Assignment 11.1 :
Advanced HBase

<u>**Task1**</u>

Explain the below concepts with an example in brief.

● Nosql Databases

● Types of Nosql Databases

● CAP Theorem

● HBase Architecture

● HBase vs RDBMS

● Nosql Databases

- NoSQL stands for Not only SQL. NoSQL are non-relational, open source, schema less and distributed database.
- They are highly popular today because of their ability to scale out or scale horizontally and flexibility to deal with a variety of data : structured, semi-structered and unstructured data.
- When compared to relational databases, NoSQL databases are more scalable and provide superior performance, and their data model addresses several issues that the relational model is not designed to address.
- They supports Auto-sharding and Replication feature.
- Object-oriented programming that is easy to use and flexible
- Geographically distributed scale-out architecture instead of expensive, monolithic architecture

● Types of Nosql Databases

- There are 4 types of NoSQL :
    1. **Key-Value pair /Key-Value store:**
       It maintains data in key-value pairs. It uses a hash table in which there exists a unique key and a pointer to a particular item of data.
       e.g.

Key	**Value**
First Name	Sachin
Last Name	Gorade
Address	Mumbai, India

       Amazon DynamoDB, LinkedIn uses key-value store NoSQL database.

    2. **Document store:**

       It maintains data in collections constituted of documents.
       It pair each key with a complex data structure known as a document.
       Documents can contain many different key-value pairs, or key-array pairs, or even nested documents.
       e.g.

