

CS6847: Cloud Computing

Cloud Assignment II

MapReduce in Hadoop framework

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I. Setting up the environment

The screenshot shows the Hadoop cluster overview page. The top navigation bar includes links for Hadoop, Overview, Datanodes, Snapshot, Startup Progress, and Utilities.

The main content area displays the following information:

Overview 'master:9000' (active)

Started:	Sun Mar 08 15:54:01 IST 2020
Version:	2.5.2, rcc72e9b000545b86b75a61f4835eb86d57bfaf0
Compiled:	2014-11-14T23:45Z by jenkins from (detached from cc72e9b)
Cluster ID:	CID-b5dfa701-004b-4f11-8ec8-da4497e2c7db
Block Pool ID:	BP-787708321-127.0.1.1-1583662983334

The screenshot shows the Hadoop cluster overview page with detailed memory and storage usage statistics.

Summary statistics:

- 6 files and directories, 8 blocks = 14 total filesystem object(s).
- Heap Memory used 78.68 MB of 118.31 MB Heap Memory. Max Heap Memory is 1.39 GB.
- Non Heap Memory used 30.44 MB of 31.38 MB Committed Non Heap Memory. Max Non Heap Memory is 112 MB.

Detailed statistics table:

Configured Capacity:	27.95 GB
DFS Used:	825.21 MB
Non DFS Used:	14.96 GB
DFS Remaining:	12.18 GB
DFS Used%:	2.88%
DFS Remaining%:	43.59%
Block Pool Used:	825.21 MB
Block Pool Used%:	2.88%
DataNodes usages% (Min/Median/Max/stdDev):	2.71% / 3.06% / 3.06% / 0.18%
Live Nodes	2 (Decommissioned: 0)
Dead Nodes	0 (Decommissioned: 0)
Decommissioning Nodes	0
Number of Under-Replicated Blocks	0

NameNode Journal Status

Current transaction ID: 48

Journal Manager	State
FileJournalManager(root=/home/mool/HDFS/namenode)	EditLogFileOutputStream(/home/mool/HDFS/ NameNode Journals)

NameNode Storage

Storage Directory	Type	State
/home/mool/HDFS/namenode	IMAGE_AND_EDITS	Active

Datanode Information

In operation

Node	Last contact	Admin State	Capacity	Used	Non DFS Used	Remaining	Blocks	Block pool used	Failed Volumes	Version
boss.mool (192.168.0.105:50010)	1	In Service	13.98 GB	387.47 MB	7.48 GB	6.12 GB	7	387.47 MB (2.71%)	0	2.5.2

Although we were running three nodes with two datanodes, since the usernames of all the nodes were same, only one entry was present in the Datanode Information block.

Startup Progress

Elapsed Time: 0 sec, Percent Complete: 100%

Phase	Completion	Elapsed Time
Loading fsimage <i>/home/mool/HDFS/namenode/current/fsimage_00000000000000000000 351 B</i>	100%	0 sec
inodes (0/0)	100%	
delegation tokens (0/0)	100%	
cache pools (0/0)	100%	
Loading edits	100%	0 sec
Saving checkpoint	100%	0 sec
Safe mode	100%	0 sec
awaiting reported blocks (0/0)	100%	

```

127.0.0.1      localhost
127.0.1.1      boss.mool      boss

#Enter IP address to hostname mapping here
192.168.0.100    master
192.168.0.105    slave1
192.168.0.106    slave2

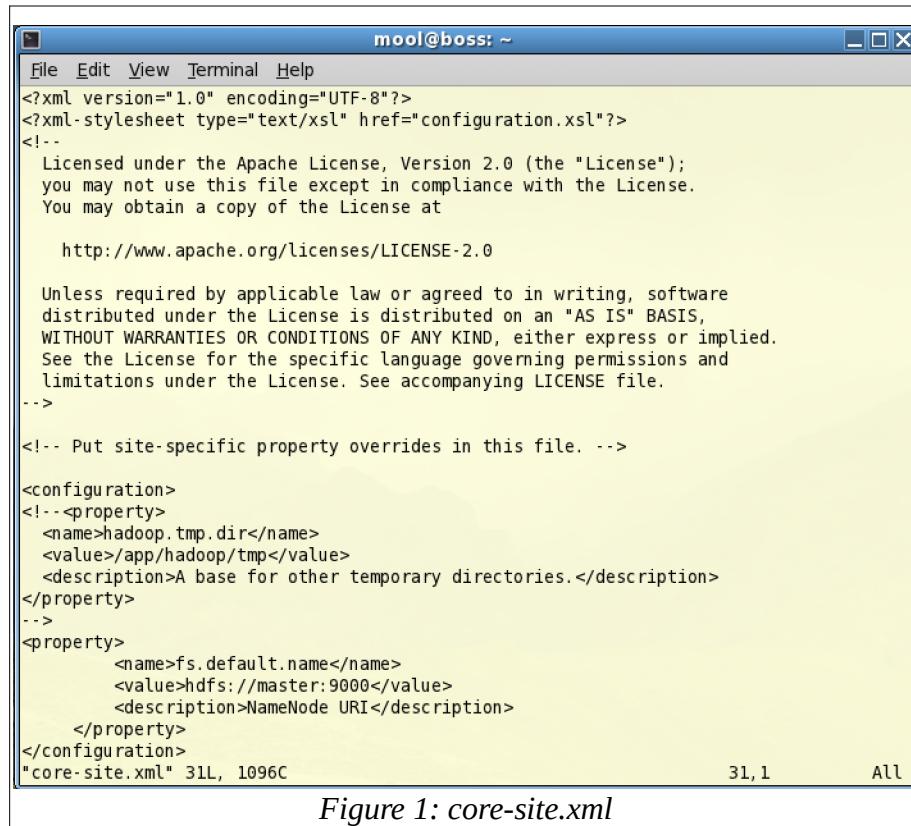
# The following lines are desirable for IPv6 capable hosts
::1      localhost ip6-localhost ip6-loopback
fe00::0 ip6-localnet
ff00::0 ip6-mcastprefix
ff02::1 ip6-allnodes
ff02::2 ip6-allrouters
~
~
```

```

slave1
slave2
~
```

