errors 0  dropped 0  overruns 0  frame 0
        TX packets 1763  bytes 268343 (268.3 KB)
        TX errors 0  dropped 0 overruns 0  carrier 0  collisions 0
```

127.0.0.1 is the IP address of the local machine. View Hadoop in browser by goingto the following link. **http://127.0.0.1:9870** (Here replace the IP with your system's IP)



- In the browser go to **Utilities > Browse the file system**

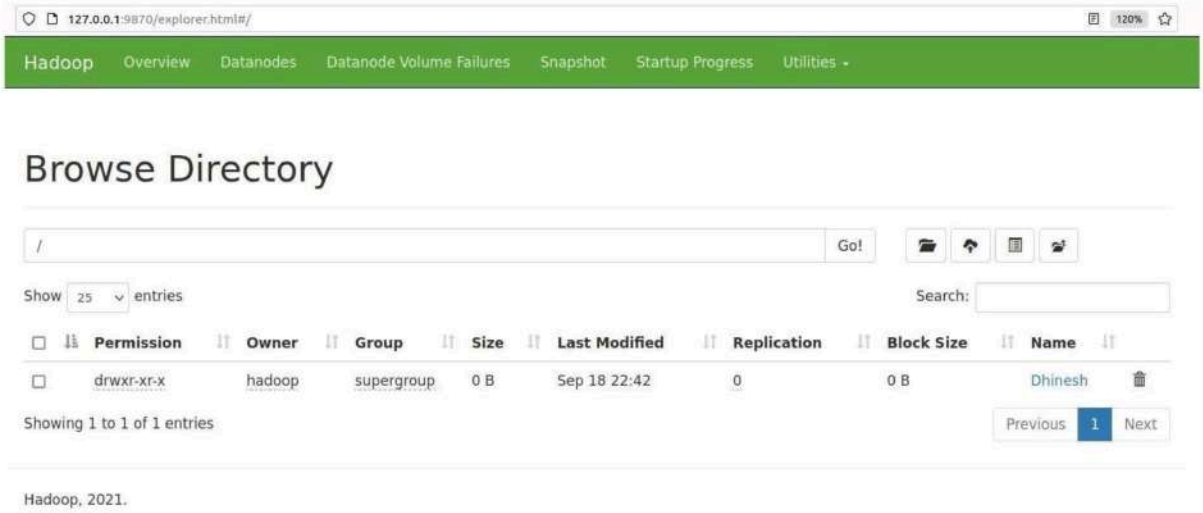


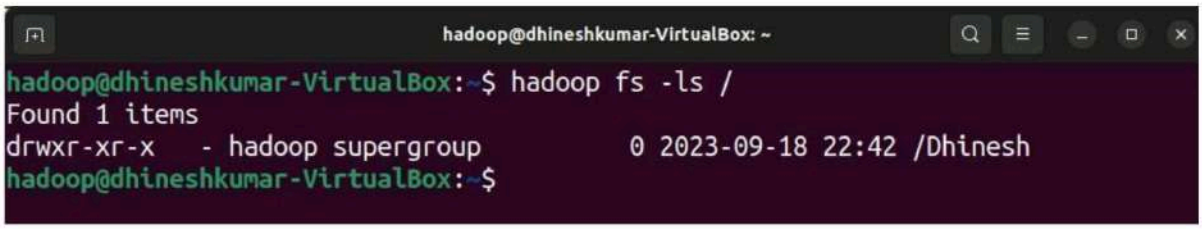
The root directory is empty initially. Any directory or file can be created from the terminal.

2. **Creating a new Directory named Dhinesh in hadoop.**

$ hadoop fs -mkdir /Dhinesh

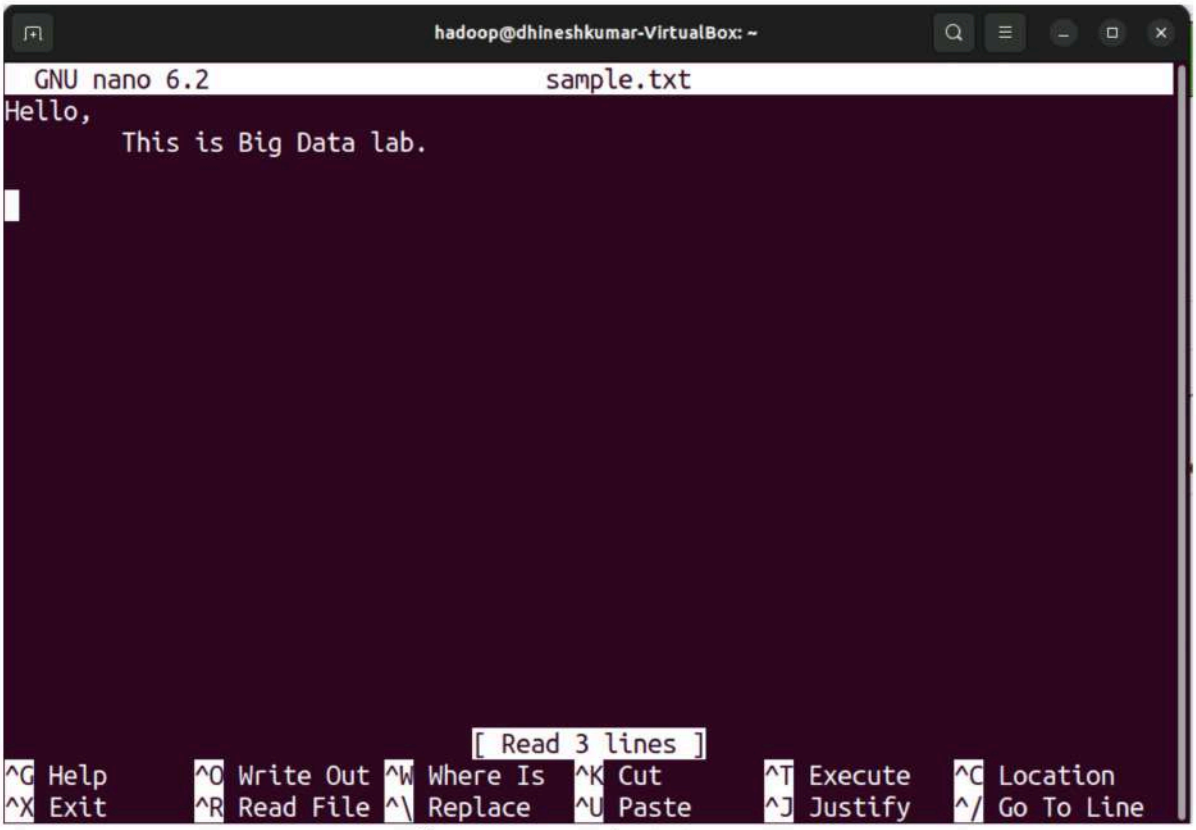
The output on the browser would look like,





Can also see the created directory from the terminal using **$ hadoop fs -ls /** command

3. Creating a new file in home of hadoop user account using VIM editor



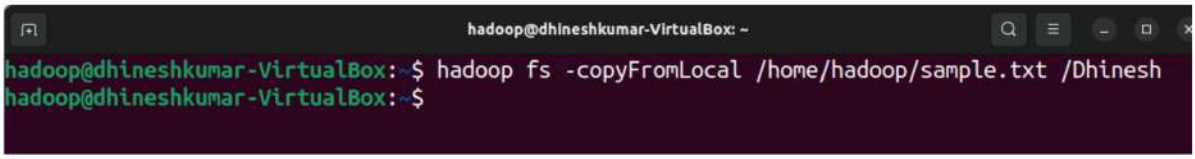
$ nano sample.txt

Save the file by,

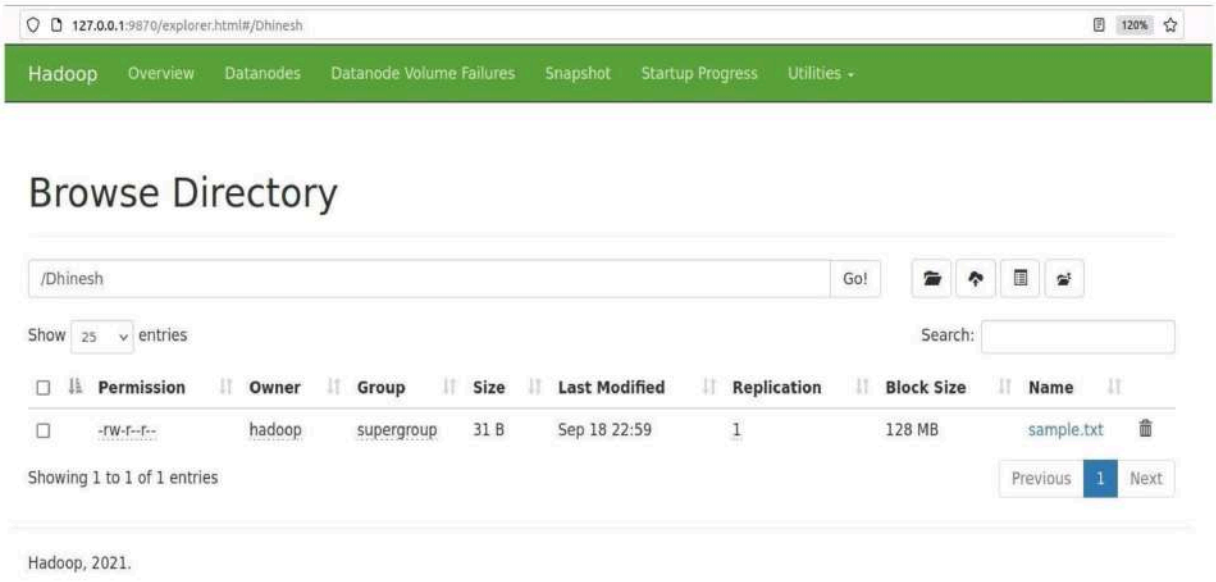
1. **CTRL + X**
2. **Choose Y (Option Yes)**
3. **Press Enter key**

Check the availability of created file using **$ ls** command.

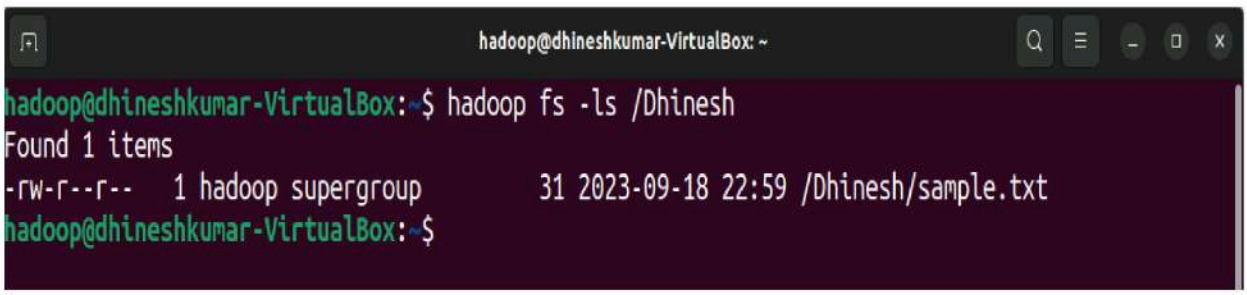
4. Moving file from local machine to hadoop user



$ hadoop fs -copyFromLocal /home/hadoop/sample.txt /Dhinesh



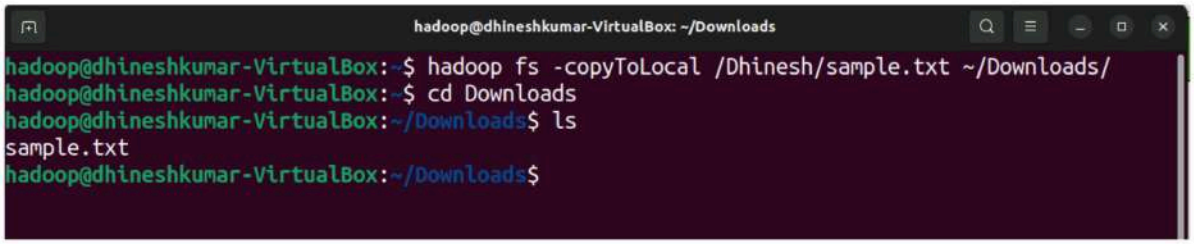
Check the moved file from browser.



Check the file creation using **$ hadoop fs -ls /Dhinesh**

5. Retrieving file from hadoop

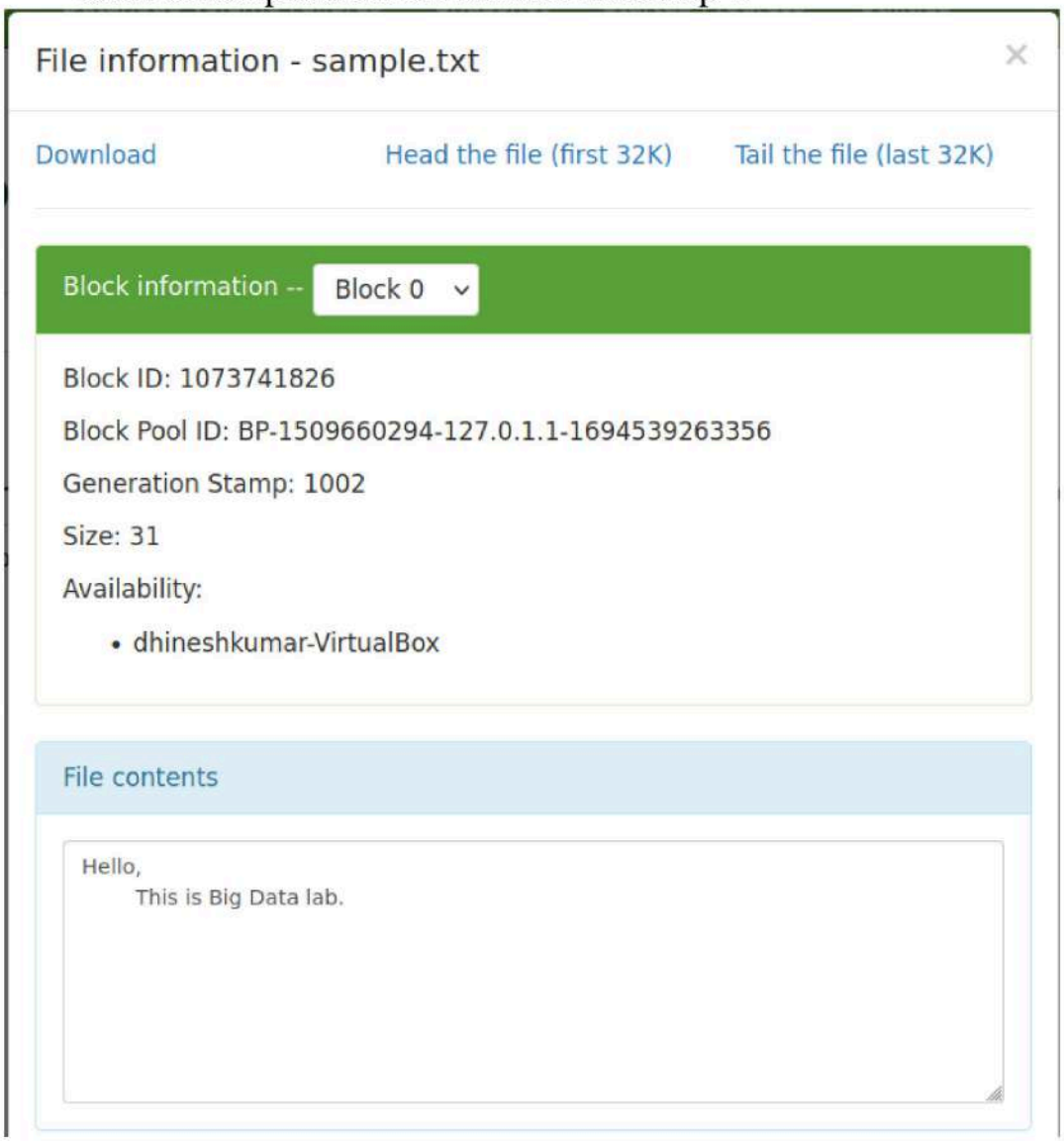
$ hadoop fs – copyToLocal /Dhinesh/sample.txt ~/Downloads/



Check the file transfer by going to Downloads folder and listing the available items using **$ ls**

6. File details

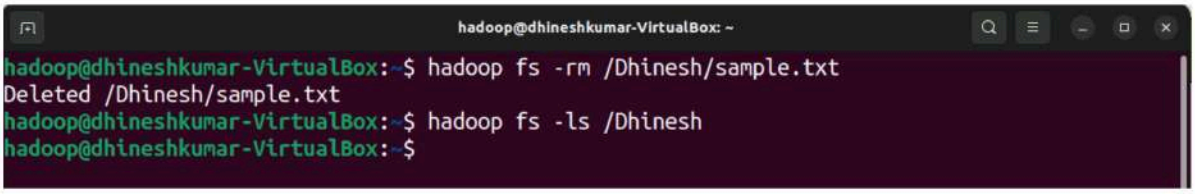
Click on sample.txt in the browser from step 4.

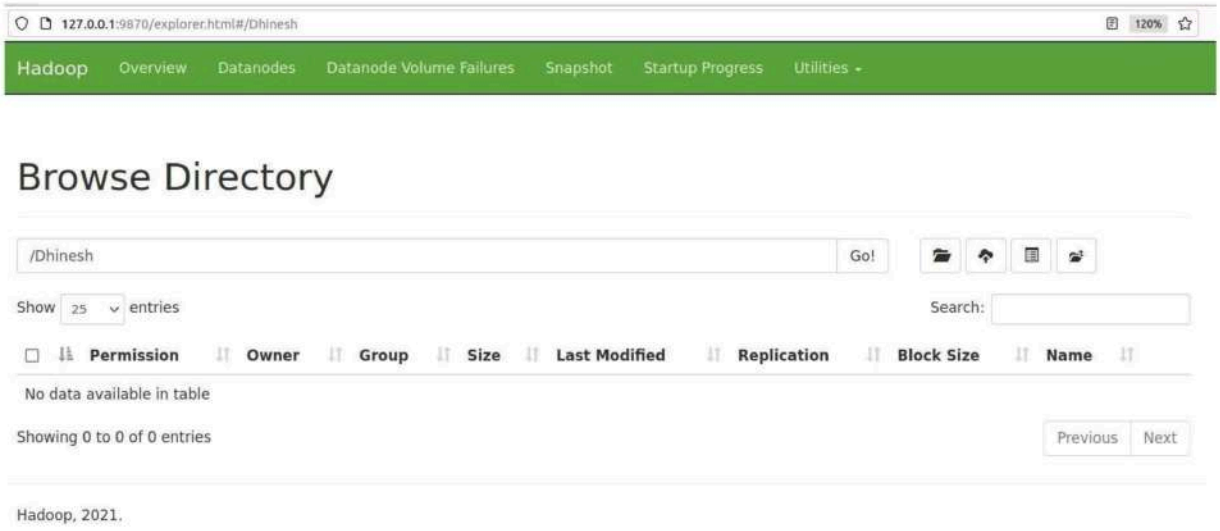


7. Deleting a file

$ hadoop fs -rm /Dhinesh/sample.txt (to delete the file)

$ hadoop fs -ls /Dhinesh (to check contents of Dhinesh directory)





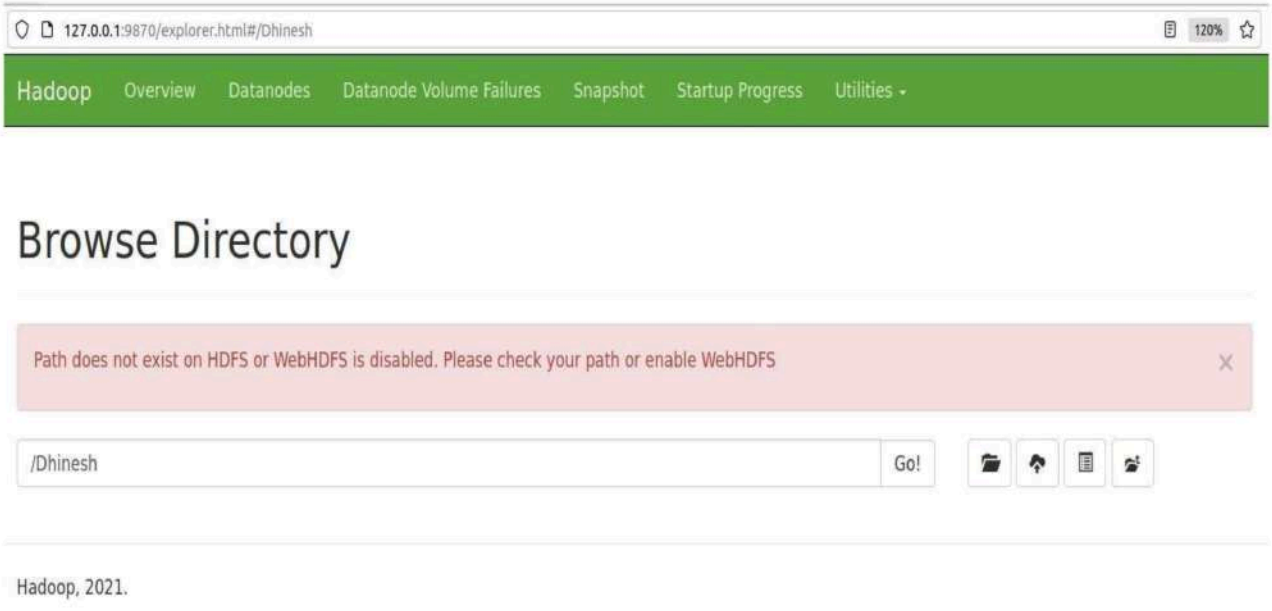
The browser also shows that the Dhinesh directory is empty.

8. Deleting the directory

$ hadoop fs -rm -r /Dhinesh (to delete the directory)

$ hadoop fs -ls / (to check the contents of root directory)

In browser the following error message is shown.

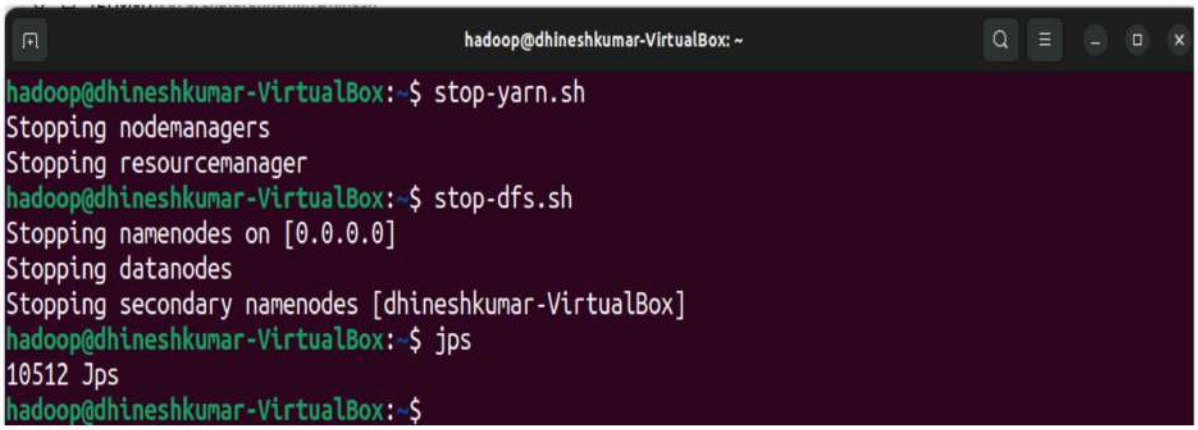


9. Stopping the hadoop resources.

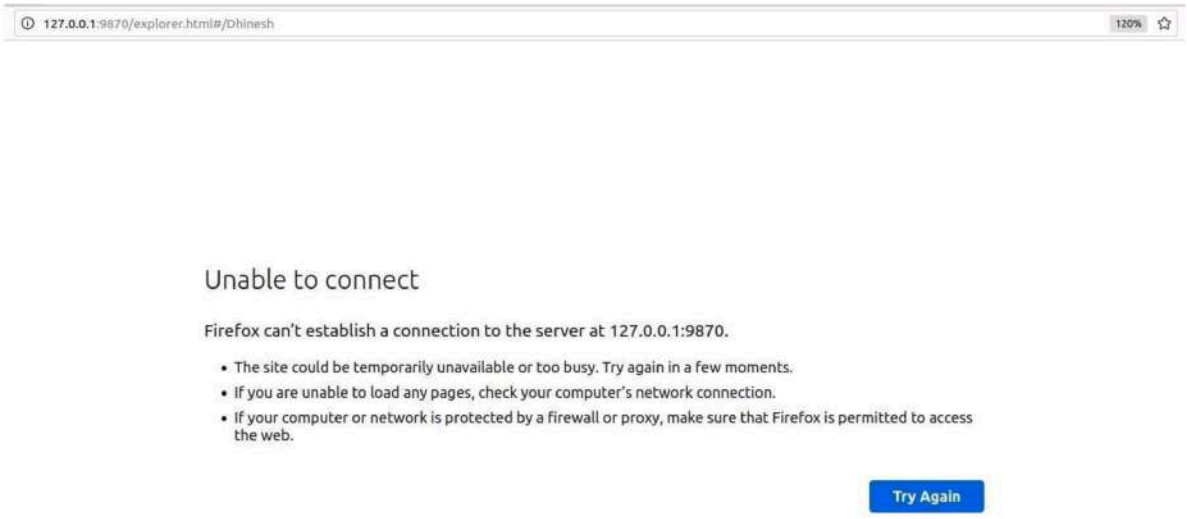
$ stop-yarn.sh

$ stop-dfs.sh

$ jps (Check the running components)



The browser's interactive hadoop dashboard will be closed.



RESULT

Thus the program has been executed successfully.

Ex No 3 Run a basic word count program to understand MapReduce paradigms
Date:

PROGRAM

WordCounter.java

