ECC Lab 1

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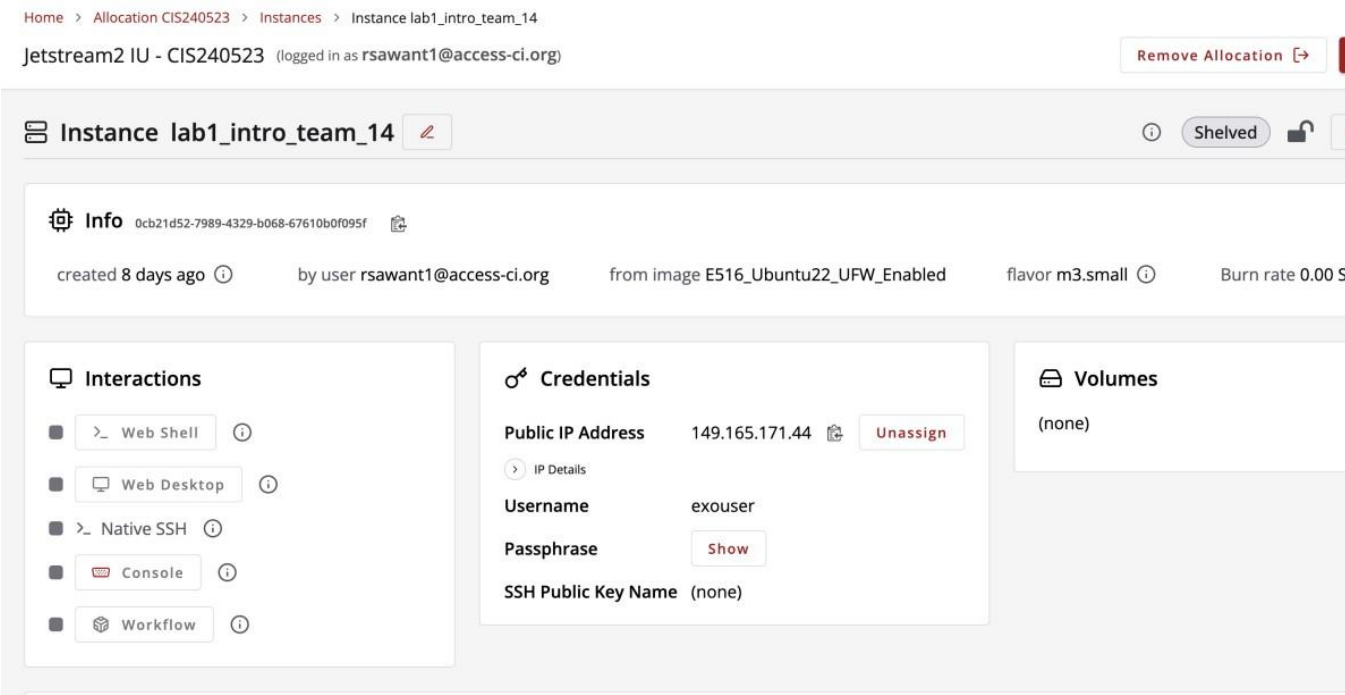
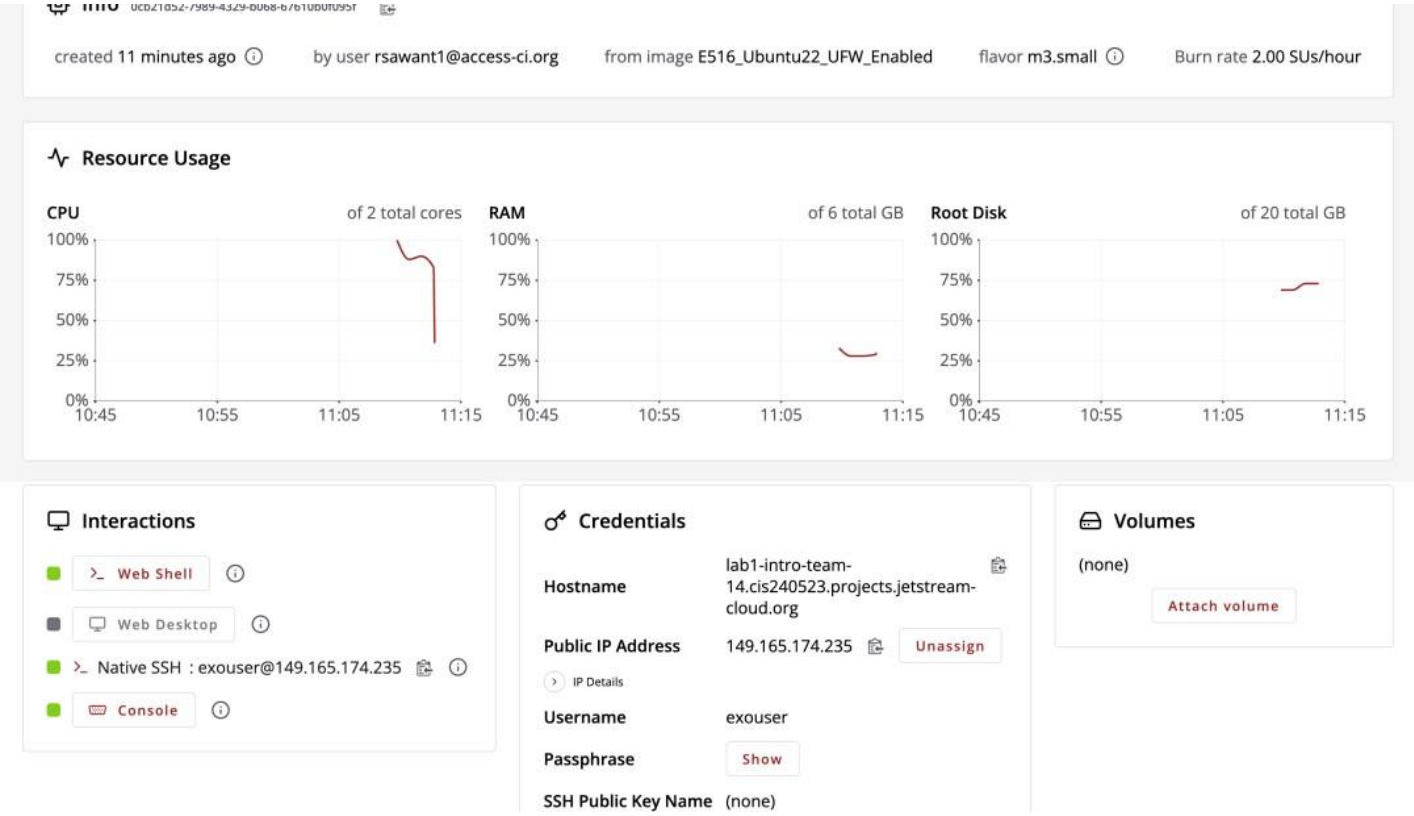
Objective:

1) Deploy a Single-Node Hadoop Cluster on Jetstream2.
2) Validate and enforce firewall rules via UFW and enable SSH key-pair authentication.
3) Install and validate Hadoop.
4) Configure the MapReduce framework.
5) Compile and run the WordStandardDeviation.java example to confirm cluster operability.