II

"etc/hadoop/slaves" 2L, 14C



mool@boss: ~

```

File Edit View Terminal Help
<?xml version="1.0" encoding="UTF-8"?>
<xm...stylesheet type="text/xsl" href="configuration.xsl"?>
<!--
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distributed under the License is distributed on an "AS IS" BASIS,
WITHOUT WARRANTIES OR CONDITIONS OF ANY KIND, either express or implied.
See the License for the specific language governing permissions and
limitations under the License. See accompanying LICENSE file.
-->

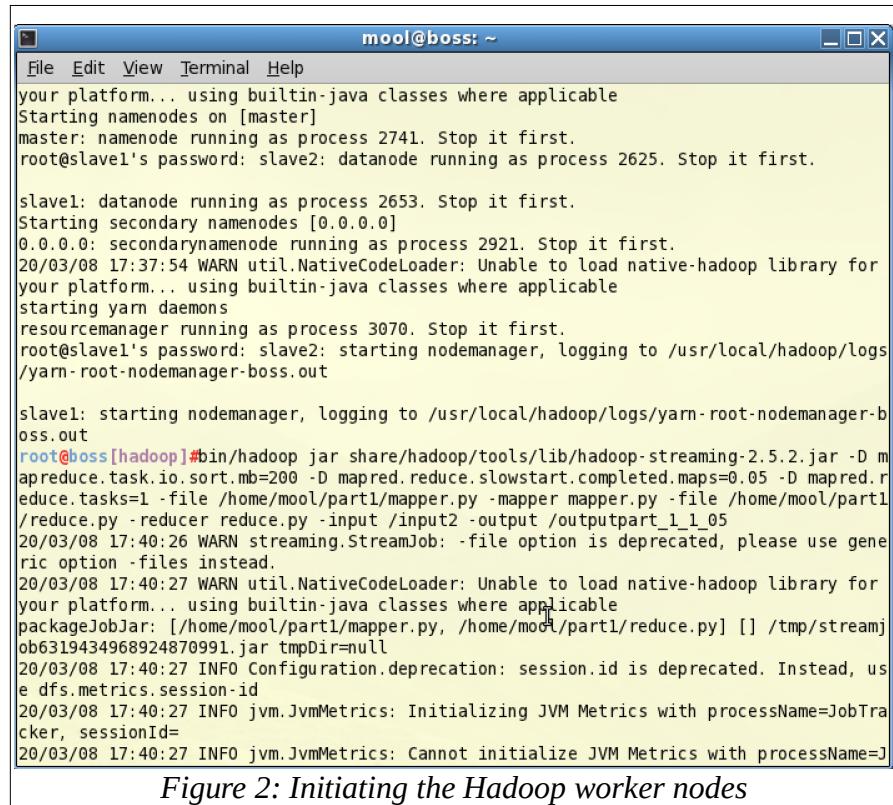
<!-- Put site-specific property overrides in this file. -->

<configuration>
<!--<property>
<name>hadoop.tmp.dir</name>
<value>/app/hadoop/tmp</value>
<description>A base for other temporary directories.</description>
</property>
-->
<property>
<name>fs.default.name</name>
<value>hdfs://master:9000</value>
<description>NameNode URI</description>
</property>
</configuration>
"core-site.xml" 31L, 1096C