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```
{
  _id: ObjectId(fdf789)
  title: 'MongoDB Overview',
  description: 'MongoDB is no sql database',
  tags: ['mongodb', 'database', 'NoSQL'],
}
```

Database: MongoDB, Apache CouchDB, Couchbase uses Document store.

3. **Column:**

Each storage block has data from only one column. It stores data using a column oriented model.
e.g. Databases : Cassandra, HBase

Facebook, eBay uses Column NoSQL.

4. **Graph :**

A Graph stores data in nodes. They are also called as Network database.

e.g. Databases: Neo4j, hyperGraphDB.

Walmart uses Graph NoSQL.

● **CAP Theorem**

The CAP theorem applies to distributed systems that store state. It states that networked shared-data systems can only guarantee or strongly support two of the following three properties:

- **Consistency** -
  A guarantee that every node in a distributed cluster returns the same, most recent, successful write. Consistency refers to every client having the same view of the data.

- **Availability –**
  Every non-failing node returns a response for all read and write requests in a reasonable amount of time. To be available, every node on (either side of a network partition) must be able to respond in a reasonable amount of time.

- **Partition Tolerant** –
  The system continues to function and upholds its consistency guarantees in spite of network partitions. Network partitions are a fact of life. Distributed systems guaranteeing partition tolerance can gracefully recover from partitions once the partition heals.

The CAP theorem categorizes systems into three categories. We can have system with one of these three categories:

- **CP (Consistent and Partition Tolerant) –**
  CP is referring to a category of systems where availability is sacrificed only in the case of a network partition.

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- **CA (Consistent and Available) –**
  CA systems are consistent and available systems in the absence of any network partition.

- **AP (Available and Partition Tolerant) –**
  These are systems that are available and partition tolerant but cannot guarantee consistency.

In case of a network partition (a rare occurrence) one needs to choose between Availability and partition tolerance. In any networked shared-data systems partition tolerance is a must. Network partitions and dropped messages are a fact of life and must be handled appropriately.

Consequently, system designers must choose between consistency and availability. A network partition forces designers to either choose perfect consistency or perfect availability. Picking consistency means not being able to answer a client's query as the system cannot guarantee to return the most recent write. This sacrifices availability. Network partition forces nonfailing nodes to reject clients' requests as these nodes cannot guarantee consistent data. At the opposite end of the spectrum, being available means being able to respond to a client's request but the system cannot guarantee consistency, i.e., the most recent value written. Available systems provide the best possible answer under the given circumstance.

