Assignment 2 : COL733

Fault Recovery in HDFS

Group 20

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A. Installing HDFS on VMs

Here, we present the steps required to install HDFS on Baadal VMs and set up the Name Node and Data Nodes.

1. Install the Java libraries on all the VMs being used.

   ```
   sudo apt-get install default-jre
   sudo apt-get install default-jdk
   ```

2. Now we add a dedicated user account with sudo privileges to install and run Hadoop Distributed File System.

   ```
   sudo addgroup hadoop
   sudo adduser --ingroup hadoop hadoopuser
   sudo usermod -aG sudo hadoopuser
   ```

3. Generate SSH keys (public and private) for the new user and enable remote SSH access to the VM using these keys.

   ```
   su - hadoopuser
   ssh-keygen -t rsa -P ""
   cat ~/.ssh/id_rsa.pub >> ~/.ssh/authorized_keys
   ```

   It is now possible for the VMs to seamlessly transfer data securely through SSH without further authentication once they exchange their keys.

4. Now edit the /etc/hosts file and add the IP addresses corresponding to the master and each slave.

```
sudo vim /etc/hosts
```

The file post editing looks like this :

> 127.0.0.1 localhost
> 127.0.1.1 baadalvm
>
> 10.17.5.18 master
> 10.17.5.65 slave-1
> 10.17.5.81 slave-2
> 10.17.5.97 slave-3
> ...

5. Copy/ Exchange the ssh keys of each VM to allow for seamless transfers between them.

```
ssh-copy-id   -i   ~/.ssh/id_rsa.pub   hadoopuser@hadoop-master
ssh-copy-id   -i   ~/.ssh/id_rsa.pub   hadoopuser@hadoop-slave-1
ssh-copy-id   -i   ~/.ssh/id_rsa.pub   hadoopuser@hadoop-slave-2
ssh-copy-id   -i   ~/.ssh/id_rsa.pub   hadoopuser@hadoop-slave-3
```

6. Install Hadoop and change its ownership to hadoopuser from the original user.

```
sudo mkdir /opt/hadoop/
cd /opt/hadoop
wget http://apache.mesi.com.ar/hadoop/common/hadoop-1.2.1/hadoop-1.2.0.tar.gz
tar -xzf hadoop-1.2.0.tar.gz
mv hadoop-1.2.0 hadoop
chown -R hadoop /opt/hadoop
```

7. Now edit the Hadoop configuration markup files in the /opt/hadoop/hadoop/conf directory as specified :

   - ***core-site.xml***

```
<configuration>
    <property>
        <name>fs.default.name</name>
        <value>hdfs://master:9000/</value>
    </property>
    <property>
        <name>dfs.permissions</name>
        <value>false</value>
    </property>
</configuration>
```

   - ***hdfs-site.xml***

```
<configuration>
    <property>
        <name>dfs.data.dir</name>
        <value>/opt/hadoop/hadoop/dfs/name/data</value>
        <final>true</final>
    </property>
    <property>
        <name>dfs.name.dir</name>
        <value>/opt/hadoop/hadoop/dfs/name</value>
        <final>true</final>
    </property>
    <property>
        <name>dfs.replication</name>
        <value>2</value>
    </property>
</configuration>
```

- ***mapred-site.xml***

```
<configuration>
    <property>
        <name>mapred.job.tracker</name>
        <value>master:9001</value>
    </property>
</configuration>
```

8. Edit the /opt/hadoop/hadoop/conf/hadoop-env.sh file and add the path variables :

```
export JAVA_HOME=/usr/lib/jvm/java-7-openjdk-amd64
export HADOOP_OPTS=-Djava.net.preferIPv4Stack=true
export HADOOP_CONF_DIR=/opt/hadoop/hadoop/conf
```