```

31, 1 All

Figure 1: core-site.xml



mool@boss: ~

```

File Edit View Terminal Help
your platform... using builtin-java classes where applicable
Starting namenodes on [master]
master: namenode running as process 2741. Stop it first.
root@slave1's password: slave2: datanode running as process 2625. Stop it first.

slave1: datanode running as process 2653. Stop it first.
Starting secondary namenodes [0.0.0.0]
0.0.0.0: secondarynamenode running as process 2921. Stop it first.
20/03/08 17:37:54 WARN util.NativeCodeLoader: Unable to load native-hadoop library for
your platform... using builtin-java classes where applicable
starting yarn daemons
resourcemanager running as process 3070. Stop it first.
root@slave1's password: slave2: starting nodemanager, logging to /usr/local/hadoop/logs
/yarn-root-nodemanager-boss.out

slave1: starting nodemanager, logging to /usr/local/hadoop/logs/yarn-root-nodemanager-b
oss.out
root@boss[hadoop]#bin/hadoop jar share/hadoop/tools/lib/hadoop-streaming-2.5.2.jar -D m
apreduce.task.io.sort.mb=200 -D mapred.reduce.slowstart.completed.maps=0.05 -D mapred.r
educe.tasks=1 -file /home/mool/part1/mapper.py -mapper mapper.py -file /home/mool/part1
/reduce.py -reducer reduce.py -input /input2 -output /outputpart_1_1_05
20/03/08 17:40:26 WARN streaming.StreamJob: -file option is deprecated, please use gene
ric option -files instead.
20/03/08 17:40:27 WARN util.NativeCodeLoader: Unable to load native-hadoop library for
your platform... using builtin-java classes where applicable
packageJobJar: [/home/mool/part1/mapper.py, /home/mool/part1/reduce.py] [] /tmp/streamj
ob6319434968924870991.jar tmpDir=null
20/03/08 17:40:27 INFO Configuration.deprecation: session.id is deprecated. Instead, us
e dfs.metrics.session.id
20/03/08 17:40:27 INFO jvm.JvmMetrics: Initializing JVM Metrics with processName=JobTra
cker, sessionId=
20/03/08 17:40:27 INFO jvm.JvmMetrics: Cannot initialize JVM Metrics with processName=J

```

Figure 2: Initiating the Hadoop worker nodes

```

20/03/08 17:44:16 INFO mapreduce.Job:  map 100% reduce 100%
20/03/08 17:44:16 INFO mapreduce.Job: Job job_local792037007_0001 completed successfully
20/03/08 17:44:16 INFO mapreduce.Job: Counters: 38
    File System Counters
        FILE: Number of bytes read=633900876
        FILE: Number of bytes written=1994284141
        FILE: Number of read operations=0
        FILE: Number of large read operations=0
        FILE: Number of write operations=0
        HDFS: Number of bytes read=4533908820
        HDFS: Number of bytes written=2494
        HDFS: Number of read operations=105
        HDFS: Number of large read operations=0
        HDFS: Number of write operations=10
    Map-Reduce Framework
        Map input records=8655190
        Map output records=8507850
        Map output bytes=299907109
        Map output materialized bytes=316922851
        Input split bytes=637
        Combine input records=0
        Combine output records=0
        Reduce input groups=7730305
        Reduce shuffle bytes=316922851
        Reduce input records=8507850
        Reduce output records=60
        Spilled Records=17015700
        Shuffled Maps =7
        Failed Shuffles=0
        Merged Map outputs=7
        GC time elapsed (ms)=615
        CPU time spent (ms)=0
        Physical memory (bytes) snapshot=0
        Virtual memory (bytes) snapshot=0
        Total committed heap usage (bytes)=3863085056
    Shuffle Errors
        BAD_ID=0
        CONNECTION=0
        IO_ERROR=0
        WRONG_LENGTH=0
        WRONG_MAP=0
        WRONG_REDUCE=0
    File Input Format Counters
        Bytes Read=857625258

```

Figure 3: After completion of the job.