Procedure:

- To start the project, we setup our instance on Jetstream. We have used the image E516_Ubuntu22_UFW_Enabled with the flavor m3.small following the steps as shown in the video provided

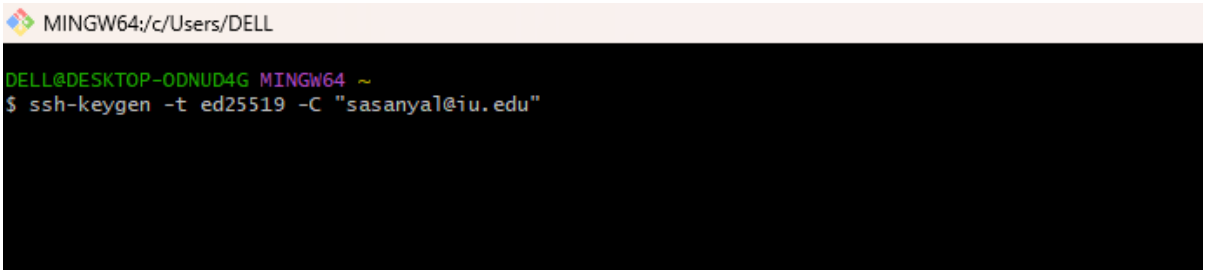




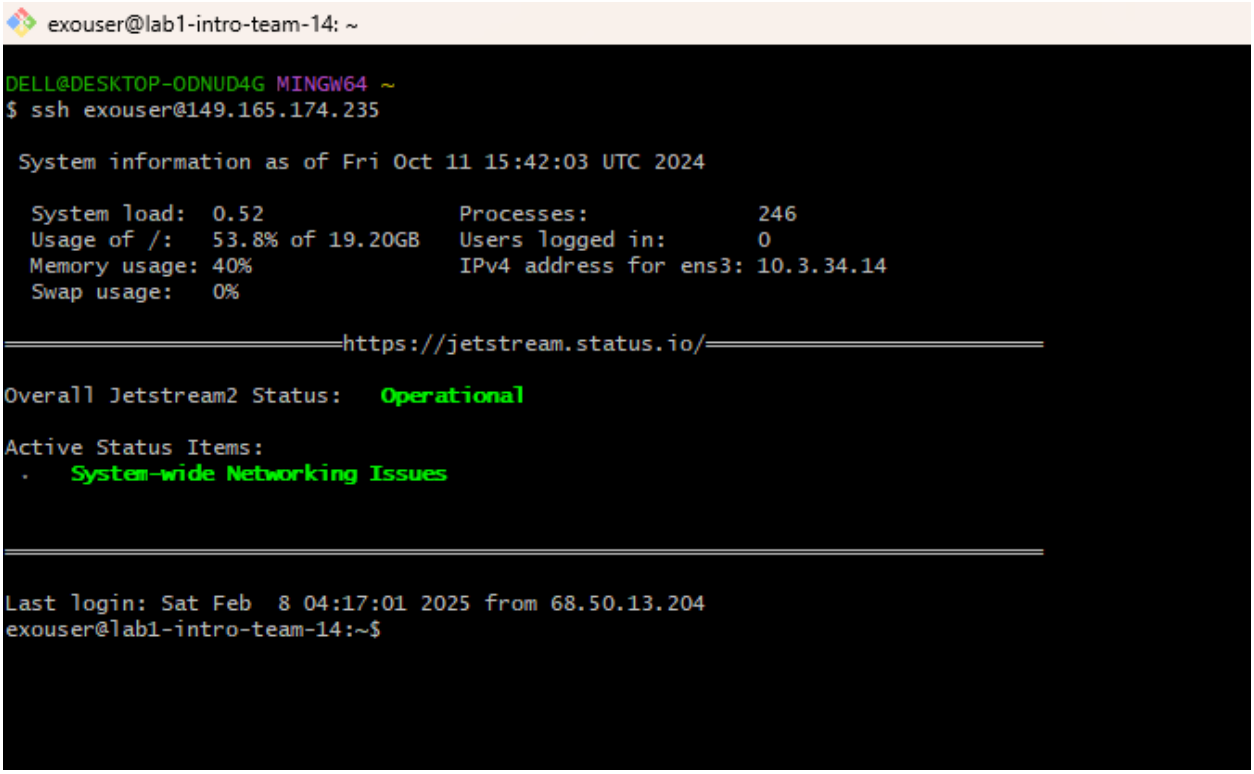
- After connecting to the instance, we first checked the firewall status. To do this we ran the command **sudo ufw status verbose**. Output showed active firewall with default deny (incoming) and allow (outgoing). Only SSH (port 22) was allowed. We then added rules to allow to permit all the incoming traffic from the IP's of our team and not just from the SSH

```
exouser@lab1-intro-team-14:~$ sudo ufw status verbose
Status: active
Logging: on (low)
Default: deny (incoming), allow (outgoing), deny (routed)
New profiles: skip

To                         Action      From
--                         ------      ----
22/tcp (OpenSSH)           ALLOW IN    Anywhere
22/tcp                     ALLOW IN    Anywhere
22/tcp (OpenSSH (v6))      ALLOW IN    Anywhere (v6)
22/tcp (v6)                ALLOW IN    Anywhere (v6)

exouser@lab1-intro-team-14:~$ sudo su -
root@lab1-intro-team-14:~# whoami
root
root@lab1-intro-team-14:~# sudo ufw allow from 68.50.13.204
Rule added
root@lab1-intro-team-14:~# sudo ufw allow from 68.50.22.130
Rule added
root@lab1-intro-team-14:~# sudo ufw status verbose
Status: active
Logging: on (low)
Default: deny (incoming), allow (outgoing), deny (routed)
New profiles: skip

To                         Action      From
--                         ------      ----
22/tcp (OpenSSH)           ALLOW IN    Anywhere
22/tcp                     ALLOW IN    Anywhere
Anywhere                   ALLOW IN    68.50.13.204
Anywhere                   ALLOW IN    68.50.22.130
22/tcp (OpenSSH (v6))      ALLOW IN    Anywhere (v6)
22/tcp (v6)                ALLOW IN    Anywhere (v6)

root@lab1-intro-team-14:~#
```