```
package count;
import java.io.IOException;
import org.apache.hadoop.fs.Path;
import org.apache.hadoop.io.IntWritable;
import org.apache.hadoop.io.Text;
import org.apache.hadoop.mapred.FileInputFormat;
import org.apache.hadoop.mapred.FileOutputFormat;
import org.apache.hadoop.mapred.JobClient;
import org.apache.hadoop.mapred.JobConf;
import org.apache.hadoop.mapred.TextInputFormat;
import org.apache.hadoop.mapred.TextOutputFormat;
public class WordCounter {
   public static void main(String[] args) throws IOException{
      JobConf conf = new JobConf(WordCounter.class);
      conf.setJobName("WordCount");
      conf.setOutputKeyClass(Text.class);
      conf.setOutputValueClass(IntWritable.class);
      conf.setMapperClass(WordCountMapper.class);
      conf.setCombinerClass(WordCountReducer.class);
      conf.setReducerClass(WordCountReducer.class);
      conf.setInputFormat(TextInputFormat.class);
      conf.setOutputFormat(TextOutputFormat.class);
      FileInputFormat.setInputPaths(conf,new Path(args[0]));
      FileOutputFormat.setOutputPath(conf,new Path(args[1]));
      JobClient.runJob(conf); }}
```

WordCountMapper.java

```
package count;
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.mapred.MapReduceBase;
import org.apache.hadoop.mapred.Mapper;
import org.apache.hadoop.mapred.OutputCollector;
import org.apache.hadoop.mapred.Reporter;
public class WordCountMapper extends MapReduceBase implements
Mapper<LongWritable,Text,Text,IntWritable>{
   private final static IntWritable one = new IntWritable(1);
   private Text word = new Text();
   public void map(LongWritable key, Text
value,OutputCollector<Text,IntWritable> output,
                Reporter reporter) throws IOException{
      String line = value.toString();
      StringTokenizer tokenizer = new StringTokenizer(line);
      while (tokenizer.hasMoreTokens()){
         word.set(tokenizer.nextToken());
         output.collect(word, one);
       /*
      String line = value.toString().toLowerCase(); // Convert to lowercase
      StringTokenizer tokenizer = new StringTokenizer(line);
      while (tokenizer.hasMoreTokens()) {
         String token = tokenizer.nextToken();
```