Apart from the instructions given in the PDF provided, we had to modify the core-site.xml in all the nodes to allow the nodes to communicate with each other. We have NOT used master node as a data node, and therefore can see that there are 2 live nodes running.

```
mool@boss: ~
File Edit View Terminal Help
root@boss[hadoop]#ip addr
1: lo: <LOOPBACK,UP,LOWER_UP> mtu 65536 qdisc noqueue state UNKNOWN
    link/loopback 00:00:00:00:00:00 brd 00:00:00:00:00:00
    inet 127.0.0.1/8 scope host lo
        valid_lft forever preferred_lft forever
    inet6 ::1/128 scope host
        valid_lft forever preferred_lft forever
2: eth5: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc pfifo_fast state UP qlen 1000
    link/ether 08:00:27:aa:92:c8 brd ff:ff:ff:ff:ff:ff
    inet 192.168.0.106/24 brd 192.168.0.255 scope global eth5
        valid_lft forever preferred_lft forever
    inet6 fe80::a00:27ff:fea:92c8/64 scope link
        valid_lft forever preferred_lft forever
3: sit0@NONE: <NOARP> mtu 1480 qdisc noop state DOWN
    link/sit 0.0.0.0 brd 0.0.0.0
root@boss[hadoop]#jps
4144 Jps
3899 DataNode
3999 NodeManager
root@boss[hadoop]#

```

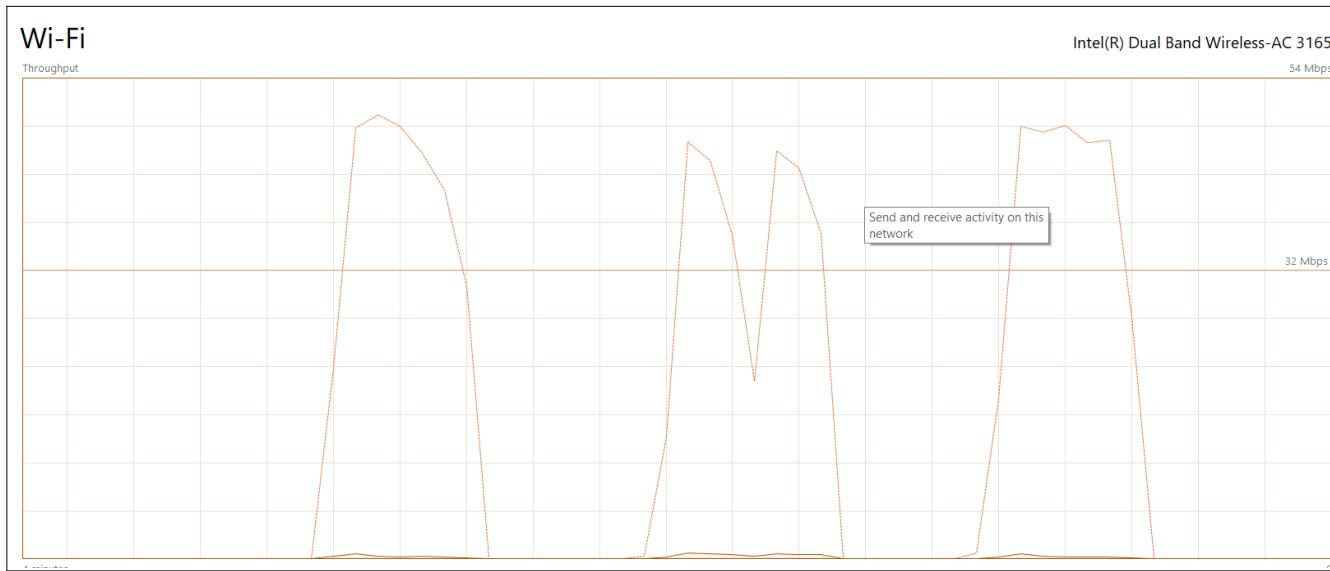


```
mool@boss: ~
File Edit View Terminal Help
root@boss[hadoop]#ip addr
1: lo: <LOOPBACK,UP,LOWER_UP> mtu 65536 qdisc noqueue state UNKNOWN
    link/loopback 00:00:00:00:00:00 brd 00:00:00:00:00:00
    inet 127.0.0.1/8 scope host lo
        valid_lft forever preferred_lft forever
    inet6 ::1/128 scope host
        valid_lft forever preferred_lft forever
2: eth4: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc pfifo_fast state UP qlen 1000
    link/ether 08:00:27:87:e2:b9 brd ff:ff:ff:ff:ff:ff
    inet 192.168.0.105/24 brd 192.168.0.255 scope global eth4
        valid_lft forever preferred_lft forever
    inet6 fe80::a00:27ff:fe87:e2b9/64 scope link
        valid_lft forever preferred_lft forever
3: sit0@NONE: <NOARP> mtu 1480 qdisc noop state DOWN
    link/sit 0.0.0.0 brd 0.0.0.0
root@boss[hadoop]#jps
3235 Jps
2990 DataNode
3090 NodeManager
root@boss[hadoop]#