9. Copy Hadoop to each of the slaves using scp (Secure Copy).

```
scp -r /opt/hadoop/hadoop hadoopuser@hadoop-slave-1:/opt/hadoop
scp -r /opt/hadoop/hadoop hadoopuser@hadoop-slave-2:/opt/hadoop
scp -r /opt/hadoop/hadoop hadoopuser@hadoop-slave-3:/opt/hadoop
```

10. Now configure Hadoop only on the master aka Name Node as follows:

- Add the following line to ***/etc/hadoop/hadoop/conf/masters***:

```
hadoop-master
```

- Add the following line to ***/etc/hadoop/hadoop/conf/slaves***:

```
hadoop-slave-1
hadoop-slave-2
hadoop-slave-3
```

11. Finally we format the Name Node and start all the configured hadoop nodes:

    ```
    /opt/hadoop/hadoop/bin/hadoop namenode –format
    /opt/hadoop/hadoop/bin start-all.sh
    ```

B. Miscellaneous commands

1. Add/Update the following environment variables to the ~/.bashrc to ease with hadoop commands.

    ```
    export JAVA_HOME=/usr/lib/jvm/java-7-openjdk-amd64
    export HADOOP_HOME=/opt/hadoop/hadoop
    export PATH=$PATH:$HADOOP_HOME/bin
    ```

    Then reload this bashfile using `source ~/.bashrc`.

2. We can use the following code to simply copy new file to the HDFS setup.

    ```
    hadoop fs -copyFromLocal ~/path-to-file /
    ```

3. We can use the files and directories present in the filesystem using :

    ```
    hadoop   fs   -ls   /
    ```

4. To run a filesystem check and report details about the nodes, files and blocks, we can use :

    ```
    hadoop fsck / -files -locations -blocks
    ```

C. Distribution of fileblocks

This third part explores the fileblock distribution of each file in the filesystem after adding these files, shutting off a data node and finally after switching it on again.
For the sake of understanding we present the files present in our filesystem:

```
hadoopuser@baadalvm:~$ hadoop fs -ls /
Found 4 items
-rw-r--r--   2 root supergroup  653592539 2017-09-08 13:22 /SUS1.mp4
-rw-r--r--   2 root supergroup  653592539 2017-09-08 13:09 /SUS2.mp4
-rw-r--r--   2 root supergroup  653592539 2017-09-08 13:21 /SUS3.mp4
-rw-r--r--   2 root supergroup  653592539 2017-09-08 13:24 /SUS4.mp4
```