- To generate the public ssh key, we used the command shown in the figure below. Once we have our public key, we copied it into the /.ssh/authorized_keys directory



- Once we have the key in place, we attempted to reestablish our connection with the instance without a password which was successful as shown in the image below:



- We proceeded to create a user called hadoop. We also tested if the hadoop user can perform ssh without password.

```
BAD PASSWORD: The password contains the user name in some form
Retype new password:
Sorry, passwords do not match.
New password:
Retype new password:
passwd: password updated successfully
Changing the user information for hadoop
Enter the new value, or press ENTER for the default
        Full Name []:
        Room Number []:
        Work Phone []:
        Home Phone []:
        Other []:
Is the information correct? [Y/n] y
exouser@lab1-intro-team-14:~$ cat /etc/passwd
root:x:0:0:root:/root:/bin/bash
daemon:x:1:1:daemon:/usr/sbin:/usr/sbin/nologin
bin:x:2:2:bin:/bin:/usr/sbin/nologin
sys:x:3:3:sys:/dev:/usr/sbin/nologin
sync:x:4:65534:sync:/bin:/bin/sync
games:x:5:60:games:/usr/games:/usr/sbin/nologin
man:x:6:12:man:/var/cache/man:/usr/sbin/nologin
lp:x:7:7:lp:/var/spool/lpd:/usr/sbin/nologin
mail:x:8:8:mail:/var/mail:/usr/sbin/nologin
news:x:9:9:news:/var/spool/news:/usr/sbin/nologin
uucp:x:10:10:uucp:/var/spool/uucp:/usr/sbin/nologin
proxy:x:13:13:proxy:/bin:/usr/sbin/nologin
www-data:x:33:33:www-data:/var/www:/usr/sbin/nologin
backup:x:34:34:backup:/var/backups:/usr/sbin/nologin
list:x:38:38:Mailing List Manager:/var/list:/usr/sbin/nologin
irc:x:39:39:ircd:/run/ircd:/usr/sbin/nologin
gnats:x:41:41:Gnats Bug-Reporting System (admin):/var/lib/gnats:/usr/sbin/nologin
nobody:x:65534:65534:nobody:/nonexistent:/usr/sbin/nologin
systemd-network:x:100:102:systemd Network Management,,,:/run/systemd:/usr/sbin/nologin
systemd-resolve:x:101:103:systemd Resolver,,,:/run/systemd:/usr/sbin/nologin
messagebus:x:102:105::/nonexistent:/usr/sbin/nologin
systemd-timesync:x:103:106:systemd Time Synchronization,,,:/run/systemd:/usr/sbin/nologin
syslog:x:104:111::/home/syslog:/usr/sbin/nologin
_apt:x:105:65534::/nonexistent:/usr/sbin/nologin
tss:x:106:112:TPM software stack,,,:/var/lib/tpm:/bin/false
uuidd:x:107:113::/run/uuidd:/usr/sbin/nologin
tcpdump:x:108:114::/nonexistent:/usr/sbin/nologin
sshd:x:109:65534::/run/sshd:/usr/sbin/nologin
pollinate:x:110:1::/var/cache/pollinate:/bin/false
landscape:x:111:116::/var/lib/landscape:/usr/sbin/nologin
fwupd-refresh:x:112:117:fwupd-refresh user,,,:/run/systemd:/usr/sbin/nologin
ubuntu:x:1000:1000:Ubuntu:/home/ubuntu:/bin/bash
lxd:x:999:100::/var/snap/lxd/common/lxd:/bin/false
ceph:x:64045:64045:Ceph storage service:/var/lib/ceph:/usr/sbin/nologin
rtkit:x:113:122:RealtimeKit,,,:/proc:/usr/sbin/nologin
dnsmasq:x:114:65534:dnsmasq,,,:/var/lib/misc:/usr/sbin/nologin
kernoops:x:115:65534:Kernel Oops Tracking Daemon,,,:/:/usr/sbin/nologin
cups-pk-helper:x:116:123:user for cups-pk-helper service,,,:/home/cups-pk-helper:/usr/sbin/nologin
systemd-oom:x:117:126:systemd Userspace OOM Killer,,,:/run/systemd:/usr/sbin/nologin
whoopsie:x:118:127::/nonexistent:/bin/false
avahi-autoipd:x:119:128:Avahi autoip daemon,,,:/var/lib/avahi-autoipd:/usr/sbin/nologin
usbmux:x:120:46:usbmux daemon,,,:/var/lib/usbmux:/usr/sbin/nologin
avahi:x:121:129:Avahi mDNS daemon,,,:/run/avahi-daemon:/usr/sbin/nologin
nm-openvpn:x:122:130:NetworkManager OpenVPN,,,:/var/lib/openvpn/chroot:/usr/sbin/nologin
geoclue:x:123:131::/var/lib/geoclue:/usr/sbin/nologin
saned:x:124:133::/var/lib/saned:/usr/sbin/nologin
colord:x:125:134:colord colour management daemon,,,:/var/lib/colord:/usr/sbin/nologin
sssd:x:126:135:SSSD system user,,,:/var/lib/sss:/usr/sbin/nologin
pulse:x:127:136:PulseAudio daemon,,,:/run/pulse:/usr/sbin/nologin
speech-dispatcher:x:128:29:Speech Dispatcher,,,:/run/speech-dispatcher:/bin/false
hplip:x:129:7:HPLIP system user,,,:/run/hplip:/bin/false
gnome-initial-setup:x:130:65534::/run/gnome-initial-setup/:/bin/false
gdm:x:131:138:Gnome Display Manager:/var/lib/gdm3:/bin/false
exouser:x:1001:1001::/home/exouser:/bin/bash
hadoop:x:1002:1003:,,,:/home/hadoop:/bin/bash
exouser@lab1-intro-team-14:~$
```

- We used wget to download the apache files and packages using the command as shown below and unzipped it using the tar command.