```

```
mool@boss: ~
File Edit View Terminal Help
root@boss[hadoop]#ip addr
1: lo: <LOOPBACK,UP,LOWER_UP> mtu 65536 qdisc noqueue state UNKNOWN
    link/loopback 00:00:00:00:00:00 brd 00:00:00:00:00:00
    inet 127.0.0.1/8 scope host lo
        valid_lft forever preferred_lft forever
    inet6 ::1/128 scope host
        valid_lft forever preferred_lft forever
2: eth4: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc pfifo_fast state UP qlen 1000
    link/ether 08:00:27:f2:ae:a1 brd ff:ff:ff:ff:ff:ff
    inet 192.168.0.100/24 brd 192.168.0.255 scope global eth4
        valid_lft forever preferred_lft forever
    inet6 fe80::a00:27ff:fef2:ae:a1/64 scope link
        valid_lft forever preferred_lft forever
3: sit0@NONE: <NOARP> mtu 1480 qdisc noop state DOWN
    link/sit 0.0.0.0 brd 0.0.0.0
root@boss[hadoop]#jps
3007 SecondaryNameNode
3428 Jps
3156 ResourceManager
2826 NameNode
root@boss[hadoop]#

```

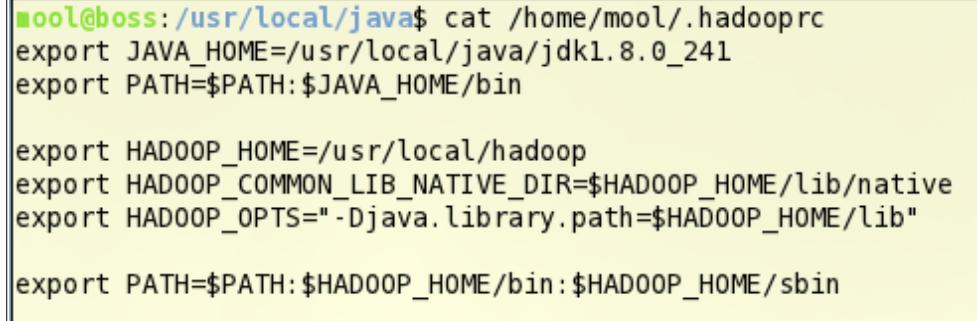


Modifications in the VDI for running Scala MapReduce

Since the JDK version available in the VDI image provided was 1.6 and is not supported by Scala, we had to update the JDK version to 1.8. A tar file containing the required JDK was copied to the VM and was extracted. The default java version used by the system was changed to JDK 1.8 by modifying the `~/.hadooprc` file.



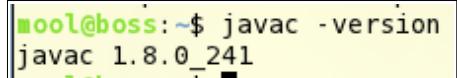
```
mool@boss: /usr/local/java
File Edit View Terminal Help
mool@boss:/usr/local/java$ ls
jdk1.6.0_31 jdk1.8.0_241 jdk-6u31-linux-i586.bin
```

```
mool@boss:/usr/local/java$ cat /home/mool/.hadooprc
export JAVA_HOME=/usr/local/java/jdk1.8.0_241
export PATH=$PATH:$JAVA_HOME/bin

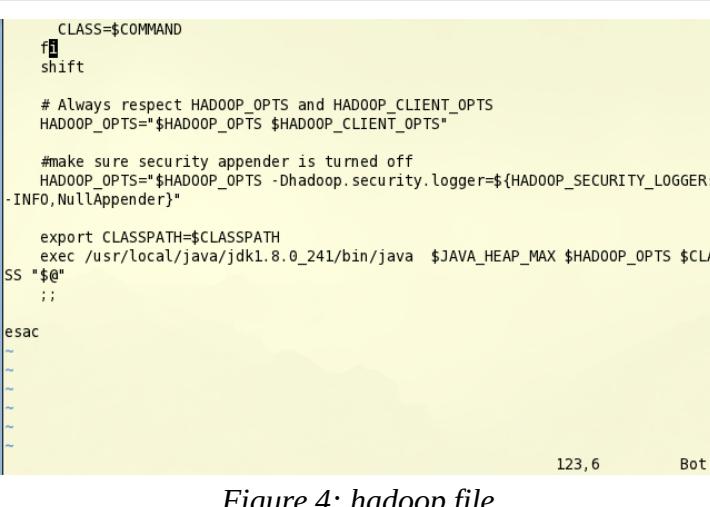
export HADOOP_HOME=/usr/local/hadoop
export HADOOP_COMMON_LIB_NATIVE_DIR=$HADOOP_HOME/lib/native
export HADOOP_OPTS="-Djava.library.path=$HADOOP_HOME/lib"

export PATH=$PATH:$HADOOP_HOME/bin:$HADOOP_HOME/sbin
```

```
mool@boss:~$ javac -version
javac 1.8.0_241
```