C.1. Initial block distribution after adding the four files

```
/SUS1.mp4 653592539 bytes, 10 block(s):  OK
0. blk_6588348971712109411_1004 len=67108864 repl=2 [10.17.5.81:50010, 10.17.5.97:
50010]
1. blk_-5804724061654281738_1004 len=67108864 repl=2 [10.17.5.97:50010, 10.17.5.65
:50010]
2. blk_1085890709272374668_1004 len=67108864 repl=2 [10.17.5.81:50010, 10.17.5.97:
50010]
3. blk_-5810969758965596659_1004 len=67108864 repl=2 [10.17.5.65:50010, 10.17.5.97:
50010]
4. blk_-3935497505041583152_1004 len=67108864 repl=2 [10.17.5.97:50010, 10.17.5.65
:50010]
5. blk_4756541502223269836_1004 len=67108864 repl=2 [10.17.5.97:50010, 10.17.5.65:
50010]
6. blk_-8732554929063348532_1004 len=67108864 repl=2 [10.17.5.97:50010, 10.17.5.65
:50010]
7. blk_-7960230668184408216_1004 len=67108864 repl=2 [10.17.5.81:50010, 10.17.5.97
:50010]
8. blk_9106741461073200789_1004 len=67108864 repl=2 [10.17.5.81:50010, 10.17.5.65:
50010]
9. blk_3619597502629408517_1004 len=49612763 repl=2 [10.17.5.81:50010, 10.17.5.65:
50010]

/SUS2.mp4 653592539 bytes, 10 block(s):  OK
0. blk_-181071918242058150_1002 len=67108864 repl=2 [10.17.5.81:50010, 10.17.5.97:
50010]
1. blk_-7828335571816508860_1002 len=67108864 repl=2 [10.17.5.81:50010, 10.17.5.97
:50010]
2. blk_2591111432898544115_1002 len=67108864 repl=2 [10.17.5.65:50010, 10.17.5.97:
50010]
3. blk_4819850744683169209_1002 len=67108864 repl=2 [10.17.5.81:50010, 10.17.5.65:
50010]
4. blk_-7672163457112356679_1002 len=67108864 repl=2 [10.17.5.97:50010, 10.17.5.65
:50010]
5. blk_-5942775327562343471_1002 len=67108864 repl=2 [10.17.5.81:50010, 10.17.5.97
:50010]
6. blk_-6905280166092196047_1002 len=67108864 repl=2 [10.17.5.81:50010, 10.17.5.65
:50010]
7. blk_-982908485361597987_1002 len=67108864 repl=2 [10.17.5.81:50010, 10.17.5.97:
```

```
50010]
8. blk_-449533941851992976_1002 len=67108864 repl=2 [10.17.5.65:50010, 10.17.5.97:
50010]
9. blk_7404801039013736151_1002 len=49612763 repl=2 [10.17.5.97:50010, 10.17.5.65:
50010]

/SUS3.mp4 653592539 bytes, 10 block(s):  OK
0. blk_1025198094299669728_1003 len=67108864 repl=2 [10.17.5.97:50010, 10.17.5.81:
50010]
1. blk_-4742368946348626998_1003 len=67108864 repl=2 [10.17.5.65:50010, 10.17.5.97
:50010]
2. blk_-671137473834085565_1003 len=67108864 repl=2 [10.17.5.81:50010, 10.17.5.97:
50010]
3. blk_-2799270936657625488_1003 len=67108864 repl=2 [10.17.5.81:50010, 10.17.5.65
:50010]
4. blk_7788514720917964278_1003 len=67108864 repl=2 [10.17.5.65:50010, 10.17.5.81:
50010]
5. blk_-5807371293679461860_1003 len=67108864 repl=2 [10.17.5.65:50010, 10.17.5.97
:50010]
6. blk_3221766431960300666_1003 len=67108864 repl=2 [10.17.5.81:50010, 10.17.5.97:
50010]
7. blk_7118178924600785626_1003 len=67108864 repl=2 [10.17.5.81:50010, 10.17.5.65:
50010]
8. blk_6705579912611729712_1003 len=67108864 repl=2 [10.17.5.65:50010, 10.17.5.97:
50010]
9. blk_6369000697544724180_1003 len=49612763 repl=2 [10.17.5.81:50010, 10.17.5.65:
50010]

/SUS4.mp4 653592539 bytes, 10 block(s):  OK
0. blk_1187652579730199034_1005 len=67108864 repl=2 [10.17.5.65:50010, 10.17.5.81:
50010]
1. blk_1151037134159860920_1005 len=67108864 repl=2 [10.17.5.81:50010, 10.17.5.97:
50010]
2. blk_-1168212695584117237_1005 len=67108864 repl=2 [10.17.5.65:50010, 10.17.5.81
:50010]
3. blk_-88858921718994576_1005 len=67108864 repl=2 [10.17.5.81:50010, 10.17.5.65:5
0010]
4. blk_-3450687638758960674_1005 len=67108864 repl=2 [10.17.5.97:50010, 10.17.5.81
:50010]
5. blk_2810725559575499863_1005 len=67108864 repl=2 [10.17.5.65:50010, 10.17.5.81:
50010]
6. blk_-8119019388714759536_1005 len=67108864 repl=2 [10.17.5.81:50010, 10.17.5.97
:50010]
7. blk_-6436396713817024387_1005 len=67108864 repl=2 [10.17.5.65:50010, 10.17.5.97
:50010]
8. blk_1275104005109459850_1005 len=67108864 repl=2 [10.17.5.65:50010, 10.17.5.81:
50010]
9. blk_-1177845176256952136_1005 len=49612763 repl=2 [10.17.5.81:50010, 10.17.5.65
```

```
:50010]
```

Observations

- We observe that the replication factor 2 is maintained for each of the blocks in every file.
- The square brackets list the data node holding each of the replica of each block of data.