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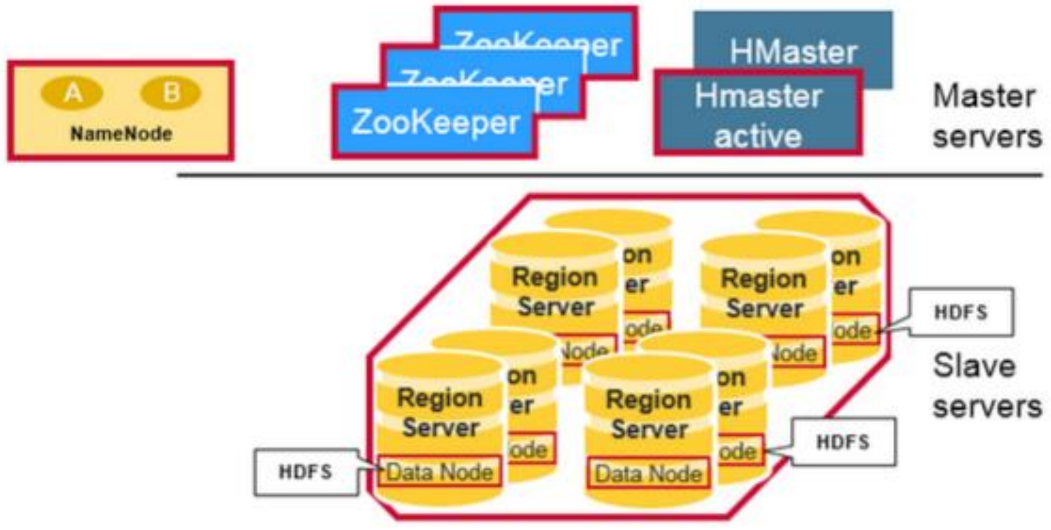
• HBase Architecture :

HBase is composed of three types of servers in a master-slave type of architecture.

• **Region servers** serve data for reads and writes

• **HBase Master** process handles the Region assignment, DDL (create, delete tables) operations

• **Zookeeper** maintains a live cluster state



Introduction to Architecture:

• The Hadoop DataNode stores the data that the Region Server is managing

• All HBase data is stored in HDFS files

• The NameNode maintains metadata information for all the physical data blocks that comprise the files

• Region assignment, DDL (create, delete tables) operations are handled by the HBase Master.

A master is responsible for:

• Coordinating the region servers
• Assigning regions on startup
• Re-assigning regions for recovery or load balancing
• Monitoring all RegionServer instances in the cluster (listens for notifications from zookeeper)
• Admin functions :
  Interface for creating, deleting, updating tables

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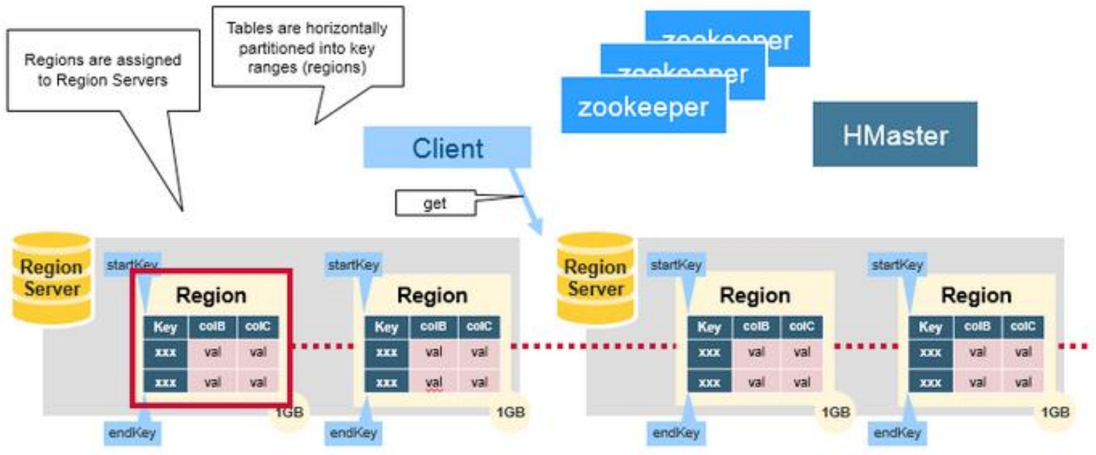

HBase First Read :

• There is a special HBase Catalog table called the META table, which holds the location of the regions in the cluster

• ZooKeeper stores the location of the META table

• The client gets the Region server that hosts the META table from ZooKeeper

• The client will query the .META. server to get the region server corresponding to the row key it wants to access. The client

caches this information along with the META table location

• It will get the row from the corresponding Region Server

• For future reads, the client uses the cache to retrieve the META location and previously read row keys

• Over time, it does not need to query the META table, unless there is a miss because a region has moved; then it will re-query and update the cache

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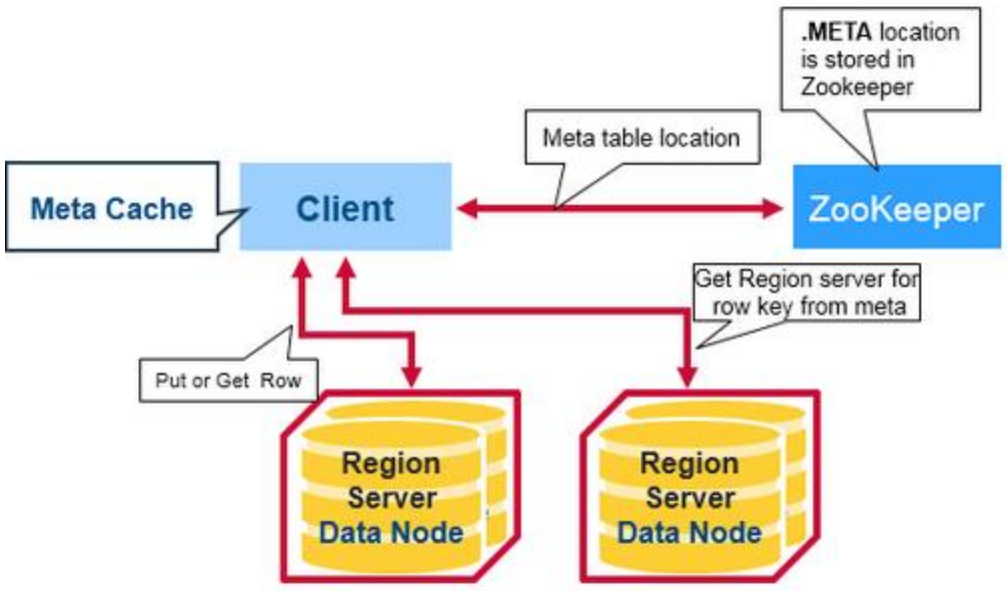
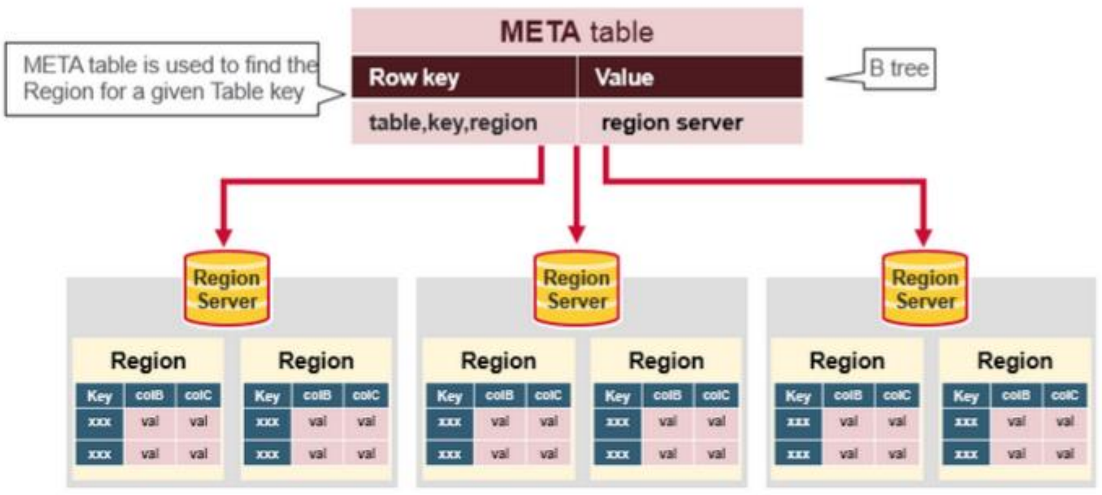


HBase Meta Table :

• This META table is an HBase table that keeps a list of all regions in the system
• The .META. table is like a b tree
• The .META. table structure is as follows: Key: region start key, region id Values: RegionServer
• Region Server runs on an HDFS data node and has the following components:



WAL :

• Write Ahead Log is a file on the distributed file system. The WAL is used to store new data that hasn't yet been persisted to permanent storage; it is used for recovery in the case of failure.