```
            // Remove punctuation symbols (only keep letters and numbers)
            token = token.replaceAll("[^a-zA-Z0-9]", "");
        if (!token.isEmpty()) { // Check if token is !empty after removing punctuation
             word.set(token);
              output.collect(word, one);
           */
          }
      }
}
```

WordCountReducer.java

```
package count;
import java.io.IOException;
import java.util.Iterator;
import org.apache.hadoop.io.IntWritable;
import org.apache.hadoop.io.Text;
import org.apache.hadoop.mapred.MapReduceBase;
import  org.apache.hadoop.mapred.OutputCollector;
import org.apache.hadoop.mapred.Reducer;
import org.apache.hadoop.mapred.Reporter;
public class WordCountReducer extends MapReduceBase implements
Reducer<Text,IntWritable,Text,IntWritable> {
   public void reduce(Text key, Iterator<IntWritable>
values,OutputCollector<Text,IntWritable> output,
                    Reporter reporter) throws IOException {
      int sum=0;
      while  (values.hasNext())  {
         sum+=values.next().get();
      }
```

```
        output.collect(key,new IntWritable(sum));
}}
```

Close the eclipse and execute the below hadoop commands in the terminal.

COMMANDS

$ start-all.sh

$ jps

$ hadoop fs -mkdir /WordCount

$ hadoop fs -mkdir /WordCount/Input

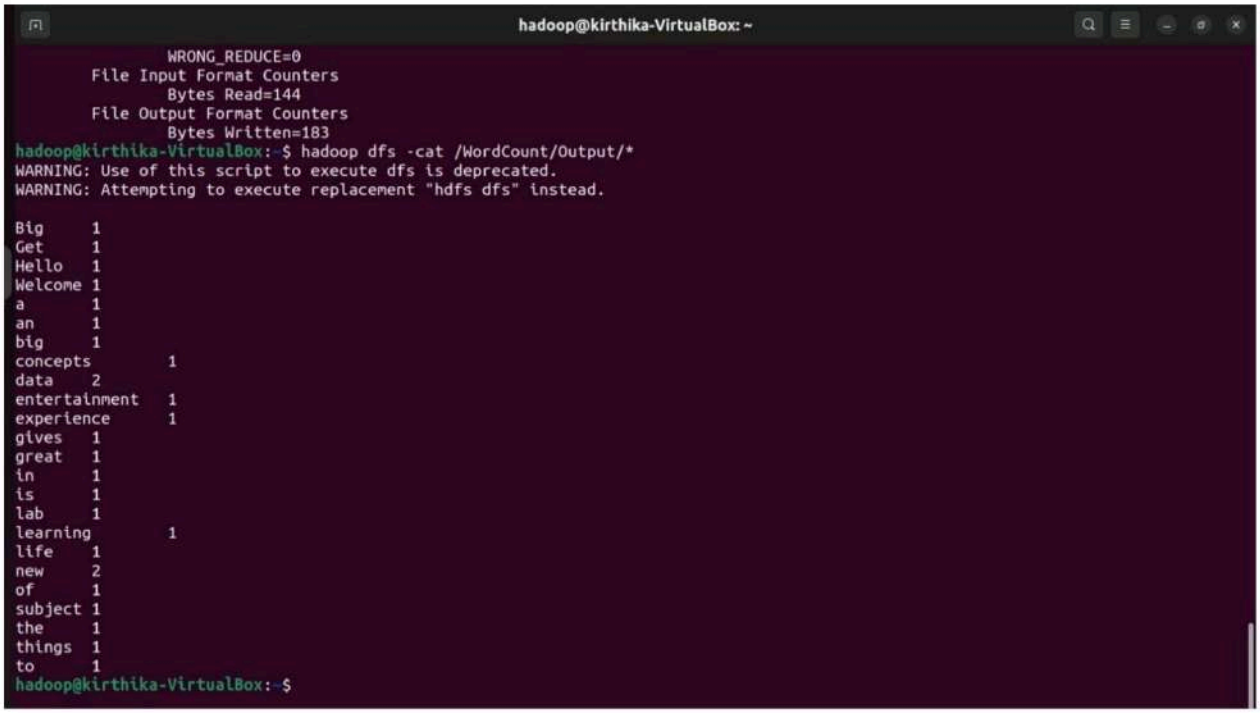
$ hadoop fs -put '/home/hadoop/eclipse-workspace/WordCount /input.txt' /WordCount /Input

$ hadoop jar '/home/hadoop/eclipse-workspace/WordCount /count.jar' / WordCount /Input / WordCount /Output

$ hadoop dfs -cat /MatrixMultiplicationTutorial/Output/*

(If any other issues are encountered, then the installation is not properly done.)

OUTPUT



RESULT

Thus the program has been executed successfully.

Ex No :4 **Data Preprocessing and Table Creation**
Date:

Step 1. Data Preprocessing

1.1 Create directories in hdfs to store the csv files

```
hadoop fs -mkdir /user/cloudera/covidAnalysis
```

1.2 Copy the files from local to hdfs

```
hadoop fs -copyFromLocal covid/covid19.csv /user/cloudera/covidAnalysis
hadoop fs -copyFromLocal covid/statewiseTesting.csv /user/cloudera/covidAnalysis
```

```
[root@quickstart Desktop]# hadoop fs -ls /user/cloudera/covidAnalysis
Found 2 items
-rw-r--r--   1 root cloudera      85487 2023-07-16 01:18 /user/cloudera/covidAnalysis/covid19.csv
-rw-r--r--   1 root cloudera      77259 2023-07-16 01:18 /user/cloudera/covidAnalysis/statewiseTesting.csv
```

1.3 Visualize the content of the files in hdfs

```
[root@quickstart Desktop]# hadoop fs -cat /user/cloudera/covidAnalysis/covid19.csv |head
530,1/4/2020,Andhra Pradesh,1,0,83
531,1/4/2020,Andaman and Nicobar Islands,0,0,10
532,1/4/2020,Assam,0,0,1
533,1/4/2020,Bihar,0,1,23
534,1/4/2020,Chandigarh,0,0,16
535,1/4/2020,Chhattisgarh,2,0,9
536,1/4/2020,Delhi,6,2,152
537,1/4/2020,Goa,0,0,5
538,1/4/2020,Gujarat,5,6,82
539,1/4/2020,Haryana,21,0,43
```

```
[root@quickstart Desktop]# hadoop fs -cat /user/cloudera/covidAnalysis/statewiseTesting.csv |head
1,4/17/2020,Andaman and Nicobar Islands,1403,1210,12
2,4/24/2020,Andaman and Nicobar Islands,2679,,27
3,4/27/2020,Andaman and Nicobar Islands,2848,,33
4,5/1/2020,Andaman and Nicobar Islands,3754,,33
5,5/16/2020,Andaman and Nicobar Islands,6677,,33
6,5/19/2020,Andaman and Nicobar Islands,6965,,33
7,5/20/2020,Andaman and Nicobar Islands,7082,,33
8,5/21/2020,Andaman and Nicobar Islands,7167,,33
9,5/22/2020,Andaman and Nicobar Islands,7263,,33
10,5/23/2020,Andaman and Nicobar Islands,7327,,33
```

1.4 Creation of Tables in Mysql

```
mysql> create table IF NOT EXISTS StateTesting(
    ->     seq int not null primary key,
    ->     date varchar(50),
    ->     state varchar(50) not null,
    ->     totalSamples int ,
    ->     negative int,
    ->     positive int
    -> );
Query OK, 0 rows affected (0.12 sec)
```

```
mysql> create table IF NOT EXISTS covidIndia(
    ->     sno int not null primary key,
    ->     date varchar(50),
    ->     state varchar(50) not null,
    ->     cured int ,
    ->     deaths int,
    ->     confirmed int
    -> );
Query OK, 0 rows affected (0.02 sec)
```

1.5 Sqoop Export of data from hdfs to Mysql

```
sqoop export \
--connect jdbc:mysql://quickstart.cloudera:3306/test_db \
--username root \
--password cloudera \
--table StateTesting \
--lines-terminated-by ',' \
--export-dir /user/cloudera/covidAnalysis/statewiseTesting.csv
```

```
                Bytes written=0
23/07/16 01:23:17 INFO mapreduce.ExportJobBase: Transferred 92.1865 KB in 52.1837 seconds (1.7666 KB/sec)
23/07/16 01:23:17 INFO mapreduce.ExportJobBase: Exported 1922 records.
```

```
sqoop export \
--connect jdbc:mysql://quickstart.cloudera:3306/test_db \
--username root \
--password cloudera \
--table covidIndia\
--lines-terminated-by ',' \
--export-dir /user/cloudera/covidAnalysis/covid19.csv
```

```
                Bytes written=0
23/07/16 01:25:31 INFO mapreduce.ExportJobBase: Transferred 100.1777 KB in 45.3055 seconds (2.2112 KB/sec)
23/07/16 01:25:31 INFO mapreduce.ExportJobBase: Exported 2390 records.
```

1.6 Verify in Mysql

```
mysql> select count(*) from covidIndia;
+----------+
| count(*) |
+----------+
|     2390 |
+----------+
1 row in set (0.00 sec)

mysql> select count(*) from StateTesting;
+----------+
| count(*) |
+----------+
|     1922 |
+----------+
1 row in set (0.00 sec)
```

1.7 Delete data from hdfs

Step 2- Sqoop Import

Command:

```
[root@quickstart Desktop]# sqoop-import \
> --connect jdbc:mysql://quickstart.cloudera:3306/test_db \
> --username root \
> --password cloudera \
> --table StateTesting \
> --incremental append \
> --check-column seq \
> --last-value 0 \
> --warehouse-dir /user/cloudera/covidAnalysis/sqoopImport
```

Command:

```
[root@quickstart Desktop]# sqoop-import \
> --connect jdbc:mysql://quickstart.cloudera:3306/test_db \
> --username root \
> --password cloudera \
> --table covidIndia \
> --incremental append \
> --check-column sno \
> --last-value 0 \
> --warehouse-dir /user/cloudera/covidAnalysis/sqoopImport
```

Output:

```
[root@quickstart Desktop]# hadoop fs -ls /user/cloudera/covidAnalysis/sqoopImport
Found 2 items
drwxr-xr-x   - root cloudera          0 2023-07-16 06:39 /user/cloudera/covidAnalysis/sqoopImport/StateTesting
drwxr-xr-x   - root cloudera          0 2023-07-16 06:43 /user/cloudera/covidAnalysis/sqoopImport/covidIndia
[root@quickstart Desktop]# hadoop fs -ls /user/cloudera/covidAnalysis/sqoopImport/StateTesting
Found 4 items
-rw-r--r--   1 root supergroup      19443 2023-07-16 06:39 /user/cloudera/covidAnalysis/sqoopImport/StateTesting/part-m-00000
-rw-r--r--   1 root supergroup      19266 2023-07-16 06:39 /user/cloudera/covidAnalysis/sqoopImport/StateTesting/part-m-00001
-rw-r--r--   1 root supergroup      18589 2023-07-16 06:39 /user/cloudera/covidAnalysis/sqoopImport/StateTesting/part-m-00002
-rw-r--r--   1 root supergroup      19815 2023-07-16 06:39 /user/cloudera/covidAnalysis/sqoopImport/StateTesting/part-m-00003
```

Step 3- Create Hive External Tables on top of data in HDFS

3.1 Connect to hive and select/create a database

```
[root@quickstart cloudera]# beeline -u jdbc:hive2://
scan complete in 2ms
Connecting to jdbc:hive2://
Connected to: Apache Hive (version 1.1.0-cdh5.13.0)
Driver: Hive JDBC (version 1.1.0-cdh5.13.0)
Transaction isolation: TRANSACTION_REPEATABLE_READ
Beeline version 1.1.0-cdh5.13.0 by Apache Hive
0: jdbc:hive2://> show databases;
OK
+----------------+--+
| database_name  |
+----------------+--+
| default        |
| mydb           |
| testdb         |
+----------------+--+
3 rows selected (1.234 seconds)
0: jdbc:hive2://> use testdb;
OK
No rows affected (0.095 seconds)
```

3.2 Creation of Hive External Tables on top of data in HDFS

StateTesting table

```
0: jdbc:hive2://> create external table if not exists stateTesting(
. . . . . > seq int,
. . . . . > date string,
. . . . . > state string,
. . . . . > totalSamples int,
. . . . . > negative int,
. . . . . > positive int
. . . . . > )
. . . . . > row format delimited
. . . . . > fields terminated by ','
. . . . . > stored as textfile
. . . . . > location '/user/cloudera/covidAnalysis/sqoopImport/StateTesting';
```

```
0: jdbc:hive2://> select * from stateTesting LIMIT 5;
OK
+-------------------+--------------------+-----------------------------+-----------------------------+---------------------------+---------------------------+--+
| statetesting.seq  | statetesting.date  |      statetesting.state     | statetesting.totalsamples   | statetesting.negative     | statetesting.positive     |
+-------------------+--------------------+-----------------------------+-----------------------------+---------------------------+---------------------------+--+
| 1                 | 4/17/2020          | Andaman and Nicobar Islands | 1403                        | 1210                      | 12                        |
| 2                 | 4/24/2020          | Andaman and Nicobar Islands | 2679                        | NULL                      | 27                        |
| 3                 | 4/27/2020          | Andaman and Nicobar Islands | 2848                        | NULL                      | 33                        |
| 4                 | 5/1/2020           | Andaman and Nicobar Islands | 3754                        | NULL                      | 33                        |
| 5                 | 5/16/2020          | Andaman and Nicobar Islands | 6677                        | NULL                      | 33                        |
+-------------------+--------------------+-----------------------------+-----------------------------+---------------------------+---------------------------+--+
```

Similarly, we do for covidIndia Table

Step 4- Create Optimized External tables in Hive

Optimizations Applied-

- File format used- ORC for Quicker and Efficient Reads
- Compression Codec used- Snappy for Fast Compression
- Partitioning on State Column
- Bucketing on Date Column

4.1 Create directories in hdfs for the Dynamically created Partitions:

```
hadoop fs -mkdir /user/cloudera/covidAnalysis/partitions_testing
hadoop fs -mkdir /user/cloudera/covidAnalysis/partitions_covidIndia
```

4.2 Enabling Dynamic Partitioning and Bucketing in Hive:

```
set hive.exec.dynamic.partition = true;
set hive.exec.dynamic.partition.mode = nonstrict;
set hive.enforce.bucketing = true;
```

```
0: jdbc:hive2://>  set hive.exec.dynamic.partition = true;
No rows affected (0.32 seconds)
0: jdbc:hive2://> set hive.exec.dynamic.partition.mode = nonstrict;
No rows affected (0.007 seconds)
0: jdbc:hive2://> set hive.enforce.bucketing = true;
No rows affected (0.015 seconds)
```

4.3 Optimized External tables creation in Hive :

```
0: jdbc:hive2://> create external table testing_OP
. . . . . > (seq INT,
. . . . . > date DATE,
. . . . . > totalSamples INT,
. . . . . > negative INT,
. . . . . > positive INT)
. . . . . > PARTITIONED BY (state STRING)
. . . . . > CLUSTERED BY (date) into 4 BUCKETS
. . . . . > STORED AS ORC
. . . . . > LOCATION '/user/cloudera/covidAnalysis/partitions_testing
. . . . . > TBLPROPERTIES('orc.compress' = 'SNAPPY');
OK
0: jdbc:hive2://> create external table covidIndia_OP
. . . . . > (sno INT,
. . . . . > date DATE,
. . . . . > cured INT,
. . . . . > deaths INT,
. . . . . > confirmed INT)
. . . . . > PARTITIONED BY (state STRING)
. . . . . > CLUSTERED BY (date) into 4 BUCKETS
. . . . . > STORED AS ORC
. . . . . > LOCATION '/user/cloudera/covidAnalysis/partitions_covidIndia'
. . . . . > TBLPROPERTIES('orc.compress' = 'SNAPPY');
OK
No rows affected (0.966 seconds)
```

Step 5: Load data to the optimized hive tables from normal hive tables.

The date in stateTesting table is of the format M/dd/yyyy . We need to

```
0: jdbc:hive2://> INSERT into TABLE testing_OP
. . . . . > PARTITION (state)
. . . . . > SELECT
. . . . . > seq,from_unixtime(unix_timestamp(date,'M/dd/yyyy'),'yyyy-MM-dd'),
. . . . . > totalSamples,negative,positive,state
. . . . . > FROM stateTesting;
```

convert it to yyyy-MM-dd format.

The date in covidIndia table is of the format dd-MM-yyyy . We need

```
0: jdbc:hive2://> INSERT OVERWRITE TABLE covidIndia_OP
. . . . . > PARTITION (state)
. . . . . > SELECT
. . . . . > sno,from_unixtime(unix_timestamp(date,'dd-MM-yyyy'),'yyyy-MM-dd'),
. . . . . > cured,deaths,confirmed,state
. . . . . > FROM covidIndia;
```

to convert it to yyyy-MM-dd format.

Verification:

Partitions based on state

```
[root@quickstart Desktop]# hadoop fs -ls /user/cloudera/covidAnalysis/partitions_covidIndia
Found 38 items
drwxr-xr-x   - root cloudera          0 2023-07-16 09:04 /user/cloudera/covidAnalysis/partitions_covidIndia/state=Andaman and Nicobar Isl
drwxr-xr-x   - root cloudera          0 2023-07-16 09:04 /user/cloudera/covidAnalysis/partitions_covidIndia/state=Andhra Pradesh
drwxr-xr-x   - root cloudera          0 2023-07-16 09:04 /user/cloudera/covidAnalysis/partitions_covidIndia/state=Arunachal Pradesh
drwxr-xr-x   - root cloudera          0 2023-07-16 09:04 /user/cloudera/covidAnalysis/partitions_covidIndia/state=Assam
drwxr-xr-x   - root cloudera          0 2023-07-16 09:04 /user/cloudera/covidAnalysis/partitions_covidIndia/state=Bihar
drwxr-xr-x   - root cloudera          0 2023-07-16 09:04 /user/cloudera/covidAnalysis/partitions_covidIndia/state=Cases being reassigned
drwxr-xr-x   - root cloudera          0 2023-07-16 09:04 /user/cloudera/covidAnalysis/partitions_covidIndia/state=Chandigarh
drwxr-xr-x   - root cloudera          0 2023-07-16 09:04 /user/cloudera/covidAnalysis/partitions_covidIndia/state=Chhattisgarh
```

4 Buckets in each partition

```
[root@quickstart Desktop]# hadoop fs -ls /user/cloudera/covidAnalysis/partitions_covidIndia/state=Odisha
Found 4 items
-rwxr-xr-x   1 root cloudera        728 2023-07-16 09:04 /user/cloudera/covidAnalysis/partitions_covidIndia/state=Odisha/000000_0
-rwxr-xr-x   1 root cloudera        729 2023-07-16 09:04 /user/cloudera/covidAnalysis/partitions_covidIndia/state=Odisha/000001_0
-rwxr-xr-x   1 root cloudera        674 2023-07-16 09:04 /user/cloudera/covidAnalysis/partitions_covidIndia/state=Odisha/000002_0
-rwxr-xr-x   1 root cloudera        701 2023-07-16 09:04 /user/cloudera/covidAnalysis/partitions_covidIndia/state=Odisha/000003_0
```

Data stored in ORC format

Step 6-Inner Join two tables in Hive and get a consolidated table.

Performing Map side join on two columns ‘date’ and ‘state’.

Here it is assumed that the State_Testing table is small enough to fit in memory

6.1 Set the below Properties

```
set hive.auto.convert.join = false;
set hive.ignore.mapjoin.hint = false;
```

6.2 Execute Inner Join as Mapside join (testing_OP is the smaller table)

```
SELECT /*+ MAPJOIN(T)
*/T.state,T.date,T.totalSamples,T.negative,T.positive,C.cured,C.deaths,
C.confirmed FROM testing_OP T JOIN covidIndia_OP C
ON (C.state = T.state) AND (C.date = T.date);
```

Joined Table Snapshot

t.state	t.date	t.totalsamples	t.negative	t.positive	c.cured	c.deaths	c.confirmed
Tamil Nadu	2020-06-09	621171	585678	34914	17527	286	33229
Tamil Nadu	2020-06-01	503339	479208	23495	12757	173	22333
Telangana	2020-04-19	14962	14104	858	186	18	844
Telangana	2020-05-16	23388	NULL	1551	959	34	1454
Telangana	2020-04-28	19063	NULL	1009	321	26	1004
Telangana	2020-04-29	19278	NULL	1016	367	26	1012
Tripura	2020-06-02	29066	28595	471	173	0	420
Tripura	2020-05-05	5850	5820	30	2	0	29
Tripura	2020-04-22	3215	3123	2	1	0	2
Tripura	2020-05-01	4828	4825	3	2	0	2
Tripura	2020-05-30	26376	26105	271	171	0	251
Tripura	2020-05-27	23264	23032	232	165	0	207
Tripura	2020-05-23	18737	18546	191	152	0	175

6.3 Create a consolidated table after join

```
CREATE TABLE covid_details AS
SELECT /*+ MAPJOIN(T)
*/T.state,T.date,T.totalSamples,T.negative,T.positive,C.cured,C.deaths,
C.confirmed FROM testing_OP T JOIN covidIndia_OP C
ON (C.state = T.state) AND (C.date = T.date);
```

Count:

_c0
1849

Step 7- Analysis

1. **Ideally, the number of samples tested positive and number of covid cases confirmed must be the same. See which state/states have more consistent data collection like The number of positive samples (table1) match mostly with number of confirmed cases(table2), for which state.**

   Ideally, the number of samples tested positive and number of covid cases confirmed must be the same. So we find the percentage of records in each state where the data is consistent.

```
select state,avg(case when positive = confirmed then 1 else 0 end)*100 as
accuracy_percent
from covid_details
group by state
order by accuracy_percent;
```

state	accuracy_percent
Haryana	0.0
Telangana	0.0
Rajasthan	0.0
Punjab	1.5384615384615385
Uttar Pradesh	1.5384615384615385
Tamil Nadu	1.5384615384615385
Gujarat	1.5873015873015872
Jammu and Kashmir	1.5873015873015872
Delhi	3.225806451612903
Karnataka	4.545454545454546
Madhya Pradesh	7.575757575757576
Kerala	8.450704225352112
Jharkhand	11.864406779661017
Assam	13.043478260869565
Bihar	17.46031746031746
Arunachal Pradesh	18.867924528301888
Puducherry	20.754716981132077
Odisha	21.21212121212121
Tripura	23.91304347826087
Chandigarh	27.419354838709676
Nagaland	30.434782608695656
Andhra Pradesh	30.64516129032258
Himachal Pradesh	30.64516129032258
West Bengal	34.32835820895522
Uttarakhand	35.38461538461539
Chhattisgarh	42.857142857142854
Ladakh	46.42857142857143
Manipur	56.666666666666664
Goa	57.89473684210527
Dadra and Nagar Haveli	70.0
Sikkim	70.58823529411765
Maharashtra	72.72727272727273
Meghalaya	76.92307692307693
Mizoram	86.4406779661017
Andaman and Nicobar Islands	88.88888888888889

35 rows selected (73.028 seconds)

According to the above results, we can conclude the top 5 states with accurate covid testing for the given 2 months are **- Sikkim, Maharashtra, Meghalaya, Mizoram and Andaman and Nicobar Islands**

While the worst-performing ones are - **Haryana, Telangana, Rajasthan, Punjab, Uttar Pradesh, Tamil Nadu and Gujarat**

2. For every state, find the total number of confirmed cases reported and also the total number of positive samples tested, in the entire duration of 2 months, starting with the state with the highest cases.

If we scan the data we can see the data is cumulative for example TotalSamples shows cumulative total, Confirmed field shows cumulative value. So the value in each day is actually the total number till that day. Hence we only need to find the maximum number.

```
select state,max(positive) as totalPositives , max(confirmed) as
totalConfirmed from covid_details
group by state
order by totalConfirmed desc;
```

state	totalpositives	totalconfirmed
Maharashtra	90787	90787
Tamil Nadu	36841	34914
Delhi	32810	31309
Gujarat	21554	21014
Uttar Pradesh	11610	11335
Rajasthan	11600	11245
Madhya Pradesh	10049	9849
West Bengal	9328	8985
Karnataka	6041	5921
Bihar	5583	5459
Haryana	5438	5209
Andhra Pradesh	4126	5070
Jammu and Kashmir	4507	4346
Odisha	3250	3140
Assam	2937	2776
Punjab	2805	2719
Kerala	2162	2096
Uttarakhand	1560	1537
Telangana	1551	1454
Jharkhand	1423	1411
Chhattisgarh	1262	1240
Tripura	897	864
Himachal Pradesh	451	445
Goa	387	359
Chandigarh	328	323
Manipur	311	304
Nagaland	128	127
Puducherry	156	127
Ladakh	108	103
Arunachal Pradesh	61	57
Meghalaya	44	43
Mizoram	88	42
Andaman and Nicobar Islands	33	33
Dadra and Nagar Haveli	27	22
Sikkim	12	13

RESULT

Thus the program has been executed successfully.

Dataframe Basic Operations (Python)

Import notebook

Creating a SparkSession

- The SparkSession is the entry point to programming with Spark SQL.
- It allows you to create DataFrames, register DataFrames as tables, execute SQL over tables, cache tables, and read parquet files.
- **SparkSession.builder**: The builder attribute is a class attribute of SparkSession that provides a way to configure and create a SparkSession instance.
- **appName("Example App")**: The appName method sets the name of the Spark application. This name will appear in the Spark web UI and can help you identify your application among others running on the same cluster.
- **config("spark.some.config.option", "some-value")**: The config method allows you to set various configuration options for the Spark session. In this example, "" is a placeholder for an actual
  configuration key, and "some-value" is the value for that configuration. You can set multiple configuration options by chaining multiple config calls.
- **getOrCreate()**: The getOrCreate method either retrieves an existing SparkSession if one already exists or creates a new one if it does not. This ensures that you do not accidentally create multiple SparkSession instances in your application.

Note:In Databricks, you do not need to create or override the SparkSession as it is automatically created for each notebook or job executed against the cluster. Databricks manages the SparkSession and SparkContext for you, ensuring optimal configuration and resource usage.

```
from pyspark.sql import SparkSession
spark = SparkSession.builder.appName("Spark DataFrames").config("spark.some.config.option", "some- value").getOrCreate()
```

Creating DataFrame

1. From Python a List of Tuples

```
%python
# List of tuples
data = [("John", 25), ("Doe", 30), ("Jane", 22)]

# Creating DataFrame
df_list = spark.createDataFrame(data, ["Name", "Age"])

# Display the DataFrame
df_list.show()
```

```
▸ df_list: pyspark.sql.dataframe.DataFrame = [Name: string, Age: long]
+----+---+
|Name|Age|
+----+---+
|John| 25|
| Doe| 30|
|Jane| 22|
+    +   +
```

1. From a List of Dictionaries

```
%python
# List of dictionaries
data = [{"Name": "Alice", "Id": 1}, {"Name": "Bob", "Id": 2}, {"Name": "Cathy", "Id": 3}]

# Creating DataFrame
df_dict = spark.createDataFrame(data)

# Display the DataFrame df_dict.show()
```

2. From a List of Rows

```
%python
from pyspark.sql import Row

# List of Rows
data = [ Row(Name="Cathy", Id=1),
      Row(Name="David", Id=2),
      Row(Name="Eva", Id=3),
      Row(Name="Frank", Id=4)]

# Creating DataFrame
df_row = spark.createDataFrame(data)

# Display the DataFrame
df_row.show()
```

```
▸ df_row:  pyspark.sql.dataframe.DataFrame = [Name: string, Id: long]
+------+---+
| Name| Id|
+-----+---+
 |Cathy|  1|
 |David|  2|
 |  Eva|  3|
 |Frank|  4|
 +-----+---+
```

1. Creating a DataFrame from an RDD

```
%python
# Import necessary modules from
pyspark.sql import Row

# Create an RDD
rdd      =      spark.sparkContext.parallelize([
      Row(Name="Alice", Age=25),
      Row(Name="Bob", Age=30),
      Row(Name="Cathy", Age=22),
      Row(Name="David", Age=35),
      Row(Name="Eva", Age=28),
      Row(Name="Frank", Age=40)
])

# Convert RDD to DataFrame
df_rdd = spark.createDataFrame(rdd)

# Display the DataFrame
df_rdd.show()
```

```
▸ df_rdd:  pyspark.sql.dataframe.DataFrame = [Name: string, Age: long]
+-----+---+
| Name|Age|
+-----+---+
|Alice| 25|
|  Bob| 30|
|Cathy| 22|
|David| 35|
|  Eva| 28|
|Frank| 40|
+-----+---+
```

2. Reading external file

spark.read: This is the entry point for reading data in Spark. It returns a DataFrameReader object that is used to read data from various sources.

.format("csv"): Specifies the format of the data source. In this case, it indicates that the data is in CSV (Comma- Separated Values) format.

.option("header", "true"): This option tells Spark that the first row of the CSV file contains the column names. If this option is set to false, Spark will treat the first row as data. "true" means that the CSV file has a header row.

.option("inferSchema", "true"): This option tells Spark to automatically infer the data types of each column in the CSV file. If this option is set to false, all columns will be read as strings (default behavior). "true" means that Spark will try to infer the schema (data types) of the columns based on the data.

.load("/FileStore/tables/retail_db/customers"):

This method specifies the path to the CSV file or directory containing CSV files that you want to read.