C.2. Block distribution post turning off a Data Node

```
/SUS1.mp4 653592539 bytes, 10 block(s):  OK
0. blk_6588348971712109411_1004 len=67108864 repl=2 [10.17.5.81:50010, 10.17.5.65:
50010]
1. blk_-5804724061654281738_1004 len=67108864 repl=2 [10.17.5.65:50010, 10.17.5.81
:50010]
2. blk_1085890709272374668_1004 len=67108864 repl=2 [10.17.5.81:50010, 10.17.5.65:
50010]
3. blk_-581096975896559659_1004 len=67108864 repl=2 [10.17.5.65:50010, 10.17.5.81:
50010]
4. blk_-3935497505041583152_1004 len=67108864 repl=2 [10.17.5.65:50010, 10.17.5.81
:50010]
5. blk_4756541502223269836_1004 len=67108864 repl=2 [10.17.5.65:50010, 10.17.5.81:
50010]
6. blk_-8732554929063348532_1004 len=67108864 repl=2 [10.17.5.65:50010, 10.17.5.81
:50010]
7. blk_-7960230668184408216_1004 len=67108864 repl=2 [10.17.5.81:50010, 10.17.5.65
:50010]
8. blk_9106741461073200789_1004 len=67108864 repl=2 [10.17.5.81:50010, 10.17.5.65:
50010]
9. blk_3619597502629408517_1004 len=49612763 repl=2 [10.17.5.81:50010, 10.17.5.65:
50010]

/SUS2.mp4 653592539 bytes, 10 block(s):  OK
0. blk_-181071918242058150_1002 len=67108864 repl=2 [10.17.5.81:50010, 10.17.5.65:
50010]
1. blk_-7828335571816508860_1002 len=67108864 repl=2 [10.17.5.81:50010, 10.17.5.65
:50010]
2. blk_2591111432898544115_1002 len=67108864 repl=2 [10.17.5.65:50010, 10.17.5.81:
50010]
3. blk_4819850744683169209_1002 len=67108864 repl=2 [10.17.5.81:50010, 10.17.5.65:
50010]
4. blk_-7672163457112356679_1002 len=67108864 repl=2 [10.17.5.65:50010, 10.17.5.81
:50010]
5. blk_-5942775327562343471_1002 len=67108864 repl=2 [10.17.5.81:50010, 10.17.5.65
:50010]
6. blk_-6905280166092196047_1002 len=67108864 repl=2 [10.17.5.81:50010, 10.17.5.65
:50010]
7. blk_-982908485361597987_1002 len=67108864 repl=2 [10.17.5.81:50010, 10.17.5.65:
```

```
50010]
8. blk_-449533941851992976_1002 len=67108864 repl=2 [10.17.5.65:50010, 10.17.5.81:
50010]
9. blk_7404801039013736151_1002 len=49612763 repl=2 [10.17.5.65:50010, 10.17.5.81:
50010]

/SUS3.mp4 653592539 bytes, 10 block(s):  OK
0. blk_1025198094299669728_1003 len=67108864 repl=2 [10.17.5.81:50010, 10.17.5.65:
50010]
1. blk_-4742368946348626998_1003 len=67108864 repl=2 [10.17.5.65:50010, 10.17.5.81
:50010]
2. blk_-671137473834085565_1003 len=67108864 repl=2 [10.17.5.81:50010, 10.17.5.65:
50010]
3. blk_-2799270936657625488_1003 len=67108864 repl=2 [10.17.5.81:50010, 10.17.5.65
:50010]
4. blk_7788514720917964278_1003 len=67108864 repl=2 [10.17.5.65:50010, 10.17.5.81:
50010]
5. blk_-5807371293679461860_1003 len=67108864 repl=2 [10.17.5.65:50010, 10.17.5.81
:50010]
6. blk_3221766431960300666_1003 len=67108864 repl=2 [10.17.5.81:50010, 10.17.5.65:
50010]
7. blk_7118178924600785626_1003 len=67108864 repl=2 [10.17.5.81:50010, 10.17.5.65:
50010]
8. blk_6705579912611729712_1003 len=67108864 repl=2 [10.17.5.65:50010, 10.17.5.81:
50010]
9. blk_6369000697544724180_1003 len=49612763 repl=2 [10.17.5.81:50010, 10.17.5.65:
50010]

/SUS4.mp4 653592539 bytes, 10 block(s):  OK
0. blk_1187652579730199034_1005 len=67108864 repl=2 [10.17.5.65:50010, 10.17.5.81:
50010]
1. blk_1151037134159860920_1005 len=67108864 repl=2 [10.17.5.81:50010, 10.17.5.65:
50010]
2. blk_-1168212695584117237_1005 len=67108864 repl=2 [10.17.5.65:50010, 10.17.5.81
:50010]
3. blk_-88858921718994576_1005 len=67108864 repl=2 [10.17.5.81:50010, 10.17.5.65:5
0010]
4. blk_-3450687638758960674_1005 len=67108864 repl=2 [10.17.5.81:50010, 10.17.5.65
:50010]
5. blk_2810725559575499863_1005 len=67108864 repl=2 [10.17.5.65:50010, 10.17.5.81:
50010]
6. blk_-8119019388714759536_1005 len=67108864 repl=2 [10.17.5.81:50010, 10.17.5.65
:50010]
7. blk_-6436396713817024387_1005 len=67108864 repl=2 [10.17.5.65:50010, 10.17.5.81
:50010]
8. blk_1275104005109459850_1005 len=67108864 repl=2 [10.17.5.65:50010, 10.17.5.81:
50010]
9. blk_-1177845176256952136_1005 len=49612763 repl=2 [10.17.5.81:50010, 10.17.5.65
```

```
:50010]
```