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BlockCache:

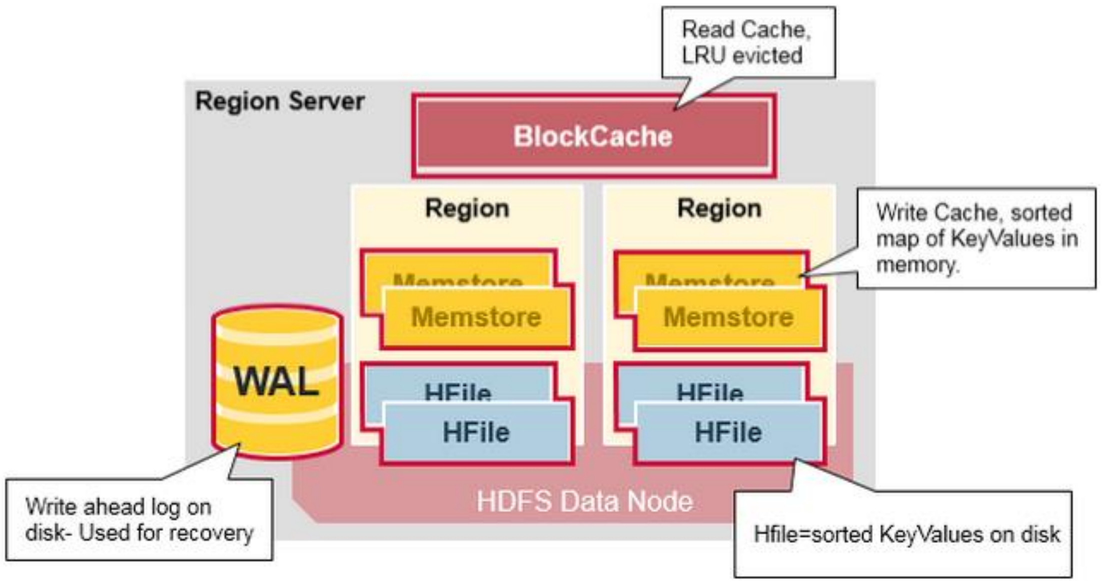
• It is the read cache. It stores frequently read data in memory. Least Recently Used data is evicted when full.

MemStore :

• It is the write cache. It stores new data which has not yet been written to disk. It is sorted before writing to disk. There is one MemStore per column family per region.

Hfiles

• They store the rows as sorted KeyValues on disk.



Region Split :

• Initially there is one region per table.

• When a region grows too large, it splits into two child regions.

• Both child regions, representing one-half of the original region, are opened in parallel on the same Region server, and then the split is reported to the HMaster.

• For load balancing reasons, the HMaster may schedule for new regions to be moved off to other servers.

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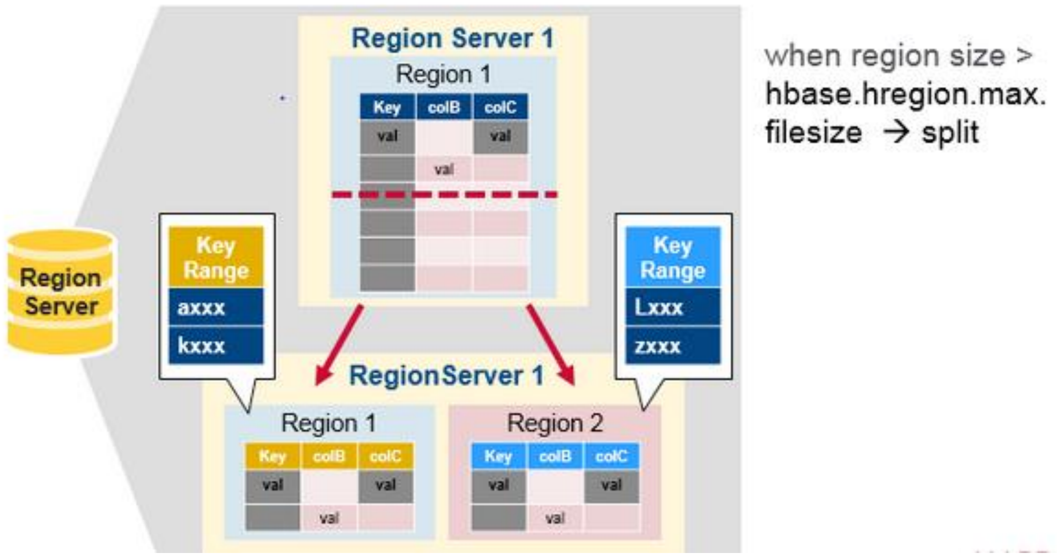

Benefits (Pros) :

Strong consistency model

- When a write returns, all readers will see same value

Scales automatically

- Regions split when data grows too large
- Uses HDFS to spread and replicate data

Built-in recovery

- Using Write Ahead Log (similar to journaling on file system)

Integrated with Hadoop

- MapReduce on HBase is straightforward

Problems (Cons) :

Business continuity reliability:

- WAL reply slow
- Slow complex crash recovery
- Major Compaction I/O storms

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- **HBase vs RDBMS**

HBase	RDBMS
1. Column-oriented	1. Row-oriented
2. Flexible schema, add columns on the Fly	2. Fixed schema
3. Does not supports SQL	3. It supports SQL
4. Good for semi-structured data as well as structured data.	4. Good for structured data only.
5. Supports Horizontal scaling(scale out). So easy to scale.	5. Supports Vertical scaling(scale up). So difficult to scale.
6. It doesn't supports referential integrity.	6. It supports referential integrity.
7. Good with sparse tables	7. Not optimized for sparse tables.
8.Tight integration with MapReduce (MR).	8. No integration with MapReduce (MR).
9. Joins are not optimized and are using MR.	9. Joins are optimized and are not using MR.
10. It does not supports ACID properties. Hence it does not supports transactions.	10. It supports ACID properties. Hence supports transactions.

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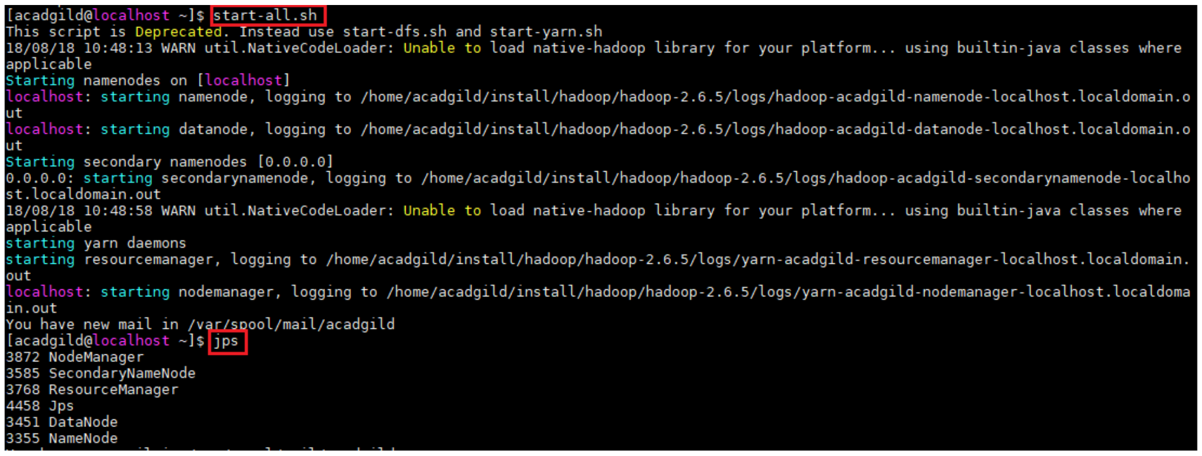
Task2 :

Execute blog present in below link

https://acadgild.com/blog/importtsv-data-from-hdfs-into-hbase/

We have started all hadoop daemons by using command : **start-all.sh**

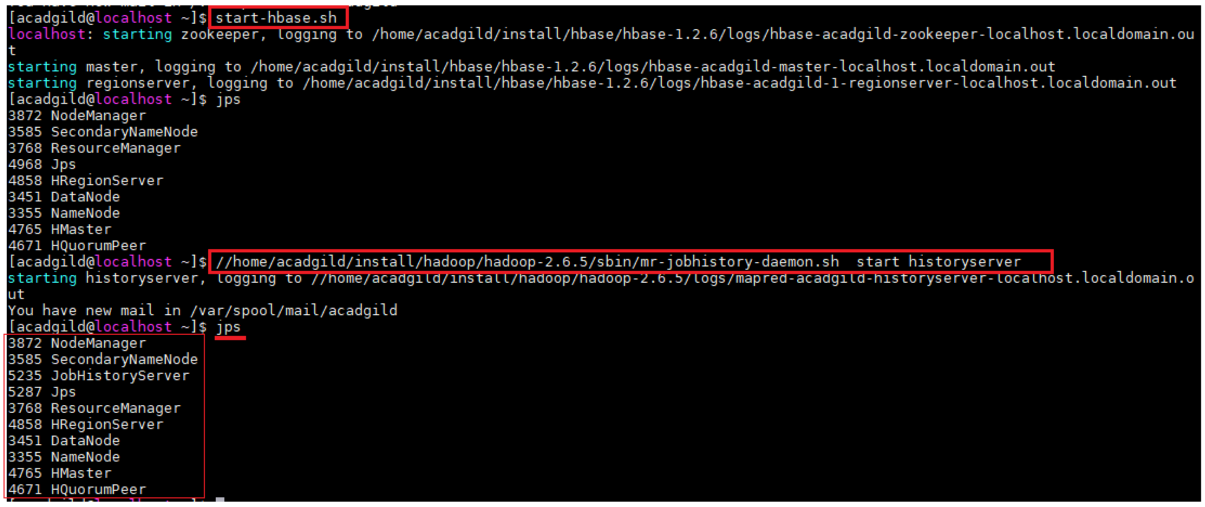
Then we have verified that all hadoop daemons are started by using **jps** command.