```
customer_df=spark.read.format("csv").option("header","true").option("inferSchema","true").load("dbfs:/FileStor
e/tables/customers_300mb.csv")
```

```
▸ customer_df:  pyspark.sql.dataframe.DataFrame = [customer_id: integer, name: string ... 5 more fields]
```

3. Using StructType & StructField

```
%python
#employee data and schemas
from pyspark.sql.types import StructType, StructField, IntegerType, StringType, FloatType, DateType from
datetime import date

# Create dummy data as a list of lists emp_data = [
    [1, 101, "John Doe", 30, "M", 60000.0, date(2020, 1, 15)],
    [2, 102, "Jane Smith", 25, "F", 65000.0, date(2019, 3, 10)],
    [3, 101, "Mike Johnson", 35, "M", 70000.0, date(2018, 5, 20)],
    [4, 103, "Emily Davis", 28, "F", 72000.0, date(2021, 7, 30)],
    [5, 102, "Robert Brown", 40, "M", 80000.0, date(2017, 9, 25)],
    [6, 101, "Linda Wilson", 32, "F", 68000.0, date(2020, 11, 5)],
    [7, 103, "David Lee", 29, "M", 75000.0, date(2019, 12, 15)]]

# Define the schema
emp_schema = StructType([
    StructField("empid", StringType(), True),
    StructField("deptid", IntegerType(), True), StructField("name",
    StringType(), True),
    StructField("age", IntegerType(), True),
    StructField("gender", StringType(), True), StructField("salary",
    FloatType(), True), StructField("hiredate", DateType(), True)
])
# Create DataFrame
df = spark.createDataFrame(emp_data, emp_schema)
#df = spark1.createDataFrame(data = emp_data, schema = emp_schema)

# Display the DataFrame df.show()
```

```
▸ df: pyspark.sql.dataframe.DataFrame = [empid: string, deptid: integer ... 5 more fields]
```

```
+-----+------+-------------+---+------+--------+ ----------------+
|empid|deptid|         name|age|gender| salary|  hiredate|
+-----+------+-------------+---+------+--------+ ----------------+
|    1|   101|     John Doe| 30|     M|60000.0|2020-01-15|
|    2|   102|   Jane Smith| 25|     F|65000.0|2019-03-10|
|    3|   101|Mike Johnson| 35|     M|70000.0|2018-05-20|
|    4|   103| Emily Davis| 28|     F|72000.0|2021-07-30|
|    5|   102|Robert Brown| 40|     M|80000.0|2017-09-25|
|    6|   101|Linda Wilson| 32|     F|68000.0|2020-11-05|
|    7|   103|    David Lee| 29|     M|75000.0|2019-12-15|
+-----+------+-------------+---+------+--------+----------------------------------------------------+
```

Basic DataFrame Operation

1. show() & display()

In Databricks, show() and display() are used to visualize DataFrames, but they have different functionalities:

show(): This is a method available on Spark DataFrames that prints the first n rows to the console. It is useful for quick inspection of data but does not provide rich formatting or interactivity. You can specify the number of rows to display, and it defaults to 20 rows if not specified.

display(): This is a Databricks-specific function that provides a rich, interactive view of the DataFrame. It is more suitable for use within notebooks as it allows for better visualization, including sorting, filtering, and graphical representation of data.

```
+-----------+-----------+------+------------+--------+-------------------+-------------------+
|customer_id|       name|  city|       state|country|registration_date|is_active|
+-----------+-----------+------+------------+--------+-------------------+-------------------+
|          0|Customer_0|  Pune|Maharashtra|  India|         2023-01-19|       true|
|          1|Customer_1|  Pune|West Bengal|  India|         2023-08-10|       true|
|          2|Customer_2| Delhi|Maharashtra|  India|         2023-08-05|       true|
|          3|Customer_3|Mumbai|  Telangana|  India|         2023-06-04|       true|
|          4|Customer_4| Delhi|  Karnataka|  India|         2023-03-15|      false|
+-----------+-----------+------+------------+--------+-------------------+-------------------+
only showing top 5 rows
```

```
customer_df.show(5)
```

```
customer_df.display()

#display(customer_df)
```

Table +

	customer_id	name	city	state	country	registration_date	is_active
1	0	Customer_0	Pune	Maharashtra	India	2023-01-19	true
2	1	Customer_1	Pune	West Bengal	India	2023-08-10	true
3	2	Customer_2	Delhi	Maharashtra	India	2023-08-05	true
4	3	Customer_3	Mumbai	Telangana	India	2023-06-04	true
5	4	Customer_4	Delhi	Karnataka	India	2023-03-15	false
6	5	Customer_5	Kolkata	West Bengal	India	2023-08-19	true
7	6	Customer_6	Kolkata	Tamil Nadu	India	2023-04-21	false
8	7	Customer_7	Mumbai	Telangana	India	2023-05-23	true
9	8	Customer_8	Pune	Tamil Nadu	India	2023-07-17	true
10	9	Customer_9	Delhi	Karnataka	India	2023-06-02	true
11	10	Customer_10	Hyderabad	Delhi	India	2023-02-23	true
12	11	Customer_11	Delhi	West Bengal	India	2023-11-08	true
13	12	Customer_12	Delhi	Delhi	India	2023-06-27	false
14	13	Customer_13	Pune	Maharashtra	India	2023-02-03	true
15	14	Customer_14	Chennai	Karnataka	India	2023-04-06	true

	customer_id	name	city	state	country	registration_date	is_active
14	13	Customer_13	Pune	Maharashtra	India	2023-02-03	true
15	14	Customer_14	Chennai	Karnataka	India	2023-04-06	true
16	15	Customer_15	Hyderabad	West Bengal	India	2023-03-31	true
17	16	Customer_16	Chennai	Maharashtra	India	2023-04-26	true
18	17	Customer_17	Pune	Delhi	India	2023-04-14	false
19	18	Customer_18	Chennai	Maharashtra	India	2023-02-04	false
20	19	Customer_19	Chennai	Karnataka	India	2023-01-22	true
21	20	Customer_20	Pune	Karnataka	India	2023-02-19	false
22	21	Customer_21	Hyderabad	Tamil Nadu	India	2023-09-16	true
23	22	Customer_22	Delhi	Karnataka	India	2023-12-27	true
24	23	Customer_23	Chennai	Tamil Nadu	India	2023-01-22	true
25	24	Customer_24	Pune	West Bengal	India	2023-09-11	true
26	25	Customer_25	Hyderabad	West Bengal	India	2023-08-22	true
27	26	Customer_26	Kolkata	West Bengal	India	2023-07-21	false
28	27	Customer_27	Pune	Gujarat	India	2023-02-09	false

10,000+ rows | Truncated data | 0.89s runtime

2. Columns & Prinschema()

In Spark, columns and printSchema() are used to inspect the structure of a DataFrame, but they serve different purposes:

- **columns:** This attribute returns a list of the column names in the DataFrame.
- **printSchema():** This method prints the schema of the DataFrame, including column names and data types, in a tree format.

```
customer_df.columns
```

```
root
 |-- customer_id: integer (nullable = true)
 |-- name: string (nullable = true)
 |-- city: string (nullable = true)
 |-- state: string (nullable = true)
 |-- country: string (nullable = true)
 |-- registration_date: date (nullable = true)
```

```
customer_df.printSchema()
```

```
['customer_id', 'name',
 'city',
 'state',
 'country',
 'registration_date',
 'is_active']
```

3. Select specific columns

```
customer_df.select("name","city").show()
```

```
|Customer_5|      Kolkata|
|Customer_6|      Kolkata|
|Customer_7|       Mumbai|
|Customer_8|         Pune|
|Customer_9|        Delhi|
|Customer_10|Hyderabad|
|Customer_11|       Delhi|
|Customer_12|       Delhi|
|Customer_13|         Pune|
|Customer_14|  Chennai|
|Customer_15|Hyderabad|
|Customer_16|  Chennai|
|Customer_17|         Pune|
|Customer_18|  Chennai|
|Customer_19|  Chennai|
+------------+-------------------------+
only showing top 20 rows
```

4. Filter rows

```
customer_df.filter(customer_df.city=="Hyderabad").show()
```

```
customer_df.where(customer_df.city=="Hyderabad").show()
```

```
|  25| Customer_25|Hyderabad|West Bengal|  India|  2023-08-22|  true|
|  34| Customer_34|Hyderabad|  Telangana|  India|  2023-10-20|  true|
|  37| Customer_37|Hyderabad|     Gujarat|  India|  2023-03-13|  false|
|  38| Customer_38|Hyderabad|  Karnataka|  India|  2023-06-19|  false|
|  21| Customer_21|Hyderabad| Tamil Nadu|  India|  2023-09-16|  true|
|  25| Customer_25|Hyderabad|West Bengal|  India|  2023-08-22|  true|
|  34| Customer_34|Hyderabad|  Telangana|  India|  2023-10-20|  true|
|  37| Customer_37|Hyderabad|  38|  Gujarat|  India|  2023-03-13|  false|
|  Customer_38|Hyderabad|  Karnataka|  India|  2023-06-19|  false|
|  40| Customer_40|Hyderabad|Maharashtra|  India|  2023-07-29|  false|
|  44|  Customer_44|Hyderabad|  Telangana|  84|  India|  2023-08-18|  false|
| Customer_84|Hyderabad|Maharashtra|  India|  2023-04-08|  false|
| 100|Customer_100|Hyderabad|Maharashtra|  India|  2023-12-30|  false|
| 110|Customer_110|Hyderabad|Maharashtra|  India|  2023-03-14|  false|
| 118|Customer_118|Hyderabad|  Gujarat|  India|  2023-01-27|  false|
| 134|Customer_134|Hyderabad|West Bengal|  India|  2023-06-25|  true|
| 137|Customer_137|Hyderabad|  Tamil Nadu|  India|  2023-03-11|  true|
| 138|Customer_138|Hyderabad|  Delhi|  India|  2023-12-26|  true|
| 149|Customer_149|Hyderabad|  Karnataka|  India|  2023-09-21|  false|
| 150|Customer_150|Hyderabad|Maharashtra|  India|  2023-11-10|  false|
| 171|Customer_171|Hyderabad|West Bengal|  India|  2023-12-24|  true|
| 173|Customer_173|Hyderabad|  Gujarat|  India|  2023-05-30|  false|
+------------+-------------+----------+-------------+--------+-------------------+
only showing top 20 rows
```

```
|        134|Customer_134|Hyderabad|West  Bengal|   India|       2023-06-25|       true|
|        137|Customer_137|Hyderabad| Tamil Nadu|   India|       2023-03-11|       true|
|        138|Customer_138|Hyderabad|      Delhi|   India|       2023-12-26|       true|
|        149|Customer_149|Hyderabad|  Karnataka|   India|       2023-09-21|      false|
|        150|Customer_150|Hyderabad|Maharashtra|   India|       2023-11-10|      false|
|        171|Customer_171|Hyderabad|West  Bengal|   India|       2023-12-24|       true|
|        173|Customer_173|Hyderabad|     Gujarat|   India|       2023-05-30|      false|
+----------+------------+---------+------------+--------+-----------------+-----------+
only showing top 20 rows
```

5. Create or replace new column

The **withColumn** method is used to create a new column or replace an existing column in a DataFrame.

```
df.withColumn("name","defination")
```

```
%python
from pyspark.sql.functions import col, concat, lit

# col: A function to reference a column in a DataFrame.
# concat: A function to concatenate multiple columns or strings. # lit: A function to
create a column with a literal value.

# Example: Adding a new column
df_with_new_column = customer_df.withColumn("full name", concat(col("name"), lit(" Singh")))

# Display the DataFrame
df_with_new_column.show()
```

```
▸ df_with_new_column:  pyspark.sql.dataframe.DataFrame = [customer_id: integer, name: string ... 6 more fields]
|         2| Customer_2|      Delhi|Maharashtra|   India|       2023-08-05|       true| Customer_2 Singh|
|         3| Customer_3|     Mumbai|  Telangana|   India|       2023-06-04|       true| Customer_3 Singh|
|         4| Customer_4|      Delhi|  Karnataka|   India|       2023-03-15|      false| Customer_4 Singh|
|         5| Customer_5|  Kolkata|West Bengal|   India|       2023-08-19|       true| Customer_5 Singh|
|         6| Customer_6|  Kolkata| Tamil Nadu|   India|       2023-04-21|      false| Customer_6 Singh|
|         7| Customer_7|     Mumbai|  Telangana|   India|       2023-05-23|       true| Customer_7 Singh|
|         8| Customer_8|       Pune| Tamil Nadu|   India|       2023-07-17|       true| Customer_8 Singh|
|         9| Customer_9|      Delhi|  Karnataka|   India|       2023-06-02|       true| Customer_9 Singh|
|        10|Customer_10|Hyderabad|      Delhi|   India|       2023-02-23|       true|Customer_10 Singh|
|        11|Customer_11|      Delhi|West Bengal|   India|       2023-11-08|       true|Customer_11 Singh|
|        12|Customer_12|      Delhi|      Delhi|   India|       2023-06-27|      false|Customer_12 Singh|
|        13|Customer_13|       Pune|Maharashtra|   India|       2023-02-03|       true|Customer_13 Singh|
|        14|Customer_14|    Chennai|  Karnataka|   India|       2023-04-06|       true|Customer_14 Singh|
|        15|Customer_15|Hyderabad|West Bengal|   India|       2023-03-31|       true|Customer_15 Singh|
|        16|Customer_16|    Chennai|Maharashtra|   India|       2023-04-26|       true|Customer_16 Singh|
|        17|Customer_17|       Pune|      Delhi|   India|       2023-04-14|      false|Customer_17 Singh|
|        18|Customer_18|    Chennai|Maharashtra|   India|       2023-02-04|      false|Customer_18 Singh|
|        19|Customer_19|    Chennai|  Karnataka|   India|       2023-01-22|       true|Customer_19 Singh|
+----------+-----------+-----------+-----------+--------+-----------------+-----------+-----------------+
only showing top 20 rows
```

withColumnRenamed

- The withColumnRenamed method is used to rename a single column in a DataFrame.