Observations

- Inspite of losing a data node, HDFS maintains the replication factor 2 for each block by creating new copies.
- The data node at 10.17.5.97 is no longer listed in any block because it is turned off.

C.3. Block distribution just after turning on the shut Data Node

```
/SUS1.mp4 653592539 bytes, 10 block(s):  OK
0. blk_6588348971712109411_1004 len=67108864 repl=3 [10.17.5.81:50010, 10.17.5.65:
50010, 10.17.5.97:50010]
1. blk_-5804724061654281738_1004 len=67108864 repl=3 [10.17.5.65:50010, 10.17.5.81
:50010, 10.17.5.97:50010]
2. blk_1085890709272374668_1004 len=67108864 repl=3 [10.17.5.81:50010, 10.17.5.65:
50010, 10.17.5.97:50010]
3. blk_-581096975896559659_1004 len=67108864 repl=3 [10.17.5.65:50010, 10.17.5.81:
50010, 10.17.5.97:50010]
4. blk_-3935497505041583152_1004 len=67108864 repl=3 [10.17.5.65:50010, 10.17.5.81
:50010, 10.17.5.97:50010]
5. blk_4756541502223269836_1004 len=67108864 repl=3 [10.17.5.65:50010, 10.17.5.81:
50010, 10.17.5.97:50010]
6. blk_-8732554929063348532_1004 len=67108864 repl=3 [10.17.5.65:50010, 10.17.5.81
:50010, 10.17.5.97:50010]
7. blk_-7960230668184408216_1004 len=67108864 repl=3 [10.17.5.81:50010, 10.17.5.65
:50010, 10.17.5.97:50010]
8. blk_9106741461073200789_1004 len=67108864 repl=2 [10.17.5.81:50010, 10.17.5.65:
50010]
9. blk_3619597502629408517_1004 len=49612763 repl=2 [10.17.5.81:50010, 10.17.5.65:
50010]

/SUS2.mp4 653592539 bytes, 10 block(s):  OK
0. blk_-181071918242058150_1002 len=67108864 repl=3 [10.17.5.81:50010, 10.17.5.65:
50010, 10.17.5.97:50010]
1. blk_-7828335571816508860_1002 len=67108864 repl=3 [10.17.5.81:50010, 10.17.5.65
:50010, 10.17.5.97:50010]
2. blk_2591111432898544115_1002 len=67108864 repl=3 [10.17.5.65:50010, 10.17.5.81:
50010, 10.17.5.97:50010]
3. blk_4819850744683169209_1002 len=67108864 repl=2 [10.17.5.81:50010, 10.17.5.65:
50010]
4. blk_-7672163457112356679_1002 len=67108864 repl=3 [10.17.5.65:50010, 10.17.5.81
:50010, 10.17.5.97:50010]
5. blk_-5942775327562343471_1002 len=67108864 repl=3 [10.17.5.81:50010, 10.17.5.65
:50010, 10.17.5.97:50010]
6. blk_-6905280166092196047_1002 len=67108864 repl=2 [10.17.5.81:50010, 10.17.5.65
:50010]
```

```
7. blk_-982908485361597987_1002 len=67108864 repl=3 [10.17.5.81:50010, 10.17.5.65:
50010, 10.17.5.97:50010]