```
[acadgild@localhost ~]$ start-all.sh
This script is Deprecated. Instead use start-dfs.sh and start-yarn.sh
18/08/18 10:48:13 WARN util.NativeCodeLoader: Unable to load native-hadoop library for your platform... using builtin-java classes where
applicable
Starting namenodes on [localhost]
localhost: starting namenode, logging to /home/acadgild/install/hadoop/hadoop-2.6.5/logs/hadoop-acadgild-namenode-localhost.localdomain.o
ut
localhost: starting datanode, logging to /home/acadgild/install/hadoop/hadoop-2.6.5/logs/hadoop-acadgild-datanode-localhost.localdomain.o
ut
Starting secondary namenodes [0.0.0.0]
0.0.0.0: starting secondarynamenode, logging to /home/acadgild/install/hadoop/hadoop-2.6.5/logs/hadoop-acadgild-secondarynamenode-localho
st.localdomain.out
18/08/18 10:48:58 WARN util.NativeCodeLoader: Unable to load native-hadoop library for your platform... using builtin-java classes where
applicable
starting yarn daemons
starting resourcemanager, logging to /home/acadgild/install/hadoop/hadoop-2.6.5/logs/yarn-acadgild-resourcemanager-localhost.localdomain.
out
localhost: starting nodemanager, logging to /home/acadgild/install/hadoop/hadoop-2.6.5/logs/yarn-acadgild-nodemanager-localhost.localdoma
in.out
You have new mail in /var/spool/mail/acadgild
[acadgild@localhost ~]$ jps
3872 NodeManager
3585 SecondaryNameNode
3768 ResourceManager
4458 Jps
3451 DataNode
3355 NameNode
```

After this, we have started hbase and job history daemons by using commands : **start-hbase.sh** and **/home/acadgild/install/hadoop/hadoop-2.6.5/sbin/mr-jobhistory-daemon.sh start historyserver**

Then we have verified that hbase and job history server daemons are started by using jps command.