```
%python
# Example: Renaming a column
df_renamed_column = df_with_new_column.withColumnRenamed("full name", "Full Name")

# Display the DataFrame df_renamed_column.show()
```

```
▸ df_renamed_column: pyspark.sql.dataframe.DataFrame = [customer_id: integer, name: string ... 6 more fields]
|          2| Customer_2|     Delhi|Maharashtra| India|     2023-08-05|     true| Customer_2 Singh|
|          3| Customer_3|    Mumbai| Telangana| India|     2023-06-04|     true| Customer_3 Singh|
|          4| Customer_4|     Delhi| Karnataka| India|     2023-03-15|    false| Customer_4 Singh|
|          5| Customer_5| Kolkata|West Bengal| India|     2023-08-19|     true| Customer_5 Singh|
|          6| Customer_6| Kolkata| Tamil Nadu| India|     2023-04-21|    false| Customer_6 Singh|
|          7| Customer_7|    Mumbai| Telangana| India|     2023-05-23|     true| Customer_7 Singh|
|          8| Customer_8|      Pune| Tamil Nadu| India|     2023-07-17|     true| Customer_8 Singh|
|          9| Customer_9|     Delhi| Karnataka| India|     2023-06-02|     true| Customer_9 Singh|
|         10|Customer_10|Hyderabad|      Delhi| India|     2023-02-23|     true|Customer_10 Singh|
|         11|Customer_11|     Delhi|West Bengal| India|     2023-11-08|     true|Customer_11 Singh|
|         12|Customer_12|     Delhi|      Delhi| India|     2023-06-27|    false|Customer_12 Singh|
|         13|Customer_13|      Pune|Maharashtra| India|     2023-02-03|     true|Customer_13 Singh|
|         14|Customer_14| Chennai| Karnataka| India|     2023-04-06|     true|Customer_14 Singh|
|         15|Customer_15|Hyderabad|West Bengal| India|     2023-03-31|     true|Customer_15 Singh|
|         16|Customer_16| Chennai|Maharashtra| India|     2023-04-26|     true|Customer_16 Singh|
|         17|Customer_17|      Pune|      Delhi| India|     2023-04-14|    false|Customer_17 Singh|
|         18|Customer_18| Chennai|Maharashtra| India|     2023-02-04|    false|Customer_18 Singh|
|         19|Customer_19| Chennai| Karnataka| India|     2023-01-22|     true|Customer_19 Singh|
+-----------+-----------+---------+-----------+------+---------------+---------+-----------------+
only showing top 20 rows
```

6. Dropping a Column

The drop method is used to remove one or more columns from a DataFrame.

```
# Dropping a single column
df_dropped_column = df_renamed_column.drop("Full Name")

# Display the DataFrame df_dropped_column.show()
```

```
▸ df_dropped_column: pyspark.sql.dataframe.DataFrame = [customer_id: integer, name: string ... 5 more fields]
|          2| Customer_2|     Delhi|Maharashtra| India|     2023-08-05|     true|
|          3| Customer_3|    Mumbai| Telangana| India|     2023-06-04|     true|
|          4| Customer_4|     Delhi| Karnataka| India|     2023-03-15|    false|
|          5| Customer_5| Kolkata|West Bengal| India|     2023-08-19|     true|
|          6| Customer_6| Kolkata| Tamil Nadu| India|     2023-04-21|    false|
|          7| Customer_7|    Mumbai| Telangana| India|     2023-05-23|     true|
|          8| Customer_8|      Pune| Tamil Nadu| India|     2023-07-17|     true|
|          9| Customer_9|     Delhi| Karnataka| India|     2023-06-02|     true|
|         10|Customer_10|Hyderabad|      Delhi| India|     2023-02-23|     true|
|         11|Customer_11|     Delhi|West Bengal| India|     2023-11-08|     true|
```

```
|         18|Customer_18|  Chennai|Maharashtra|  India|          2023-02-04|  false|
|         19|Customer_19|  Chennai|  Karnataka|  India|          2023-01-22|   true|
+-----------+------------+---------+-----------+-------+--------------------+-------+
```

Dropping Multiple Columns

```
%python
# Dropping multiple columns
df_dropped_columns = df_renamed_column.drop("name", "country")

# Display the DataFrame after dropping columns
df_dropped_columns.show()
```

```
df_dropped_columns:  pyspark.sql.dataframe.DataFrame = [customer_id: integer, city: string ... 4 more fields]
|         2|  Delhi|  Karnataka|  2023-08-05|   true| Customer_2 Singh|
|         3|  Mumbai| Telangana|  2023-06-04|   true|  Customer_3  Singh|  false|
|         4|  Delhi|  Karnataka|  2023-03-15|  Customer_4  Singh|  true|
|         5|  Kolkata|West Bengal|  2023-08-19|  Customer_5  Singh|  false|
|         6|  Kolkata| Tamil Nadu|  2023-04-21|  Customer_6  Singh|  true|
|         7|  Mumbai|  Telangana| Pune|  2023-05-23|  Customer_7  Singh|  true|
|         8|  Tamil Nadu|  2023-07-17|  Customer_8  Singh|  true|
|         9|  Delhi|  Karnataka|  2023-06-02|  Customer_9  Singh|

|        10|Hyderabad|  Delhi|  2023-02-23|  true|Customer_10  Singh|

|        11|  Delhi|West Bengal|  2023-11-08|  true|Customer_11  Singh|
|        12|  Delhi|  Delhi|  2023-06-27|  false|Customer_12  Singh|
|        13|  Pune|Maharashtra|  2023-02-03|  true|Customer_13  Singh|
|        14|  Chennai|  Karnataka|  2023-04-06|  true|Customer_14  Singh|

|        15|Hyderabad|West Bengal|  2023-03-31|  true|Customer_15  Singh|

|        16|  Chennai|Maharashtra|  2023-04-26|  true|Customer_16  Singh|
|        17|  Pune|  Delhi|  2023-04-14|  false|Customer_17  Singh|
|        18|  Chennai|Maharashtra|  2023-02-04|  false|Customer_18  Singh|
|        19|  Chennai|  Karnataka|  2023-01-22|  true|Customer_19 Singh|

+          +         +           +            +       +
only showing top 20 rows
```

7. Removing Duplicate Rows

```
%python
# Removing duplicate rows
df_distinct = df_renamed_column.distinct()

# Display the DataFrame df_distinct.show()
```

```
df_distinct:  pyspark.sql.dataframe.DataFrame = [customer_id: integer, name: string ... 6 more fields]
|         5| Customer_5|  Kolkata|West Bengal|  India|          2023-08-19|   true| Customer_5 Singh|
|         6| Customer_6|  Kolkata| Tamil Nadu|  India|          2023-04-21|  false| Customer_6 Singh|
```

```
|          3| Customer_3|      Mumbai|  Telangana|   India|2023-06-04|          true| Customer_3 Singh|
|         16|Customer_16|     Chennai|Maharashtra|   India|2023-04-26|          true|Customer_16 Singh|
|         12|Customer_12|       Delhi|      Delhi|   India|2023-06-27|         false|Customer_12 Singh|
|         20|Customer_20|        Pune|  Karnataka|   India|2023-02-19|         false|Customer_20 Singh|
|         11|Customer_11|       Delhi| West Bengal|   India|2023-11-08|          true|Customer_11 Singh|
|          4| Customer_4|       Delhi|  Karnataka|   India|2023-03-15|         false| Customer_4 Singh|
|         19|Customer_19|     Chennai|  Karnataka|   India|2023-01-22|          true|Customer_19 Singh|
|          7| Customer_7|      Mumbai|  Telangana|   India|2023-05-23|          true| Customer_7 Singh|
|         14|Customer_14|     Chennai|  Karnataka|   India|2023-04-06|          true|Customer_14 Singh|
|          1| Customer_1|        Pune| West Bengal|   India|2023-08-10|          true| Customer_1 Singh|
|         13|Customer_13|        Pune|Maharashtra|   India|2023-02-03|          true|Customer_13 Singh|
+-----------+-----------+------------+-----------+--------+----------+--------------+-----------------------------------------------------------------------------------------------------------+
only showing top 20 rows
```

Aggregation

- Will cover in detail tomorrow

```
+----------+-------+
|      city|  count|
+----------+-------+
|Bangalore|661013|
|   Chennai|660249|
|    Mumbai|661241|
|Ahmedabad|660218|
|   Kolkata|660174|
|      Pune|660737|
|     Delhi|661025|
|Hyderabad|662281|
+----------+-------+
```

 # PySpark SQL Joins comes with more optimizations by default (thanks to DataFrames), but there are still some p #

Understanding how to effectively utilize PySpark joins is essential for conducting comprehensive data analysi # In this PySpark

SQL Join, you will learn different Join syntaxes and use different Join types on two or more

 # PySpark Join Syntax #
PySpark Join Types #
Inner Join DataFrame
 # Full Outer Join DataFrame #
Left Outer Join DataFrame #
Right Outer Join DataFrame #
Left Anti Join DataFrame #
Left Semi Join DataFrame #
Self Join DataFrame
 # Using SQL Expression

Result:

This program has been executed successfully.

EXNO. :6 **PYSPARK- JOIN and SQL Commands**
Date:

```
# PySpark Join is used to combine two DataFrames and by chaining these you can join multiple DataFrames; it
# PySpark Joins are wider transformations that involve data shuffling across the network.
```

1. PySpark Join Syntax

PySpark SQL join has a below syntax and it can be accessed directly from DataFrame.

```
# Syntax
# join(self, other, on=None, how=None)
```

```
# join() operation takes parameters as below and returns DataFrame.

# param other: Right side of the join
# param on: a string for the join column name
# param how: default inner. Must be one of inner, cross, outer,full, full_outer, left, left_outer, right, right
```

```
# You can also write Join expression by adding where() and filter() methods on DataFrame and can have Join on m
```

2. PySpark Join Types

```
# Below are the different Join Types PySpark supports.

# Join #          String Equivalent SQL Join INNER
inner #          JOIN
outer, #         full, fullouter, full_outer          FULL OUTER JOIN
left, # right,   leftouter, left_outer          LEFT JOIN
# cross #        rightouter, right_outer RIGHT JOIN
anti,
# semi,          leftanti, left_anti leftsemi, left_semi
```

```
# Before diving into PySpark SQL Join illustrations, let's initiate "emp" and "dept" DataFrames.
# The emp DataFrame contains the "emp_id" column with unique values, while the dept DataFrame contains the "dep # Additionally, the "emp_dept_id" from
"emp" refers to the "dept_id" in the "dept" dataset.
```

```
import findspark findspark.init()
```

```
# Prepare Data
import pyspark
from pyspark.sql import SparkSession

spark = SparkSession.builder.appName('Joins').master('local[*]').getOrCreate() emp = [(1, "Smith", -1, "2018", "10",

"M", 3000),
        (2, "Rose", 1, "2010", "20", "M", 4000),
        (3, "Williams", 1, "2010", "10", "M", 1000),
        (4, "Jones", 2, "2005", "10", "F", 2000),
        (5, "Brown", 2, "2010", "40", "", -1),
        (6, "Brown", 2, "2010", "50", "", -1)
      ]

empColumns = ["emp_id", "name", "superior_emp_id", "year_joined", \ "emp_dept_id", "gender", "salary"]

empDF = spark.createDataFrame(data = emp, schema = empColumns) empDF.printSchema()
empDF.show(truncate = False)
```

```
root
 |-- emp_id: long (nullable = true)
 |-- name: string (nullable = true)
 |-- superior_emp_id: long (nullable = true)
 |-- year_joined: string (nullable = true)
 |-- emp_dept_id: string (nullable = true)
 |-- gender: string (nullable = true)
 |-- salary: long (nullable = true)
```

```
+------+--------+---------------+-----------+-----------+------+------+
|emp_id|name    |superior_emp_id|year_joined|emp_dept_id|gender|salary|
+------+--------+---------------+-----------+-----------+------+------+
|1     |Smith   |-1             |2018       |10         |M     |3000  |
|2     |Rose    |1              |2010       |20         |M     |4000  |
|3     |Williams|1              |2010       |10         |M     |1000  |
|4     |Jones   |2              |2005       |10         |F     |2000  |
|5     |Brown   |2              |2010       |40         |      |-1    |
|6     |Brown   |2              |2010       |50         |      |-1    |
+------+--------+---------------+-----------+-----------+------+------+
```

```
dept = [("Finance", 10),
        ("Marketing", 20),
        ("Sales", 30),
        ("IT", 40)
       ]

deptColumns = ["dept_name", "dept_id"]

deptDF = spark.createDataFrame(data = dept, schema = deptColumns)
deptDF.printSchema()
deptDF.show(truncate = False)
```

```
root
 |-- dept_name: string (nullable = true)
 |-- dept_id: long (nullable = true)
```

```
+---------+-------+
|dept_name|dept_id|
+---------+-------+
|Finance  |10     |
|Marketing|20     |
|Sales    |30     |
|IT       |40     |
+---------+-------+
```

3. How Join Works?

```
# PySpark's join operation combines data from two or more Datasets based on a
common column or key. # It is a fundamental operation in PySpark and is similar to
SQL joins.