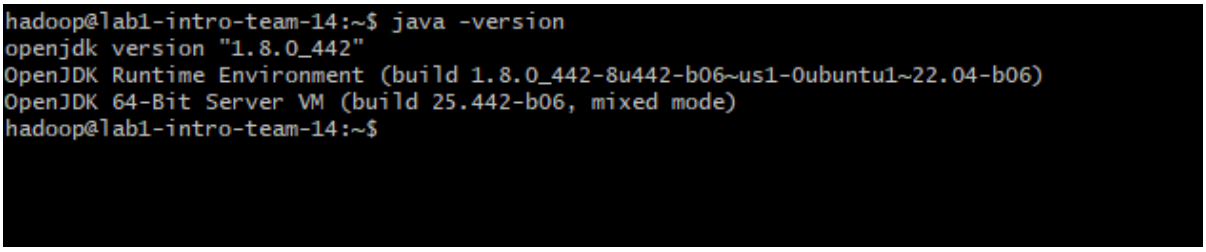
```
hadoop@lab1-intro-team-14:~$ history
    1  clear
    2  ls -ltr
    3  ls -ltr -a
    4  wget https://dlcdn.apache.org/hadoop/common/hadoop-3.3.6/hadoop-3.3.6.tar.gz
    5  tar -xvzf hadoop-3.3.6.tar.gz
    6  history
hadoop@lab1-intro-team-14:~$
```

- We used the vi editor to add the following commands to .bashsrc file:
  export JAVA_HOME=/usr/lib/jvm/java-8-openjdk-amd64

export HADOOP_HOME=/home/hadoop/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 HADOOP_YARN_HOME=$HADOOP_HOME
export HADOOP_COMMON_LIB_NATIVE_DIR=$HADOOP_HOME/lib/native export PATH=$PATH:$HADOOP_HOME/sbin:$HADOOP_HOME/bin
export HADOOP_OPTS="-Djava.library.path=$HADOOP_HOME/lib/native"

- To load the configuration we used the command source ~/.bashrc By editing the .bashrc file we have added the correct path the packages and openjdk.

- We checked the openjdk version and by default Ubuntu uses 11 so we uninstalled and downgraded it to 8 so that hive does not cause any issue.



- We also configured JAVA_HOME in hadoop-env.sh file. Edit the Hadoop environment variable file in the text editor to setup the variable environment. Also checked the hostname as changes needed to be made to configuration files.

```
hadoop@lab1-intro-team-14:~/hadoop/etc/hadoop$ ls -ltr
total 180
-rw-r--r-- 1 hadoop hadoop    10 Jun 18  2023 workers
-rw-r--r-- 1 hadoop hadoop  2697 Jun 18  2023 ssl-server.xml.example
-rw-r--r-- 1 hadoop hadoop  2316 Jun 18  2023 ssl-client.xml.example
drwxr-xr-x 2 hadoop hadoop  4096 Jun 18  2023 shellprofile.d
-rw-r--r-- 1 hadoop hadoop 13700 Jun 18  2023 log4j.properties
-rw-r--r-- 1 hadoop hadoop  3414 Jun 18  2023 hadoop-user-functions.sh.example
-rw-r--r-- 1 hadoop hadoop 11765 Jun 18  2023 hadoop-policy.xml
-rw-r--r-- 1 hadoop hadoop  3321 Jun 18  2023 hadoop-metrics2.properties
-rw-r--r-- 1 hadoop hadoop  3999 Jun 18  2023 hadoop-env.cmd
-rw-r--r-- 1 hadoop hadoop   682 Jun 18  2023 kms-site.xml
-rw-r--r-- 1 hadoop hadoop  1860 Jun 18  2023 kms-log4j.properties
-rw-r--r-- 1 hadoop hadoop  1351 Jun 18  2023 kms-env.sh
-rw-r--r-- 1 hadoop hadoop  3518 Jun 18  2023 kms-acls.xml
-rw-r--r-- 1 hadoop hadoop  2681 Jun 18  2023 user_ec_policies.xml.template
-rw-r--r-- 1 hadoop hadoop   620 Jun 18  2023 httpfs-site.xml
-rw-r--r-- 1 hadoop hadoop  1657 Jun 18  2023 httpfs-log4j.properties
-rw-r--r-- 1 hadoop hadoop  1484 Jun 18  2023 httpfs-env.sh
-rw-r--r-- 1 hadoop hadoop   683 Jun 18  2023 hdfs-rbf-site.xml
-rw-r--r-- 1 hadoop hadoop  2591 Jun 18  2023 yarnservice-log4j.properties
-rw-r--r-- 1 hadoop hadoop  6329 Jun 18  2023 yarn-env.sh
-rw-r--r-- 1 hadoop hadoop  2250 Jun 18  2023 yarn-env.cmd
-rw-r--r-- 1 hadoop hadoop  2567 Jun 18  2023 container-executor.cfg
-rw-r--r-- 1 hadoop hadoop  9213 Jun 18  2023 capacity-scheduler.xml
-rw-r--r-- 1 hadoop hadoop  4113 Jun 18  2023 mapred-queues.xml.template
-rw-r--r-- 1 hadoop hadoop  1764 Jun 18  2023 mapred-env.sh
-rw-r--r-- 1 hadoop hadoop   951 Jun 18  2023 mapred-env.cmd
-rw-r--r-- 1 hadoop hadoop  1335 Jun 18  2023 configuration.xsl
-rw-r--r-- 1 hadoop hadoop 16668 Feb  8 17:21 hadoop-env.sh
-rw-r--r-- 1 hadoop hadoop   893 Feb  8 17:25 core-site.xml
-rw-r--r-- 1 hadoop hadoop  1152 Feb  8 17:27 hdfs-site.xml
-rw-r--r-- 1 hadoop hadoop  1215 Feb  8 17:28 mapred-site.xml
-rw-r--r-- 1 hadoop hadoop   758 Feb  8 17:29 yarn-site.xml
hadoop@lab1-intro-team-14:~/hadoop/etc/hadoop$
```

```
hadoop@lab1-intro-team-14:~/hadoop/etc/hadoop$ cat hadoop-env.sh | grep export
export JAVA_HOME=/usr/lib/jvm/java-8-openjdk-amd64
# export HADOOP_HOME=
# export HADOOP_CONF_DIR=${HADOOP_HOME}/etc/hadoop
# export HADOOP_HEAPSIZE_MAX=
# export HADOOP_HEAPSIZE_MIN=
# export HADOOP_JAAS_DEBUG=true
# export HADOOP_OPTS="-Djava.net.preferIPv4Stack=true"
# export HADOOP_OPTS="-Djava.net.preferIPv4Stack=true -Dsun.security.krb5.debug=true -Dsun.security.spnego.debug"
export HADOOP_OS_TYPE=${HADOOP_OS_TYPE:-$(uname -s)}
# export HADOOP_CLIENT_OPTS=""
# export HADOOP_CLASSPATH="/some/cool/path/on/your/machine"
# export HADOOP_USER_CLASSPATH_FIRST="yes"
# export HADOOP_USE_CLIENT_CLASSLOADER=true
# export HADOOP_CLIENT_CLASSLOADER_SYSTEM_CLASSES="-org.apache.hadoop.UserClass,java.,javax.,org.apache.hadoop."
# export HADOOP_OPTIONAL_TOOLS="hadoop-kafka,hadoop-aws,hadoop-azure-datalake,hadoop-aliyun,hadoop-azure"
```

```
hadoop@lab1-intro-team-14:~/hadoop/etc/hadoop$ hostname
lab1-intro-team-14
hadoop@lab1-intro-team-14:~/hadoop/etc/hadoop$
```