8. blk_-449533941851992976_1002 len=67108864 repl=3 [10.17.5.65:50010, 10.17.5.81:
50010, 10.17.5.97:50010]
9. blk_7404801039013736151_1002 len=49612763 repl=3 [10.17.5.65:50010, 10.17.5.81:
50010, 10.17.5.97:50010]

/SUS3.mp4 653592539 bytes, 10 block(s):  OK
0. blk_1025198094299669728_1003 len=67108864 repl=3 [10.17.5.81:50010, 10.17.5.65:
50010, 10.17.5.97:50010]
1. blk_-4742368946348626998_1003 len=67108864 repl=3 [10.17.5.65:50010, 10.17.5.81
:50010, 10.17.5.97:50010]
2. blk_-671137473834085565_1003 len=67108864 repl=3 [10.17.5.81:50010, 10.17.5.65:
50010, 10.17.5.97:50010]
3. blk_-2799270936657625488_1003 len=67108864 repl=2 [10.17.5.81:50010, 10.17.5.65
:50010]
4. blk_7788514720917964278_1003 len=67108864 repl=2 [10.17.5.65:50010, 10.17.5.81:
50010]
5. blk_-5807371293679461860_1003 len=67108864 repl=3 [10.17.5.65:50010, 10.17.5.81
:50010, 10.17.5.97:50010]
6. blk_3221766431960300666_1003 len=67108864 repl=3 [10.17.5.81:50010, 10.17.5.65:
50010, 10.17.5.97:50010]
7. blk_7118178924600785626_1003 len=67108864 repl=2 [10.17.5.81:50010, 10.17.5.65:
50010]
8. blk_6705579912611729712_1003 len=67108864 repl=3 [10.17.5.65:50010, 10.17.5.81:
50010, 10.17.5.97:50010]
9. blk_6369000697544724180_1003 len=49612763 repl=2 [10.17.5.81:50010, 10.17.5.65:
50010]

/SUS4.mp4 653592539 bytes, 10 block(s):  OK
0. blk_1187652579730199034_1005 len=67108864 repl=2 [10.17.5.65:50010, 10.17.5.81:
50010]
1. blk_1151037134159860920_1005 len=67108864 repl=3 [10.17.5.81:50010, 10.17.5.65:
50010, 10.17.5.97:50010]
2. blk_-1168212695584117237_1005 len=67108864 repl=2 [10.17.5.65:50010, 10.17.5.81
:50010]
3. blk_-88858921718994576_1005 len=67108864 repl=2 [10.17.5.81:50010, 10.17.5.65:5
0010]
4. blk_-3450687638758960674_1005 len=67108864 repl=3 [10.17.5.81:50010, 10.17.5.65
:50010, 10.17.5.97:50010]
5. blk_2810725559575499863_1005 len=67108864 repl=2 [10.17.5.65:50010, 10.17.5.81:
50010]
6. blk_-8119019388714759536_1005 len=67108864 repl=3 [10.17.5.81:50010, 10.17.5.65
:50010, 10.17.5.97:50010]
7. blk_-6436396713817024387_1005 len=67108864 repl=3 [10.17.5.65:50010, 10.17.5.81
:50010, 10.17.5.97:50010]
8. blk_1275104005109459850_1005 len=67108864 repl=2 [10.17.5.65:50010, 10.17.5.81:
50010]
```

```
9. blk_-1177845176256952136_1005 len=49612763 repl=2 [10.17.5.81:50010, 10.17.5.65
:50010]
```