Apart from this, the `hdfs`, `yarn` and `hadoop` files in `/usr/local/hadoop/bin/` are to be modified to make use of the new java environment.



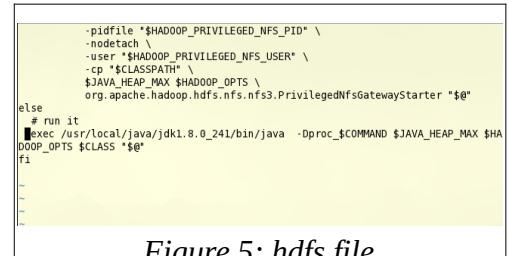
```
CLASS=$COMMAND
shift

# Always respect HADOOP_OPTS and HADOOP_CLIENT_OPTS
HADOOP_OPTS="$HADOOP_OPTS $HADOOP_CLIENT_OPTS"

#make sure security appender is turned off
HADOOP_OPTS="$HADOOP_OPTS -Dhadoop.security.logger=${HADOOP_SECURITY_LOGGER:-INFO,NullAppender}"

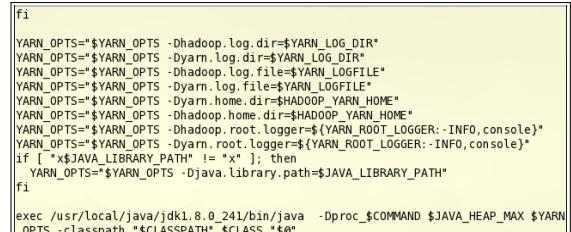
export CLASSPATH=$CLASSPATH
exec /usr/local/java/jdk1.8.0_241/bin/java $JAVA_HEAP_MAX $HADOOP_OPTS $CLASS "$@"
;;
esac
~
~
~
~
123,6      Bot
```

Figure 4: hadoop file



```
-pidfile "$HADOOP_PRIVILEGED_NFS_PID" \
-nodetach \
-user "$HADOOP_PRIVILEGED_NFS_USER" \
-cp "$CLASSPATH" \
$JAVA_HEAP_MAX $HADOOP_OPTS \
org.apache.hadoop.hdfs.nfs.PrivilegedNfsGatewayStarter "$@"
fi
-
-
-
```

Figure 5: hdfs file



```
fi
YARN_OPTS="$YARN_OPTS -Dhadoop.log.dir=$YARN_LOG_DIR"
YARN_OPTS="$YARN_OPTS -Dyarn.log.dir=$YARN_LOG_DIR"
YARN_OPTS="$YARN_OPTS -Dhadoop.log.file=$YARN_LOGFILE"
YARN_OPTS="$YARN_OPTS -Dyarn.log.file=$YARN_LOGFILE"
YARN_OPTS="$YARN_OPTS -Dyarn.home.dir=$HADOOP_YARN_HOME"
YARN_OPTS="$YARN_OPTS -Dhadoop.home.dir=$HADOOP_YARN_HOME"
YARN_OPTS="$YARN_OPTS -Dyarn.root.logger=$(YARN_ROOT_LOGGER:-INFO,console)"
YARN_OPTS="$YARN_OPTS -Dyarn.root.logger=$(YARN_ROOT_LOGGER:-INFO,console)"
if [ "x$JAVA_LIBRARY_PATH" != "x" ]; then
  YARN_OPTS="$YARN_OPTS -Djava.library.path=$JAVA_LIBRARY_PATH"
fi
exec /usr/local/java/jdk1.8.0_241/bin/java -Dproc_$COMMAND $JAVA_HEAP_MAX $YARN_OPTS -classpath "$CLASSPATH" $CLASS "$@"
```