```
[acadgild@localhost ~]$ start-hbase.sh
localhost: starting zookeeper, logging to /home/acadgild/install/hbase/hbase-1.2.6/logs/hbase-acadgild-zookeeper-localhost.localdomain.ou
t
starting master, logging to /home/acadgild/install/hbase/hbase-1.2.6/logs/hbase-acadgild-master-localhost.localdomain.out
starting regionserver, logging to /home/acadgild/install/hbase/hbase-1.2.6/logs/hbase-acadgild-1-regionserver-localhost.localdomain.out
[acadgild@localhost ~]$ jps
3872 NodeManager
3585 SecondaryNameNode
3768 ResourceManager
4968 Jps
4858 HRegionServer
3451 DataNode
3355 NameNode
4765 HMaster
4671 HQuorumPeer
[acadgild@localhost ~]$ //home/acadgild/install/hadoop/hadoop-2.6.5/sbin/mr-jobhistory-daemon.sh  start historyserver
starting historyserver, logging to //home/acadgild/install/hadoop/hadoop-2.6.5/logs/mapred-acadgild-historyserver-localhost.localdomain.o
ut
You have new mail in /var/spool/mail/acadgild
[acadgild@localhost ~]$ jps
3872 NodeManager
3585 SecondaryNameNode
5235 JobHistoryServer
5287 Jps
3768 ResourceManager
4858 HRegionServer
3451 DataNode
3355 NameNode
4765 HMaster
4671 HQuorumPeer
```

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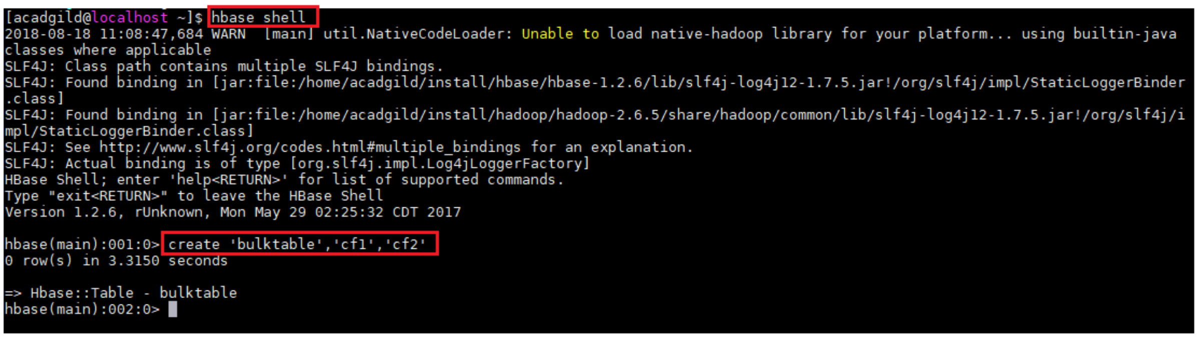
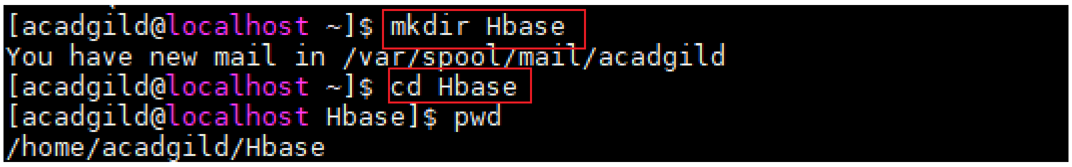
Then we have started **hbase shell** and created table **'bulktable'** with column families **cf1** and **cf2**.



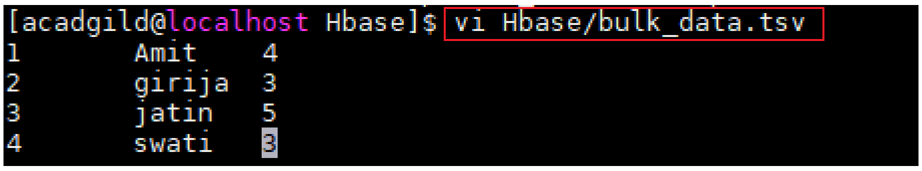
```
[acadgild@localhost ~]$ hbase shell
2018-08-18 11:08:47,684 WARN  [main] util.NativeCodeLoader: Unable to load native-hadoop library for your platform... using builtin-java
classes where applicable
SLF4J: Class path contains multiple SLF4J bindings.
SLF4J: Found binding in [jar:file:/home/acadgild/install/hbase/hbase-1.2.6/lib/slf4j-log4j12-1.7.5.jar!/org/slf4j/impl/StaticLoggerBinder
.class]
SLF4J: Found binding in [jar:file:/home/acadgild/install/hadoop/hadoop-2.6.5/share/hadoop/common/lib/slf4j-log4j12-1.7.5.jar!/org/slf4j/i
mpl/StaticLoggerBinder.class]
SLF4J: See http://www.slf4j.org/codes.html#multiple_bindings for an explanation.
SLF4J: Actual binding is of type [org.slf4j.impl.Log4jLoggerFactory]
HBase Shell; enter 'help<RETURN>' for list of supported commands.
Type "exit<RETURN>" to leave the HBase Shell
Version 1.2.6, rUnknown, Mon May 29 02:25:32 CDT 2017