# Common Key:
# ============
# In order to join two or more datasets we need a common key or a column on which you want to
join. This key is # Partitioning:
# ===============

# PySpark Datasets are distributed and partitioned across multiple nodes
in a cluster. # Ideally, data with the same join key should be located in the
same partition.
# If the Datasets are not already partitioned on the join key, PySpark may perform a shuffle
operation to redis # Shuffling can be an expensive operation, especially for large Datasets.

# Join Type Specification:
# ==========================

# We can specify the type of join like inner join, full join, left join, etc., by specifying on "how"

parameter # This parameter determines which rows should be included or excluded in the

resulting Dataset.

# Join Execution:
# =================
# PySpark performs the join by comparing the values in the common key column
between the Datasets. # Inner Join:
# ============

# Returns only the rows with matching keys in both DataFrames.
```

```
# Left Join:
# ============

# Returns all rows from the left DataFrame and matching rows from the right DataFrame. #

Right Join:
# =============

# Returns all rows from the right DataFrame and matching rows from the left DataFrame. # Full

Outer Join:
# ==================

# Returns all rows from both DataFrames, including matching and non-matching rows. #

Left Semi Join:
# =================

# Returns all rows from the left DataFrame where there is a match in the right DataFrame. # Left

Anti Join:
# ================

# Returns all rows from the left DataFrame where there is no match in the right DataFrame.
```

4. PySpark Inner Join DataFrame

The default join in PySpark is the inner join, commonly used to retrieve

```
# Inner Join
empDF.join(deptDF, empDF.emp_dept_id == deptDF.dept_id, "inner") \
     .show(truncate = False)
```

data from two or more DataFrames based on a shared key. An Inner join combines two DataFrames based on the key (common column) provided and results in rows where there is a matching found. Rows from both DataFrames are dropped with a non-matching key.

```
+------+--------+---------------+-----------+-----------+------+------+---------+-------+
|emp_id|name    |superior_emp_id|year_joined|emp_dept_id|gender|salary|dept_name|dept_id|
+------+--------+---------------+-----------+-----------+------+------+---------+-------+
|1     |Smith   |-1             |2018       |10         |M     |3000  |Finance  |10     |
|3     |Williams|1              |2010       |10         |M     |1000  |Finance  |10     |
|4     |Jones   |2              |2005       |10         |F     |2000  |Finance  |10     |
|2     |Rose    |1              |2010       |20         |M     |4000  |Marketing|20     |
|5     |Brown   |2              |2010       |40         |      |-1    |IT       |40     |
+------+--------+---------------+-----------+-----------+------+------+---------+-------+
```

This example drops “emp_dept_id” with value 50 from “emp” And “dept_id” with value 30 from “dept” datasets. Following is the result of the above Join statement.

5. PySpark Left Outer Join

Left a.k.a Leftouter join returns all rows from the left dataset regardless of match found on the right dataset when join expression doesn't match, it assigns null for that record and drops records from right where match not found.

```
# Left Outer Join
empDF.join(deptDF, empDF.emp_dept_id == deptDF.dept_id, "left") \
    .show(truncate = False)

empDF.join(deptDF, empDF.emp_dept_id == deptDF.dept_id, "leftouter") \
    .show(truncate = False)
```

```
+------+--------+---------------+-----------+-----------+------+------+---------+-------+
|emp_id|name    |superior_emp_id|year_joined|emp_dept_id|gender|salary|dept_name|dept_id|
+------+--------+---------------+-----------+-----------+------+------+---------+-------+
|1     |Smith   |-1             |2018       |10         |M     |3000  |Finance  |10     |
|2     |Rose    |1              |2010       |20         |M     |4000  |Marketing|20     |
|3     |Williams|1              |2010       |10         |M     |1000  |Finance  |10     |
|4     |Jones   |2              |2005       |10         |F     |2000  |Finance  |10     |
|5     |Brown   |2              |2010       |40         |      |-1    |IT       |40     |
|6     |Brown   |2              |2010       |50         |      |-1    |NULL     |NULL   |
+------+--------+---------------+-----------+-----------+------+------+---------+-------+
```

```
+------+--------+---------------+-----------+-----------+------+------+---------+-------+
|emp_id|name    |superior_emp_id|year_joined|emp_dept_id|gender|salary|dept_name|dept_id|
+------+--------+---------------+-----------+-----------+------+------+---------+-------+
|1     |Smith   |-1             |2018       |10         |M     |3000  |Finance  |10     |
|2     |Rose    |1              |2010       |20         |M     |4000  |Marketing|20     |
|3     |Williams|1              |2010       |10         |M     |1000  |Finance  |10     |
|4     |Jones   |2              |2005       |10         |F     |2000  |Finance  |10     |
|5     |Brown   |2              |2010       |40         |      |-1    |IT       |40     |
|6     |Brown   |2              |2010       |50         |      |-1    |NULL     |NULL   |
+------+--------+---------------+-----------+-----------+------+------+---------+-------+
```

In our dataset, the record with “emp_dept_id” 50 does not have a corresponding entry in the “dept” dataset, resulting in null values in the “dept” columns (dept_name & dept_id). Additionally, the entry with “dept_id” 30 from the “dept” dataset is omitted from the results. Above is the outcome of the provided join expression.

6. Right Outer Join

Right a.k.a Rightouter join is opposite of left join, here it returns all rows from the right dataset regardless of math found on the left dataset, when join expression doesn’t match, it assigns null for that record and drops records from left where match not found.

```
# Right Outer Join
empDF.join(deptDF, empDF.emp_dept_id == deptDF.dept_id, "right") \
    .show(truncate = False)

empDF.join(deptDF, empDF.emp_dept_id == deptDF.dept_id, "rightouter") \
    .show(truncate = False)
```

```
+------+--------+---------------+-----------+-----------+------+------+---------+-------+
|emp_id|name    |superior_emp_id|year_joined|emp_dept_id|gender|salary|dept_name|dept_id|
+------+--------+---------------+-----------+-----------+------+------+---------+-------+
|4     |Jones   |2              |2005       |10         |F     |2000  |Finance  |10     |
|3     |Williams|1              |2010       |10         |M     |1000  |Finance  |10     |
|1     |Smith   |-1             |2018       |10         |M     |3000  |Finance  |10     |
|2     |Rose    |1              |2010       |20         |M     |4000  |Marketing|20     |
|NULL  |NULL    |NULL           |NULL       |NULL       |NULL  |NULL  |Sales    |30     |
|5     |Brown   |2              |2010       |40         |      |-1    |IT       |40     |
+------+--------+---------------+-----------+-----------+------+------+---------+-------+

+------+--------+---------------+-----------+-----------+------+------+---------+-------+
|emp_id|name    |superior_emp_id|year_joined|emp_dept_id|gender|salary|dept_name|dept_id|
+------+--------+---------------+-----------+-----------+------+------+---------+-------+
|4     |Jones   |2              |2005       |10         |F     |2000  |Finance  |10     |
|3     |Williams|1              |2010       |10         |M     |1000  |Finance  |10     |
|1     |Smith   |-1             |2018       |10         |M     |3000  |Finance  |10     |
|2     |Rose    |1              |2010       |20         |M     |4000  |Marketing|20     |
|NULL  |NULL    |NULL           |NULL       |NULL       |NULL  |NULL  |Sales    |30     |
|5     |Brown   |2              |2010       |40         |      |-1    |IT       |40     |
+------+--------+---------------+-----------+-----------+------+------+---------+-------+
```

In our example, the dataset on the right, containing “dept_id” with a value of 30, does not have a corresponding record in the left dataset “emp”. Consequently, this record contains null values for the columns from “emp”. Additionally, the record with “emp_dept_id” value 50 is dropped

as no match was found in the left dataset. Below is the result of the aforementioned join expression.

7. PySpark Full Outer Join

Outer a.k.a full, fullouter join in PySpark combines the results of both left and right outer joins, ensuring that all records from both DataFrames are

```
# Full Outer Join
empDF.join(deptDF, empDF.emp_dept_id == deptDF.dept_id, "outer") \
    .show(truncate = False)

empDF.join(deptDF, empDF.emp_dept_id == deptDF.dept_id, "full") \
    .show(truncate = False)

empDF.join(deptDF, empDF.emp_dept_id == deptDF.dept_id, "fullouter") \
    .show(truncate = False)
```

included in the resulting DataFrame. It includes all rows from both DataFrames and fills in missing values with nulls where there is no match. In other words, it merges the DataFrames based on a common key, but retains all rows from both DataFrames, even if there's no match. This join type is useful when you want to preserve all the information from both datasets, regardless of whether there's a match on the key or not.

```
+------+--------+---------------+-----------+-----------+------+------+-----------+-------+
|emp_id|name    |superior_emp_id|year_joined|emp_dept_id|gender|salary|dept_name  |dept_id|
+------+--------+---------------+-----------+-----------+------+------+-----------+-------+
|1     |Smith   |-1             |2018       |10         |M     |3000  |Finance    |10     |
|3     |Williams|1              |2010       |10         |M     |1000  |Finance    |10     |
|4     |Jones   |2              |2005       |10         |F     |2000  |Finance    |10     |
|2     |Rose    |1              |2010       |20         |M     |4000  |Marketing  |20     |
|NULL  |NULL    |NULL           |NULL       |NULL       |NULL  |NULL  |Sales      |30     |
|5     |Brown   |2              |2010       |40         |      |-1    |IT         |40     |
|6     |Brown   |2              |2010       |50         |      |-1    |NULL       |NULL   |
+------+--------+---------------+-----------+-----------+------+------+-----------+-------+

+------+--------+---------------+-----------+-----------+------+------+-----------+-------+
|emp_id|name    |superior_emp_id|year_joined|emp_dept_id|gender|salary|dept_name  |dept_id|
+------+--------+---------------+-----------+-----------+------+------+-----------+-------+
|1     |Smith   |-1             |2018       |10         |M     |3000  |Finance    |10     |
|3     |Williams|1              |2010       |10         |M     |1000  |Finance    |10     |
|4     |Jones   |2              |2005       |10         |F     |2000  |Finance    |10     |
|2     |Rose    |1              |2010       |20         |M     |4000  |Marketing  |20     |
|NULL  |NULL    |NULL           |NULL       |NULL       |NULL  |NULL  |Sales      |30     |
|5     |Brown   |2              |2010       |40         |      |-1    |IT         |40     |
|6     |Brown   |2              |2010       |50         |      |-1    |NULL       |NULL   |
+------+--------+---------------+-----------+-----------+------+------+-----------+-------+

+------+--------+---------------+-----------+-----------+------+------+-----------+-------+
|emp_id|name    |superior_emp_id|year_joined|emp_dept_id|gender|salary|dept_name  |dept_id|
+------+--------+---------------+-----------+-----------+------+------+-----------+-------+
|1     |Smith   |-1             |2018       |10         |M     |3000  |Finance    |10     |
|3     |Williams|1              |2010       |10         |M     |1000  |Finance    |10     |
|4     |Jones   |2              |2005       |10         |F     |2000  |Finance    |10     |
|2     |Rose    |1              |2010       |20         |M     |4000  |Marketing  |20     |
|NULL  |NULL    |NULL           |NULL       |NULL       |NULL  |NULL  |Sales      |30     |
|5     |Brown   |2              |2010       |40         |      |-1    |IT         |40     |
|6     |Brown   |2              |2010       |50         |      |-1    |NULL       |NULL   |
+------+--------+---------------+-----------+-----------+------+------+-----------+-------+
```

This code snippet performs a full outer join between two PySpark DataFrames, empDF and deptDF, based on the condition that emp_dept_id from empDF is equal to dept_id from deptDF. In our “emp” dataset, the “emp_dept_id” with a value of 50 does not have a corresponding record in the “dept” dataset, resulting in null values in the “dept” columns. Similarly, the “dept_id” 30 does not have a record in the “emp” dataset, hence you observe null values in the “emp” columns. Above Code is the output of the provided join example.

8. Left Semi Join

A Left Semi Join in PySpark returns only the rows from the left DataFrame (the first DataFrame mentioned in the join operation) where

```
# Left Semi Join
empDF.join(deptDF, empDF.emp_dept_id == deptDF.dept_id, "leftsemi") \
     .show(truncate = False)
```

there is a match with the right DataFrame (the second DataFrame). It does not include any columns from the right DataFrame in the resulting DataFrame. This join type is useful when you only want to filter rows from the left DataFrame based on whether they have a matching key in the right DataFrame. Left Semi Join can also be achieved by selecting only the columns from the left dataset from the result of the inner join

```
+------+--------+---------------+-----------+-----------+------+------+
|emp_id|name    |superior_emp_id|year_joined|emp_dept_id|gender|salary|
+------+--------+---------------+-----------+-----------+------+------+
|1     |Smith   |-1             |2018       |10         |M     |3000  |
|3     |Williams|1              |2010       |10         |M     |1000  |
|4     |Jones   |2              |2005       |10         |F     |2000  |
|2     |Rose    |1              |2010       |20         |M     |4000  |
|5     |Brown   |2              |2010       |40         |      |-1    |
+------+--------+---------------+-----------+-----------+------+------+
```

9. Left Anti Join

A Left Anti Join in PySpark returns only the rows from the left DataFrame (the first DataFrame mentioned in the join operation) where there is no

```
# Left Anti Join
empDF.join(deptDF, empDF.emp_dept_id == deptDF.dept_id, "leftanti") \
     .show(truncate = False)
```

match with the right DataFrame (the second DataFrame). It excludes any rows from the left DataFrame that have a corresponding key in the right DataFrame. This join type is useful when you want to filter out rows from the left DataFrame that have matching keys in the right DataFrame.

```
+------+-------+---------------+-----------+-----------+------+------+
|emp_id|name   |superior_emp_id|year_joined|emp_dept_id|gender|salary|
+------+-------+---------------+-----------+-----------+------+------+
|6     |Brown  |2              |2010       |50         |      |-1    |
+------+-------+---------------+-----------+-----------+------+------+
```

10. PySpark Self Join

Joins are not complete without a self join, Though there is no self-join

```
# Self Join

from pyspark.sql.functions import col

empDF.alias("emp1").join(empDF.alias("emp2"), \
    col("emp1.superior_emp_id") == col("emp2.emp_id"), "inner") \
    .select(col("emp1.emp_id"), col("emp1.name"), \
    col("emp2.emp_id").alias("superior_emp_id"), \
    col("emp2.name").alias("superior_emp_name")) \
    .show(truncate = False)
```

type available in PySpark, we can use any of the above-explained join types to join DataFrame to itself. below example use inner self join.