Additionally, plugins were required to be added to sbt project to create the jar file that hadoop uses.

```
assemblyMergeStrategy in assembly := {
  case PathList("META-INF", xs @ _) => MergeStrategy.discard
  case x => MergeStrategy.first
}
```

```
libraryDependencies += "org.apache.hadoop" % "hadoop-core" % "1.2.1"
```

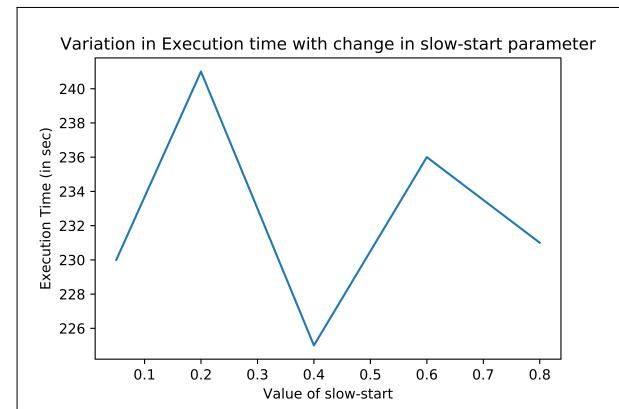
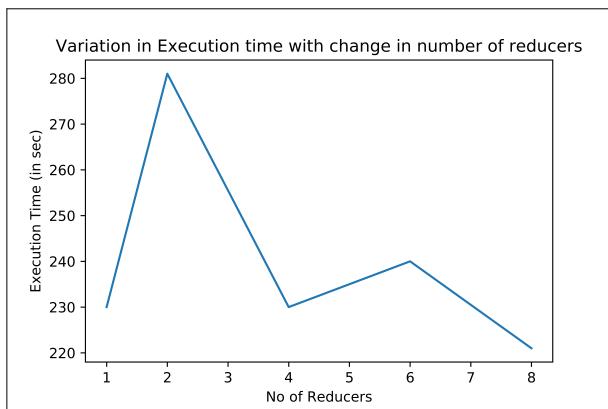
Above lines are to be added to build.sbt file in the sbt folder.

```
|addSbtPlugin("com.eed3si9n" % "sbt-assembly" % "0.14.6")
```

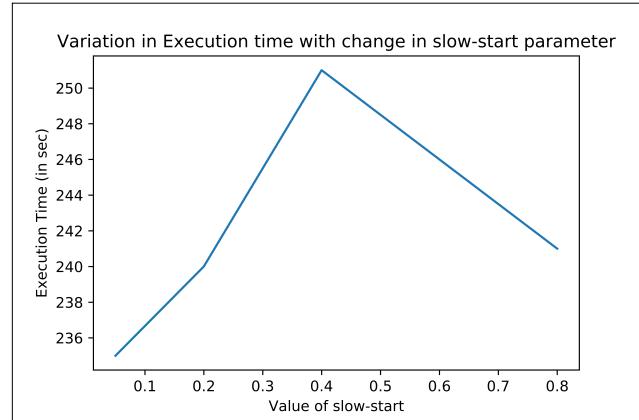
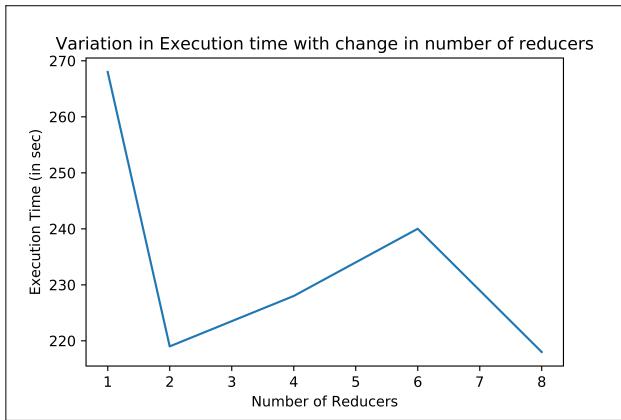
This line is to be added to assembly.sbt file in the sbt project folder.