- Next, we edited the core-site.xml file and updated it with instance name: **vi etc/hadoop/core-site.xml**

```
hadoop@lab1-intro-team-14:~/hadoop/etc/hadoop$ cat core-site.xml
<?xml version="1.0" encoding="UTF-8"?>
<?xml-stylesheet type="text/xsl" href="configuration.xsl"?>
<!--
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  you may not use this file except in compliance with the License.
  You may obtain a copy of the License at

    http://www.apache.org/licenses/LICENSE-2.0

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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>fs.defaultFS</name>
        <value>hdfs://lab1-intro-team-14:9000</value>
    </property>
</configuration>
hadoop@lab1-intro-team-14:~/hadoop/etc/hadoop$
```
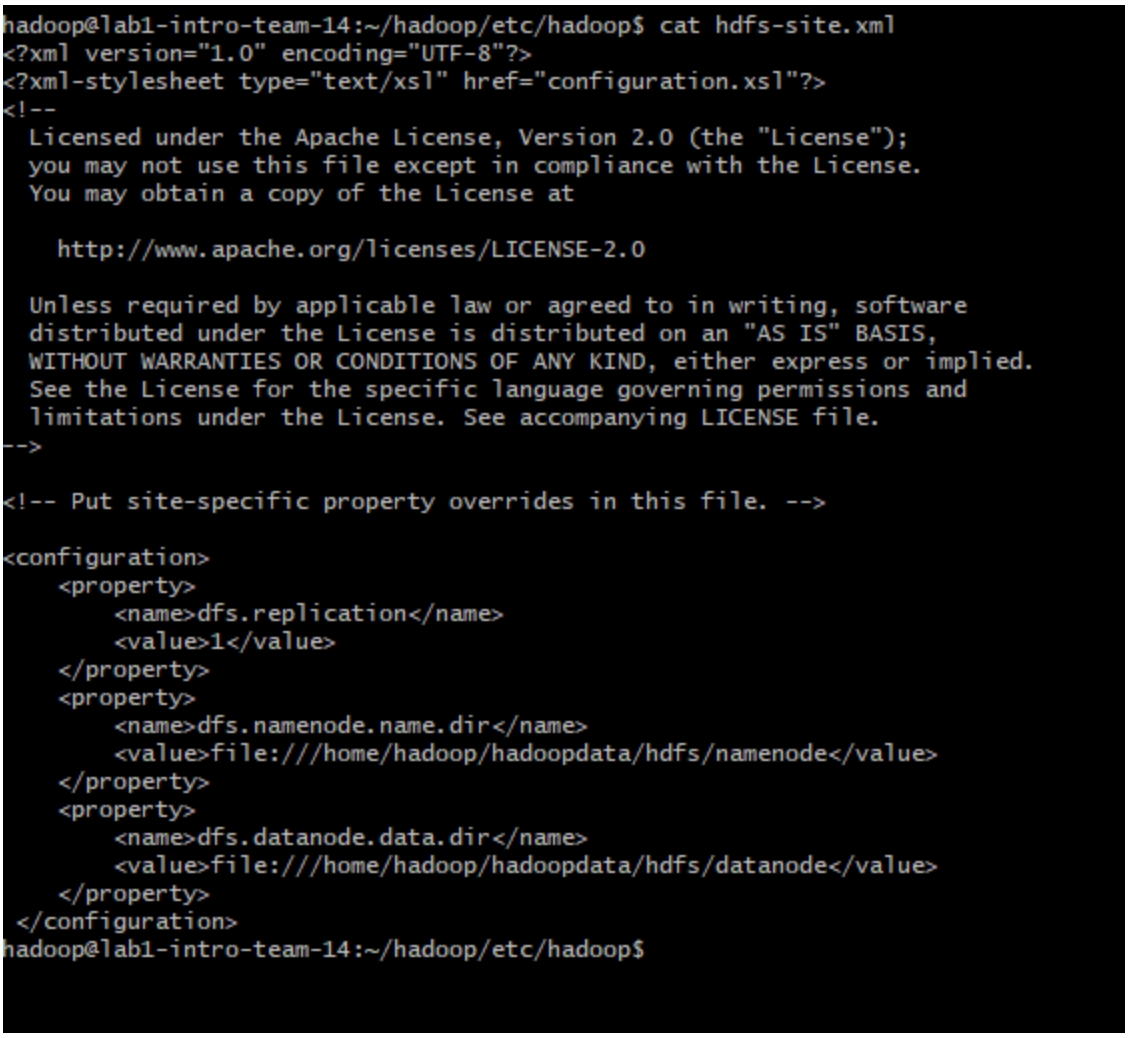

- Then, we edited the hdfs-site.xml file: **vi etc/hadoop/hdfs-site.xml** and used vi to edit the hdfs-site.xml file



```
hadoop@lab1-intro-team-14:~/hadoop/etc/hadoop$ cat hdfs-site.xml
<?xml version="1.0" encoding="UTF-8"?>
<?xml-stylesheet type="text/xsl" href="configuration.xsl"?>
<!--
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  you may not use this file except in compliance with the License.
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    http://www.apache.org/licenses/LICENSE-2.0

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  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>dfs.replication</name>
        <value>1</value>
    </property>
    <property>
        <name>dfs.namenode.name.dir</name>
        <value>file:///home/hadoop/hadoopdata/hdfs/namenode</value>
    </property>
    <property>
        <name>dfs.datanode.data.dir</name>
        <value>file:///home/hadoop/hadoopdata/hdfs/datanode</value>
    </property>
 </configuration>
hadoop@lab1-intro-team-14:~/hadoop/etc/hadoop$
```