```
+------+--------+---------------+-----------------+
|emp_id|name    |superior_emp_id|superior_emp_name|
+------+--------+---------------+-----------------+
|2     |Rose    |1              |Smith            |
|3     |Williams|1              |Smith            |
|4     |Jones   |2              |Rose             |
|5     |Brown   |2              |Rose             |
|6     |Brown   |2              |Rose             |
+------+--------+---------------+-----------------+
```

11. Using SQL Expression

Alternatively, you can also use SQL query to join DataFrames/tables in

```
# Using spark.sql

empDF.createOrReplaceTempView("EMP")
deptDF.createOrReplaceTempView("DEPT")

joinDF = spark.sql("SELECT * FROM EMP e, DEPT d WHERE e.emp_dept_id == d.dept_id") \
    .show(truncate = False)

joinDF2 = spark.sql("SELECT * FROM EMP e INNER JOIN DEPT d ON e.emp_dept_id == d.dept_id") \
    .show(truncate = False)
```

PySpark. To do so, first, create a temporary view using createOrReplaceTempView(), then use the spark.sql() to execute the join query.

```
+------+--------+---------------+-----------+-----------+------+------+---------+-------+
|emp_id|name    |superior_emp_id|year_joined|emp_dept_id|gender|salary|dept_name|dept_id|
+------+--------+---------------+-----------+-----------+------+------+---------+-------+
|1     |Smith   |-1             |2018       |10         |M     |3000  |Finance  |10     |
|3     |Williams|1              |2010       |10         |M     |1000  |Finance  |10     |
|4     |Jones   |2              |2005       |10         |F     |2000  |Finance  |10     |
|2     |Rose    |1              |2010       |20         |M     |4000  |Marketing|20     |
|5     |Brown   |2              |2010       |40         |      |-1    |IT       |40     |
```

```
+------+--------+---------------+-----------+-----------+------+------+---------+-------+
|emp_id|name    |superior_emp_id|year_joined|emp_dept_id|gender|salary|dept_name|dept_id|
+------+--------+---------------+-----------+-----------+------+------+---------+-------+
|1     |Smith   |-1             |2018       |10         |M     |3000  |Finance  |10     |
|3     |Williams|1              |2010       |10         |M     |1000  |Finance  |10     |
|4     |Jones   |2              |2005       |10         |F     |2000  |Finance  |10     |
|2     |Rose    |1              |2010       |20         |M     |4000  |Marketing|20     |
|5     |Brown   |2              |2010       |40         |      |-1    |IT       |40     |
+------+--------+---------------+-----------+-----------+------+------+---------+-------+
```

12. PySpark SQL Join on multiple DataFrames

When you need to join more than two tables, you either use SQL expression after creating a temporary view on the DataFrame or use the result of join operation to join with another DataFrame like chaining them. for example# Join on multiple dataframes df1.join(df2, df1.id1 == df2.id2, "inner") \ .join(df2, df1.id1 == df3.id3, "inner")

13. PySpark SQL Join Complete Example

```
import pyspark

from pyspark.sql import SparkSession
from pyspark.sql.functions import col
spark =
SparkSession.builder.appName('Join').master('local[*]').getOrCreate()
emp = [(1,"Smith",-1,"2018","10","M",3000), \
```

```
    (2,"Rose",1,"2010","20","M",4000), \
    (3,"Williams",1,"2010","10","M",1000), \
    (4,"Jones",2,"2005","10","F",2000), \
    (5,"Brown",2,"2010","40","",-1), \
      (6,"Brown",2,"2010","50","",-1) \
  ]

empColumns = ["emp_id", "name", "superior_emp_id",
              "year_joined", \ "emp_dept_id",  "gender",
              "salary"]

empDF = spark.createDataFrame(data=emp, schema =
empColumns) empDF.printSchema()
empDF.show(truncate=False)



dept = [("Finance",10), \
    ("Marketing",20), \
    ("Sales",30), \
    ("IT",40) \
  ]
deptColumns = ["dept_name","dept_id"]
deptDF = spark.createDataFrame(data=dept, schema =
deptColumns) deptDF.printSchema()
deptDF.show(truncate=False)

empDF.join(deptDF,empDF.emp_dept_id ==  deptDF.dept_id,"inner") \
       .show(truncate=False)

empDF.join(deptDF,empDF.emp_dept_id ==  deptDF.dept_id,"outer") \
     .show(truncate=False)
empDF.join(deptDF,empDF.emp_dept_id ==  deptDF.dept_id,"full") \
     .show(truncate=False)
empDF.join(deptDF,empDF.emp_dept_id ==  deptDF.dept_id,"fullouter") \
     .show(truncate=False)

empDF.join(deptDF,empDF.emp_dept_id ==  deptDF.dept_id,"left") \
     .show(truncate=False)
empDF.join(deptDF,empDF.emp_dept_id ==  deptDF.dept_id,"leftouter") \
    .show(truncate=False)

empDF.join(deptDF,empDF.emp_dept_id ==  deptDF.dept_id,"right") \
    .show(truncate=False)
empDF.join(deptDF,empDF.emp_dept_id ==  deptDF.dept_id,"rightouter") \
    .show(truncate=False)

empDF.join(deptDF,empDF.emp_dept_id ==  deptDF.dept_id,"leftsemi") \
    .show(truncate=False)

empDF.join(deptDF,empDF.emp_dept_id ==  deptDF.dept_id,"leftanti") \
```

```
    .show(truncate=False)

empDF.alias("emp1").join(empDF.alias("emp2"), \
    col("emp1.superior_emp_id") == \
    col("emp2.emp_id"),"inner") \
    .select(col("emp1.emp_id"),col("emp1.name"), \
      col("emp2.emp_id").alias("superior_emp_id"), \
      col("emp2.name").alias("superior_emp_name")) \
  .show(truncate=False)

empDF.createOrReplaceTempView("EMP")
deptDF.createOrReplaceTempView("DEPT")

joinDF = spark.sql("select * from EMP e, DEPT d where e.emp_dept_id == d.dept_id") \
  .show(truncate=False)

joinDF2 = spark.sql("select * from EMP e INNER JOIN DEPT d ON e.emp_dept_id == 
d.dept_id") \
  .show(truncate=False)
```

```
root
 |-- emp_id: long (nullable = true)
 |-- name: string (nullable = true)
 |-- superior_emp_id: long (nullable = true)
 |-- year_joined: string (nullable = true)
 |-- emp_dept_id: string (nullable = true)
 |-- gender: string (nullable = true)
 |-- salary: long (nullable = true)
```

emp_id	name	superior_emp_id	year_joined	emp_dept_id	gender	salary
1	Smith	-1	2018	10	M	3000
2	Rose	1	2010	20	M	4000
3	Williams	1	2010	10	M	1000
4	Jones	2	2005	10	F	2000
5	Brown	2	2010	40		-1
6	Brown	2	2010	50		-1

```
root
 |-- dept_name: string (nullable = true)
 |-- dept_id: long (nullable = true)
```

```
+---------+-------+
|dept_name|dept_id|
+---------+-------+
|Finance  |10     |
|Marketing|20     |
|Sales    |30     |
|IT       |40     |
+---------+-------+
```

```
+------+-----+---------------+-----------+-----------+------+------+---------+-------+
|emp_id|name |superior_emp_id|year_joined|emp_dept_id|gender|salary|dept_name|dept_id|
+------+-----+---------------+-----------+-----------+------+------+---------+-------+
|1     |Smith|-1             |2018       |10         |M     |3000  |Finance  |10     |
|3     |Williams|1           |2010       |10         |M     |1000  |Finance  |10     |
|4     |Jones|2              |2005       |10         |F     |2000  |Finance  |10     |
|2     |Rose |1              |2010       |20         |M     |4000  |Marketing|20     |
|5     |Brown|2              |2010       |40         |      |-1    |IT       |40     |
+------+-----+---------------+-----------+-----------+------+------+---------+-------+
```

```
+------+-----+---------------+-----------+-----------+------+------+---------+-------+
|emp_id|name |superior_emp_id|year_joined|emp_dept_id|gender|salary|dept_name|dept_id|
+------+-----+---------------+-----------+-----------+------+------+---------+-------+
|1     |Smith|-1             |2018       |10         |M     |3000  |Finance  |10     |
|3     |Williams|1           |2010       |10         |M     |1000  |Finance  |10     |
|4     |Jones|2              |2005       |10         |F     |2000  |Finance  |10     |
|2     |Rose |1              |2010       |20         |M     |4000  |Marketing|20     |
|NULL  |NULL |NULL           |NULL       |NULL       |NULL  |NULL  |Sales    |30     |
|5     |Brown|2              |2010       |40         |      |-1    |IT       |40     |
|6     |Brown|2              |2010       |50         |      |-1    |NULL     |NULL   |
+------+-----+---------------+-----------+-----------+------+------+---------+-------+
```

```
+------+-----+---------------+-----------+-----------+------+------+---------+-------+
|emp_id|name |superior_emp_id|year_joined|emp_dept_id|gender|salary|dept_name|dept_id|
+------+-----+---------------+-----------+-----------+------+------+---------+-------+
|1     |Smith|-1             |2018       |10         |M     |3000  |Finance  |10     |
|3     |Williams|1           |2010       |10         |M     |1000  |Finance  |10     |
|4     |Jones|2              |2005       |10         |F     |2000  |Finance  |10     |
|2     |Rose |1              |2010       |20         |M     |4000  |Marketing|20     |
|NULL  |NULL |NULL           |NULL       |NULL       |NULL  |NULL  |Sales    |30     |
|5     |Brown|2              |2010       |40         |      |-1    |IT       |40     |
|6     |Brown|2              |2010       |50         |      |-1    |NULL     |NULL   |
+------+-----+---------------+-----------+-----------+------+------+---------+-------+
```

```
+------+-----+---------------+-----------+-----------+------+------+---------+-------+
|emp_id|name |superior_emp_id|year_joined|emp_dept_id|gender|salary|dept_name|dept_id|
+------+-----+---------------+-----------+-----------+------+------+---------+-------+
|1     |Smith|-1             |2018       |10         |M     |3000  |Finance  |10     |
|3     |Williams|1           |2010       |10         |M     |1000  |Finance  |10     |
|4     |Jones|2              |2010       |5          |Brown |2     |         |       |
|2     |Rose |1              |           |           |      |      |         |       |
|NULL  |NULL |NULL           |           |           |      |      |         |       |
+------+-----+---------------+-----------+-----------+------+------+---------+-------+
```

2010	20	M	4000	Marketing	20
NULL	NULL	NULL	NULL	Sales	30
2010	40		-1	IT	40
2010	50		-1	NULL	NULL

emp_id	name	superior_emp_id	year_joined	emp_dept_id	gender	salary	dept_name	dept_id
1	Smith	-1	2018	10	M	3000	Finance	10
2	Rose	1	2010	20	M	4000	Marketing	20
3	Williams	1	2010	10	M	1000	Finance	10
4	Jones	2	2005	10	F	2000	Finance	10
5	Brown	2	2010	40		-1	IT	40
6	Brown	2	2010	50		-1	NULL	NULL

emp_id	name	superior_emp_id	year_joined	emp_dept_id	gender	salary	dept_name	dept_id
1	Smith	-1	2018	10	M	3000	Finance	10
2	Rose	1	2010	20	M	4000	Marketing	20
3	Williams	1	2010	10	M	1000	Finance	10
4	Jones	2	2005	10	F	2000	Finance	10
5	Brown	2	2010	40		-1	IT	40
6	Brown	2	2010	50		-1	NULL	NULL

emp_id	name	superior_emp_id	year_joined	emp_dept_id	gender	salary	dept_name	dept_id
4	Jones	2	2005	10	F	2000	Finance	10
3	Williams	1	2010	10	M	1000	Finance	10
1	Smith	-1	2018	10	M	3000	Finance	10
2	Rose	1	2010	20	M	4000	Marketing	20
NULL	NULL	NULL	NULL	NULL	NULL	NULL	Sales	30
5	Brown	2	2010	40		-1	IT	40

emp_id	name	superior_emp_id	year_joined	emp_dept_id	gender	salary	dept_name	dept_id
4	Jones	2	2005	10	F	2000	Finance	10
3	Williams	1	2010	10	M	1000	Finance	10
1	Smith	-1	2018	10	M	3000	Finance	10
2	Rose	1	2010	20	M	4000	Marketing	20
NULL	NULL	NULL	NULL	NULL	NULL	NULL	Sales	30
5	Brown	2	2010	40		-1	IT	40

emp_id	name	superior_emp_id	year_joined	emp_dept_id	gender	salary
1	Smith	-1	2018	10	M	3000
3	Williams	1	2010	10	M	1000
4	Jones	2	2005	10	F	2000
2	Rose	1	2010	20	M	4000
5	Brown	2	2010	40		-1

emp_id	name	superior_emp_id	year_joined	emp_dept_id	gender	salary
6	Brown	2	2010	50		-1

emp_id	name	superior_emp_id	superior_emp_name
2	Rose	1	Smith
3	Williams	1	Smith
4	Jones	2	Rose
5	Brown	2	Rose
6	Brown	2	Rose

emp_id	name	superior_emp_id	year_joined	emp_dept_id	gender	salary	dept_name	dept_id
1	Smith	-1	2018	10	M	3000	Finance	10
3	Williams	1	2010	10	M	1000	Finance	10
4	Jones	2	2005	10	F	2000	Finance	10
2	Rose	1	2010	20	M	4000	Marketing	20
5	Brown	2	2010	40		-1	IT	40

emp_id	name	superior_emp_id	year_joined	emp_dept_id	gender	salary	dept_name	dept_id
1	Smith	-1	2018	10	M	3000	Finance	10
3	Williams	1	2010	10	M	1000	Finance	10
4	Jones	2	2005	10	F	2000	Finance	10
2	Rose	1	2010	20	M	4000	Marketing	20
5	Brown	2	2010	40		-1	IT	40

Result:

Thus we learned all Pyspark commands.