hbase(main):001:0> create 'bulktable','cf1','cf2'
0 row(s) in 3.3150 seconds

=> Hbase::Table - bulktable
hbase(main):002:0>
```

Then we have created Hbase directory in local system.



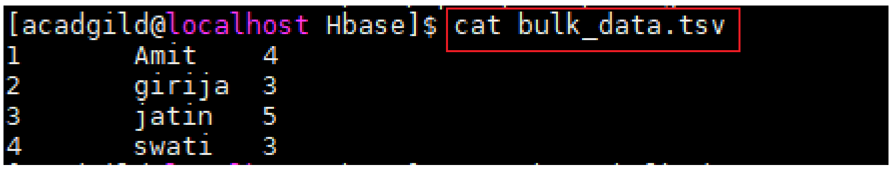
```
[acadgild@localhost ~]$ mkdir Hbase
You have new mail in /var/spool/mail/acadgild
[acadgild@localhost ~]$ cd Hbase
[acadgild@localhost Hbase]$ pwd
/home/acadgild/Hbase
```

Then we have created and edited bulk_data.tsv file by using **VI editor**.



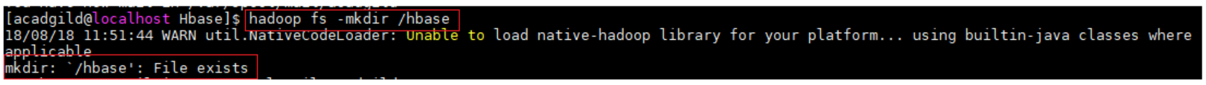
```
[acadgild@localhost Hbase]$ vi Hbase/bulk_data.tsv
1       Amit    4
2       girija  3
3       jatin   5
4       swati   3
```

By using below cat command, we could see that data has been inserted successfully in bulk_data.tsv file.



```
[acadgild@localhost Hbase]$ cat bulk_data.tsv
1       Amit    4
2       girija  3
3       jatin   5
4       swati   3
```

As data should be present in HDFS, we have to copy bulk_data.tsv file from local to HDFS.
So we are creating hbase directory in HDFS via command : **hadoop fs -mkdir /hbase**.
But as this hbase directory is already present, we are getting below error as
hbase directory already exists.