- Then, we edited the hdfs-site.xml file: **vi etc/hadoop/mapred-site.xml** and used vi to edit the mapred-site.xml file

```
hadoop@lab1-intro-team-14:~/hadoop/etc/hadoop$ cat mapred-site.xml
<?xml version="1.0"?>
<?xml-stylesheet type="text/xsl" href="configuration.xsl"?>
<!--
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  you may not use this file except in compliance with the License.
  You may obtain a copy of the License at

    http://www.apache.org/licenses/LICENSE-2.0

  Unless required by applicable law or agreed to in writing, software
  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>yarn.app.mapreduce.am.env</name>
      <value>HADOOP_MAPRED_HOME=$HADOOP_HOME/home/hadoop/hadoop/bin/hadoop</value>
   </property>
   <property>
      <name>mapreduce.map.env</name>
      <value>HADOOP_MAPRED_HOME=$HADOOP_HOME/home/hadoop/hadoop/bin/hadoop</value>
   </property>
   <property>
      <name>mapreduce.reduce.env</name>
      <value>HADOOP_MAPRED_HOME=$HADOOP_HOME/home/hadoop/hadoop/bin/hadoop</value>
   </property>
</configuration>
hadoop@lab1-intro-team-14:~/hadoop/etc/hadoop$
```

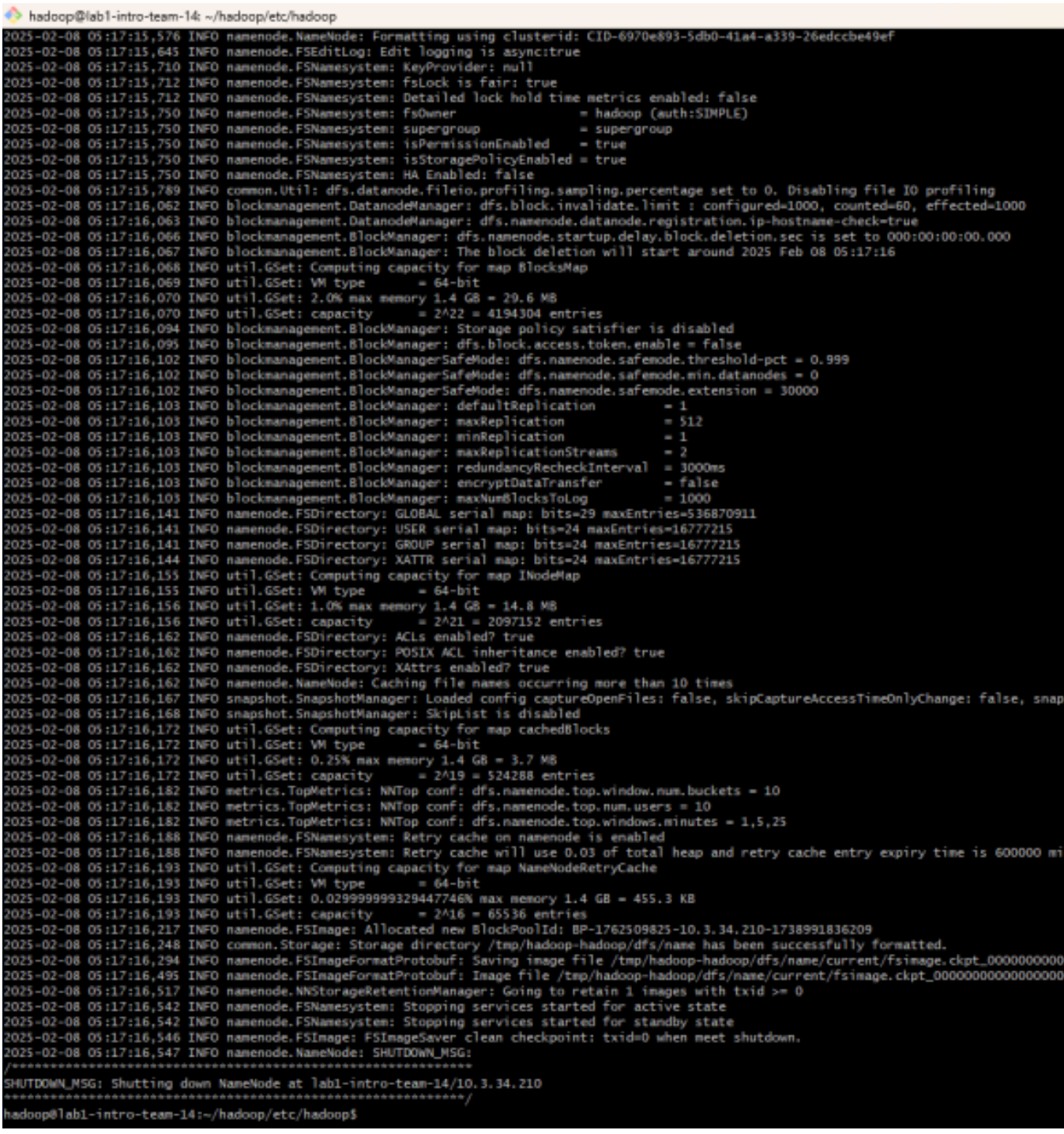
- We then edited the the yarn-site.xml file: **vi etc/hadoop/yarn-site.xml**

```
hadoop@lab1-intro-team-14:~/hadoop/etc/hadoop$ cat yarn-site.xml
<?xml version="1.0"?>
<!--
  Licensed under the Apache License, Version 2.0 (the "License");
  you may not use this file except in compliance with the License.
  You may obtain a copy of the License at

    http://www.apache.org/licenses/LICENSE-2.0

  Unless required by applicable law or agreed to in writing, software
  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.
-->
<configuration>
    <property>
        <name>yarn.nodemanager.aux-services</name>
        <value>mapreduce_shuffle</value>
    </property>
</configuration>
hadoop@lab1-intro-team-14:~/hadoop/etc/hadoop$
```

- Before starting the Hadoop cluster, we formatted the namenode as a hadoop user and ran the command **hdfs namenode -format** By doing this we format the namenode and make it usable**.**



```
/************************************************************
SHUTDOWN_MSG: Shutting down NameNode at lab1-intro-team-14/10.3.34.210
************************************************************/
hadoop@lab1-intro-team-14:~/hadoop/etc/hadoop$ start-all.sh
WARNING: Attempting to start all Apache Hadoop daemons as hadoop in 10 seconds.
WARNING: This is not a recommended production deployment configuration.
WARNING: Use CTRL-C to abort.
Starting namenodes on [lab1-intro-team-14]
Starting datanodes
Starting secondary namenodes [lab1-intro-team-14]
Starting resourcemanager
Starting nodemanagers
hadoop@lab1-intro-team-14:~/hadoop/etc/hadoop$ jps
144676 SecondaryNameNode
145781 Jps
145050 ResourceManager
145243 NodeManager
144139 NameNode
144350 DataNode
hadoop@lab1-intro-team-14:~/hadoop/etc/hadoop$ hdfs dfs -mkdir /test1
hadoop@lab1-intro-team-14:~/hadoop/etc/hadoop$ hdfs dfs -mkdir /logs
hadoop@lab1-intro-team-14:~/hadoop/etc/hadoop$ hdfs dfs -ls /
Found 2 items
drwxr-xr-x   - hadoop supergroup          0 2025-02-08 17:31 /logs
drwxr-xr-x   - hadoop supergroup          0 2025-02-08 17:31 /test1
hadoop@lab1-intro-team-14:~/hadoop/etc/hadoop$
```