II Plots

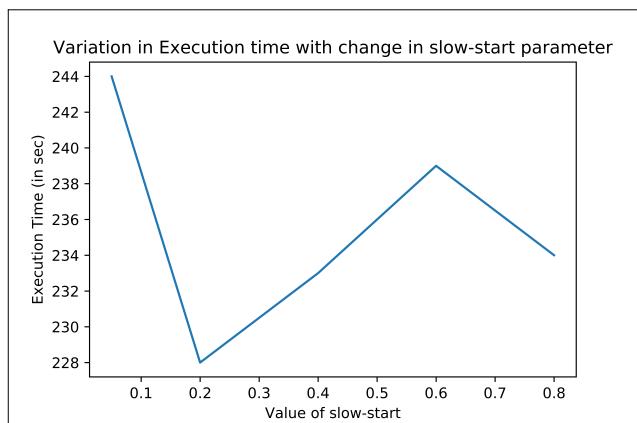
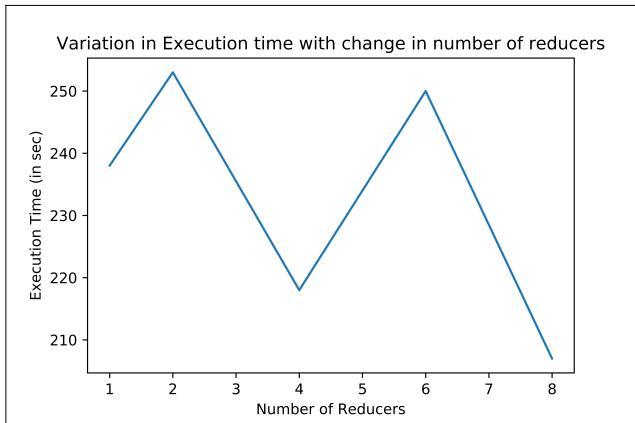
1. Query 1



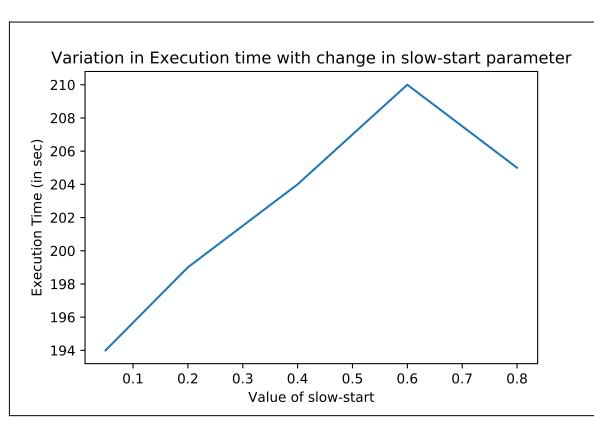
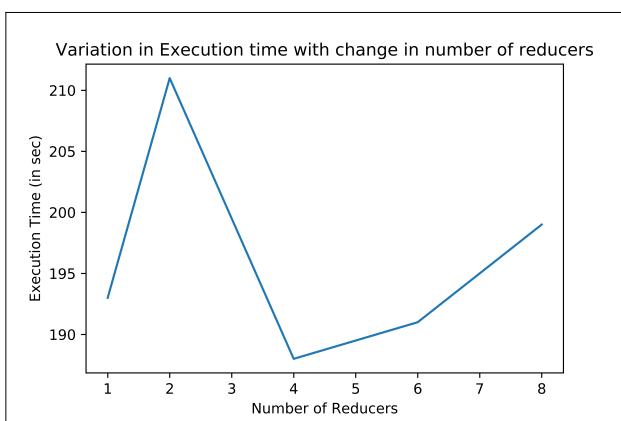
2. Query 2



3. Query 3



4. Query 4



III Observation & Inferences

We see that to perform the same task in CPU of a single node, it takes way less time to complete the task. This is because the number of nodes in the cluster is very small compared to what is required to see appreciable improvement.

Increasing number of reducers generally decreases the execution time, but the change is not substantial, because we all reducer tasks run on the master node, as can be seen from CPU usage

Changing the slow-start parameter does not observably start the reducer tasks at the set value, infact reducers always start after >90% of map task is finished

The average time for task 4 is lower than other tasks, this is because the number of keys outputted by the mapper will be considerably smaller, as only 8pm to 2am time window is captured

IV Output files

In the Outputs folder, there are 4 folders corresponding to each query. In each of the folders, the codes that were used for the task are shown. In the final_monthwise_outputs folder, the outputs for every month are shown

V Acknowledgements

The following websites were referred to for writing MapReduce programs in Scala:

1. <https://dzone.com/articles/wordcount-on-hadoop-with-scala-emmanouil-gkatzour>
2. <https://dzone.com/articles/hadoop-word-count-program-in-scala>
3. <https://www.scala-lang.org/>