Observations

- The blocks that were initially present in the data node at 10.17.5.97 now have 3 replicas available which is more than the mandated replication factor (= 2).

C.4. Block distribution post turning off a Data Node

```
/SUS1.mp4 653592539 bytes, 10 block(s):  OK
0. blk_6588348971712109411_1004 len=67108864 repl=2 [10.17.5.81:50010, 10.17.5.97:
50010]
1. blk_-5804724061654281738_1004 len=67108864 repl=2 [10.17.5.97:50010, 10.17.5.81
:50010]
2. blk_1085890709272374668_1004 len=67108864 repl=2 [10.17.5.81:50010, 10.17.5.97:
50010]
3. blk_-5810969758965596659_1004 len=67108864 repl=2 [10.17.5.97:50010, 10.17.5.81:
50010]
4. blk_-3935497505041583152_1004 len=67108864 repl=2 [10.17.5.97:50010, 10.17.5.81
:50010]
5. blk_4756541502223269836_1004 len=67108864 repl=2 [10.17.5.97:50010, 10.17.5.81:
50010]
6. blk_-8732554929063348532_1004 len=67108864 repl=2 [10.17.5.97:50010, 10.17.5.81
:50010]
7. blk_-7960230668184408216_1004 len=67108864 repl=2 [10.17.5.81:50010, 10.17.5.97
:50010]
8. blk_9106741461073200789_1004 len=67108864 repl=2 [10.17.5.81:50010, 10.17.5.65:
50010]
9. blk_3619597502629408517_1004 len=49612763 repl=2 [10.17.5.81:50010, 10.17.5.65:
50010]

/SUS2.mp4 653592539 bytes, 10 block(s):  OK
0. blk_-181071918242058150_1002 len=67108864 repl=2 [10.17.5.81:50010, 10.17.5.97:
50010]
1. blk_-7828335571816508860_1002 len=67108864 repl=2 [10.17.5.81:50010, 10.17.5.97
:50010]
2. blk_2591111432898544115_1002 len=67108864 repl=2 [10.17.5.97:50010, 10.17.5.81:
50010]
3. blk_4819850744683169209_1002 len=67108864 repl=2 [10.17.5.81:50010, 10.17.5.65:
50010]
4. blk_-7672163457112356679_1002 len=67108864 repl=2 [10.17.5.97:50010, 10.17.5.81
:50010]
5. blk_-5942775327562343471_1002 len=67108864 repl=2 [10.17.5.81:50010, 10.17.5.97
:50010]
6. blk_-6905280166092196047_1002 len=67108864 repl=2 [10.17.5.81:50010, 10.17.5.65
:50010]
```

```
7. blk_-982908485361597987_1002 len=67108864 repl=2 [10.17.5.81:50010, 10.17.5.97:
50010]
8. blk_-449533941851992976_1002 len=67108864 repl=2 [10.17.5.97:50010, 10.17.5.81:
50010]
9. blk_7404801039013736151_1002 len=49612763 repl=2 [10.17.5.97:50010, 10.17.5.81:
50010]

/SUS3.mp4 653592539 bytes, 10 block(s):  OK
0. blk_1025198094299669728_1003 len=67108864 repl=2 [10.17.5.81:50010, 10.17.5.97:
50010]
1. blk_-4742368946348626998_1003 len=67108864 repl=2 [10.17.5.97:50010, 10.17.5.81
:50010]
2. blk_-671137473834085565_1003 len=67108864 repl=2 [10.17.5.81:50010, 10.17.5.97:
50010]
3. blk_-2799270936657625488_1003 len=67108864 repl=2 [10.17.5.81:50010, 10.17.5.65
:50010]
4. blk_7788514720917964278_1003 len=67108864 repl=2 [10.17.5.65:50010, 10.17.5.81:
50010]
5. blk_-5807371293679461860_1003 len=67108864 repl=2 [10.17.5.97:50010, 10.17.5.81
:50010]
6. blk_3221766431960300666_1003 len=67108864 repl=2 [10.17.5.81:50010, 10.17.5.97:
50010]
7. blk_7118178924600785626_1003 len=67108864 repl=2 [10.17.5.81:50010, 10.17.5.65:
50010]
8. blk_6705579912611729712_1003 len=67108864 repl=2 [10.17.5.97:50010, 10.17.5.81:
50010]
9. blk_6369000697544724180_1003 len=49612763 repl=2 [10.17.5.81:50010, 10.17.5.65:
50010]

/SUS4.mp4 653592539 bytes, 10 block(s):  OK
0. blk_1187652579730199034_1005 len=67108864 repl=2 [10.17.5.65:50010, 10.17.5.81:
50010]
1. blk_1151037134159860920_1005 len=67108864 repl=2 [10.17.5.81:50010, 10.17.5.97:
50010]
2. blk_-1168212695584117237_1005 len=67108864 repl=2 [10.17.5.65:50010, 10.17.5.81
:50010]
3. blk_-88858921718994576_1005 len=67108864 repl=2 [10.17.5.81:50010, 10.17.5.65:5
0010]
4. blk_-3450687638758960674_1005 len=67108864 repl=2 [10.17.5.81:50010, 10.17.5.97
:50010]
5. blk_2810725559575499863_1005 len=67108864 repl=2 [10.17.5.65:50010, 10.17.5.81:
50010]
6. blk_-8119019388714759536_1005 len=67108864 repl=2 [10.17.5.81:50010, 10.17.5.97
:50010]
7. blk_-6436396713817024387_1005 len=67108864 repl=2 [10.17.5.97:50010, 10.17.5.81
:50010]
8. blk_1275104005109459850_1005 len=67108864 repl=2 [10.17.5.65:50010, 10.17.5.81:
50010]
```

```
9. blk_-1177845176256952136_1005 len=49612763 repl=2 [10.17.5.81:50010, 10.17.5.65
:50010]
```

Observations

- Eventually, HDFS mantains the minimum required replication factor (2).
- The extra replicas that were previously observed have now been removed and the block load across data node VMs is now balanced.

D. Concluding Remarks

- Hadoop File System is infact very fault tolerant and therefore we are able to retrieve the original file even after shutting down one of the VMs.
- This is verified by checking the checksum of the original and retrieved file which match each other.
- The distribution of each file's blocks are such that the net storage load across data node VMs is balanced.
- Even post shutting down and starting a VM again, HDFS eventually manages to balance the data blocks across the VMs.

E. References

- Blog by Michael G. Noll
- HortonWorks
- Tutorials Point