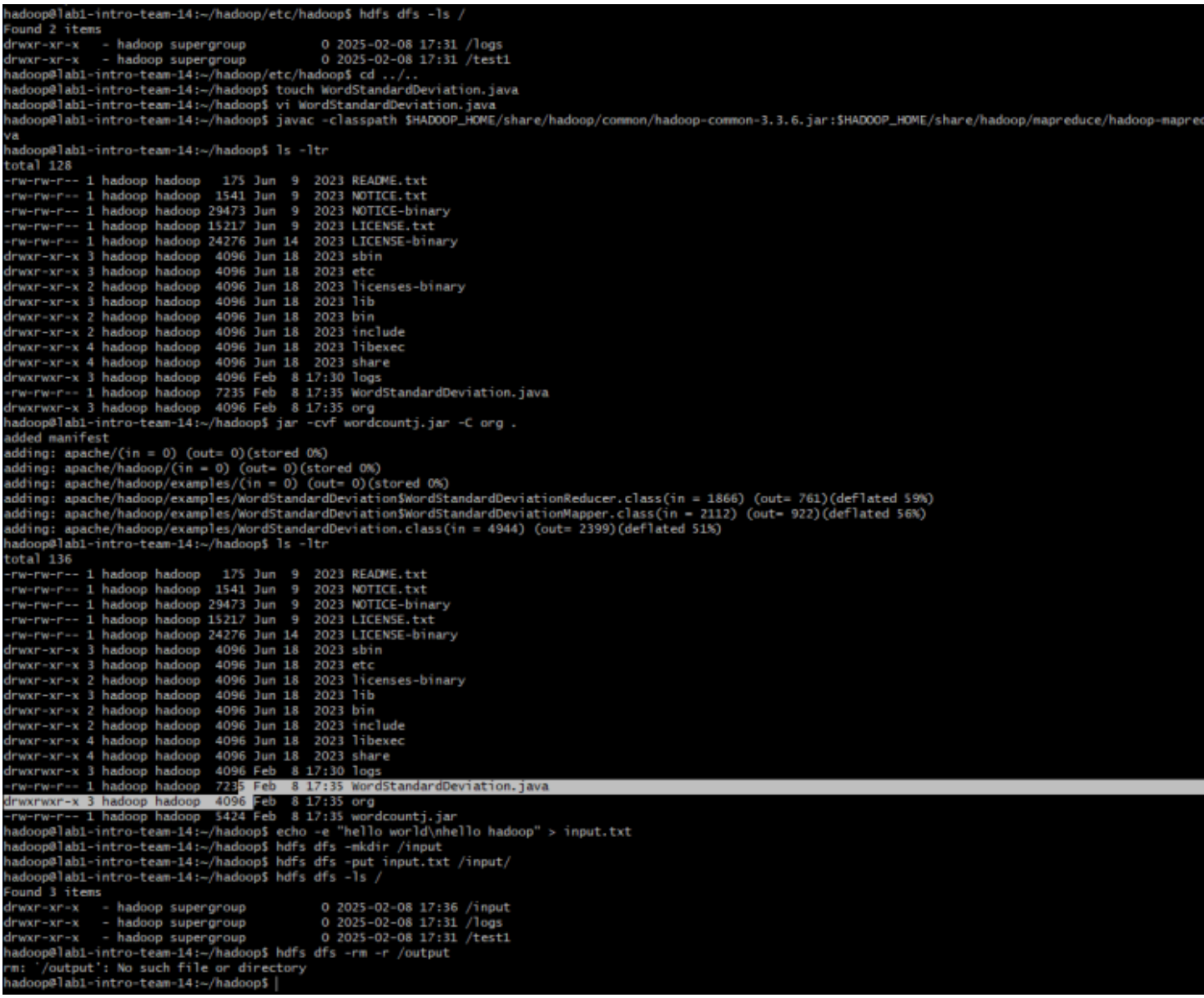
- We then started the hadoop cluster using the command **start-all.sh** We also used **jps** command to check the status of all the hadoop services.


```
/************************************************************
SHUTDOWN_MSG: Shutting down NameNode at lab1-intro-team-14/10.3.34.210
************************************************************/
hadoop@lab1-intro-team-14:~/hadoop/etc/hadoop$ start-all.sh
WARNING: Attempting to start all Apache Hadoop daemons as hadoop in 10 seconds.
WARNING: This is not a recommended production deployment configuration.
WARNING: Use CTRL-C to abort.
Starting namenodes on [lab1-intro-team-14]
Starting datanodes
Starting secondary namenodes [lab1-intro-team-14]
Starting resourcemanager
Starting nodemanagers
hadoop@lab1-intro-team-14:~/hadoop/etc/hadoop$ jps
144676 SecondaryNameNode
145781 Jps
145050 ResourceManager
145243 NodeManager
144139 NameNode
144350 DataNode
hadoop@lab1-intro-team-14:~/hadoop/etc/hadoop$ hdfs dfs -mkdir /test1
hadoop@lab1-intro-team-14:~/hadoop/etc/hadoop$ hdfs dfs -mkdir /logs
hadoop@lab1-intro-team-14:~/hadoop/etc/hadoop$ hdfs dfs -ls /
Found 2 items
drwxr-xr-x   - hadoop supergroup          0 2025-02-08 17:31 /logs
drwxr-xr-x   - hadoop supergroup          0 2025-02-08 17:31 /test1
hadoop@lab1-intro-team-14:~/hadoop/etc/hadoop$
```

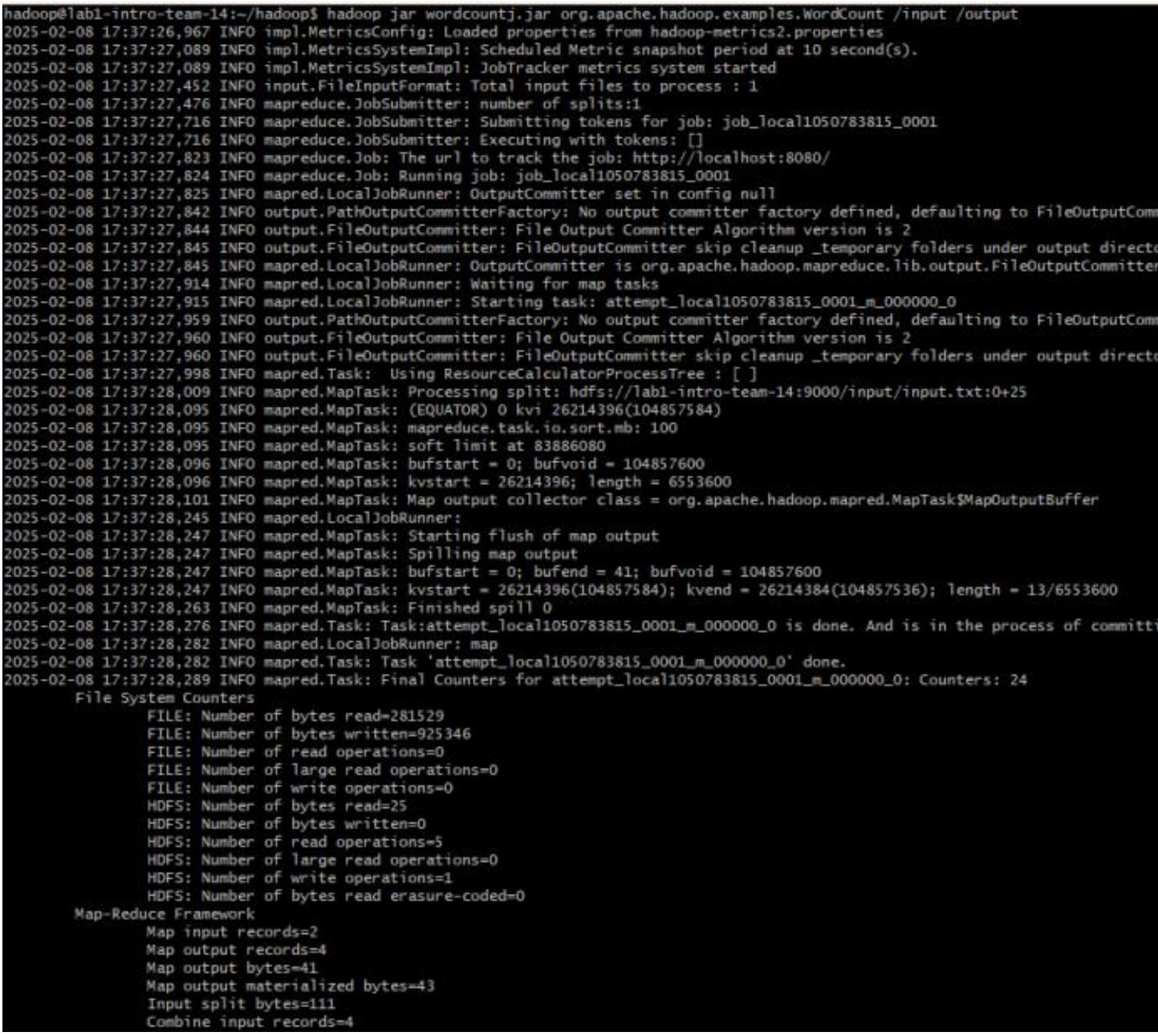

- At this point, the Hadoop cluster is installed and configured. Next we created some directories in the HDFS filesystem to test the Hadoop. We have successfully created the directories and confirmed that Hadoop has been installed correctly and its working fine.

- Now that we know everything is working as intended we copied the word count java code into our server. We directly copied the code and we used touch to create .java file on the instance. The process involved the steps as mentioned below:

1. Compile WordStandardDeviation.java



2. Run WordStandardDeviation.java
3. WordStandardDeviation.java is a simple map reduce function, it will calculate the number of total words in a distributed way.



4. Run hadoop with map reduce **hadoop jar wordcountj.jar org.apache.hadoop.examples.WordCount /input /output**

```
                Reduce input groups=3
                Reduce shuffle bytes=43
                Reduce input records=3
                Reduce output records=3
                Spilled Records=3
                Shuffled Maps =1
                Failed Shuffles=0
                Merged Map outputs=1
                GC time elapsed (ms)=16
                Total committed heap usage (bytes)=357040128
        Shuffle Errors
                BAD_ID=0
                CONNECTION=0
                IO_ERROR=0
                WRONG_LENGTH=0
                WRONG_MAP=0
                WRONG_REDUCE=0
        File Output Format Counters
                Bytes Written=25
2025-02-08 17:37:28,534 INFO mapred.LocalJobRunner: Finishing task: attempt_local1050783815_0001_r_000000_0
2025-02-08 17:37:28,534 INFO mapred.LocalJobRunner: reduce task executor complete.
2025-02-08 17:37:28,833 INFO mapreduce.Job: Job job_local1050783815_0001 running in uber mode : false
2025-02-08 17:37:28,833 INFO mapreduce.Job:  map 100% reduce 100%
2025-02-08 17:37:28,834 INFO mapreduce.Job: Job job_local1050783815_0001 completed successfully
2025-02-08 17:37:28,844 INFO mapreduce.Job: Counters: 36
        File System Counters
                FILE: Number of bytes read=563176
                FILE: Number of bytes written=1850735
                FILE: Number of read operations=0
                FILE: Number of large read operations=0
                FILE: Number of write operations=0
                HDFS: Number of bytes read=50
                HDFS: Number of bytes written=25
                HDFS: Number of read operations=15
                HDFS: Number of large read operations=0
                HDFS: Number of write operations=4
                HDFS: Number of bytes read erasure-coded=0
        Map-Reduce Framework
                Map input records=2
                Map output records=4
                Map output bytes=41
                Map output materialized bytes=43
                Input split bytes=111
                Combine input records=4
                Combine output records=3
                Reduce input groups=3
                Reduce shuffle bytes=43
                Reduce input records=3
                Reduce output records=3
                Spilled Records=6
                Shuffled Maps =1
                Failed Shuffles=0
                Merged Map outputs=1
                GC time elapsed (ms)=16
                Total committed heap usage (bytes)=713555968
        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=25
        File Output Format Counters
                Bytes Written=25
hadoop@lab1-intro-team-14:~/hadoop$ hdfs dfs -cat /output/part-r-00000
hadoop  1
hello   2
world   1
hadoop@lab1-intro-team-14:~/hadoop$
```

5. Print the output result **hdfs dfs -cat /output/part-r-00000**

```
hadoop@lab1-intro-team-14:~/hadoop$ hdfs dfs -cat /output/part-r-00000
hadoop  1
hello   2
world   1
hadoop@lab1-intro-team-14:~/hadoop$
```

- As we can see, we have gotten the correct output. We then stopped the services and shelved the instance.

```
451  vi hadoop-env.sh
452  stop-all.sh
453  start-all.sh
```