```
[acadgild@localhost Hbase]$ hadoop fs -mkdir /hbase
18/08/18 11:51:44 WARN util.NativeCodeLoader: Unable to load native-hadoop library for your platform... using builtin-java classes where
applicable
mkdir: `/hbase': File exists
```

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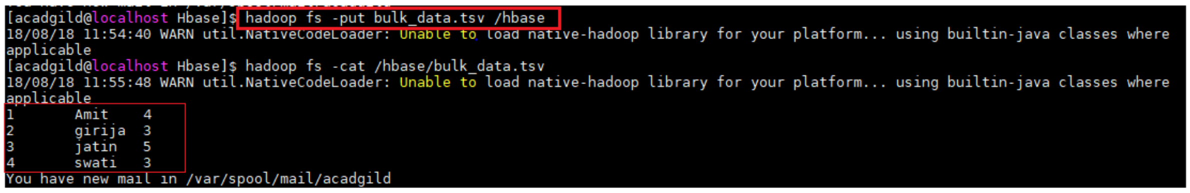
Then we have copied bulk_data.csv file from local to hbase directory in HDFS.

By using below command, you could see content in bulk_data.tsv file :

hadoop fs -cat /hbase/bulk_data.tsv

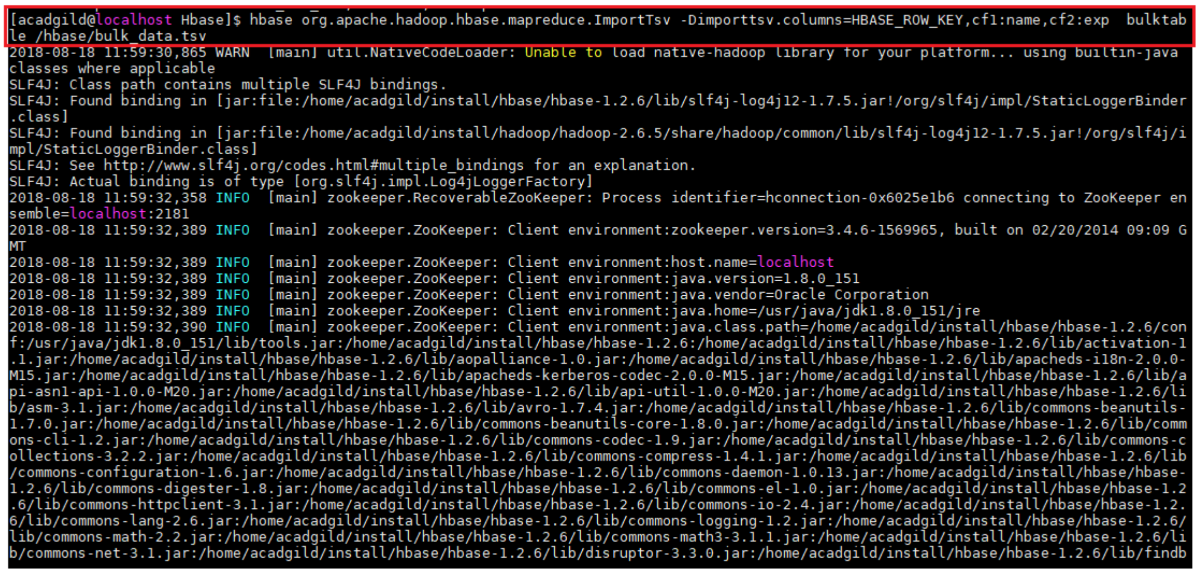


```
[acadgild@localhost Hbase]$ hadoop fs -put bulk_data.tsv /hbase
18/08/18 11:54:40 WARN util.NativeCodeLoader: Unable to load native-hadoop library for your platform... using builtin-java classes where
applicable
[acadgild@localhost Hbase]$ hadoop fs -cat /hbase/bulk_data.tsv
18/08/18 11:55:48 WARN util.NativeCodeLoader: Unable to load native-hadoop library for your platform... using builtin-java classes where
applicable
1       Amit    4
2       girija  3
3       jatin   5
4       swati   3
You have new mail in /var/spool/mail/acadgild
```

Now to import data from HDFS to HBase, we have used following command along with arguments<tablename> and <path of data in HDFS>.

hbase org.apache.hadoop.hbase.mapreduce.ImportTsv -Dimporttsv.columns=HBASE_ROW_KEY,cf1:name,cf2:exp bulktable /hbase/bulk_data.tsv

Here, tablename is **bulktable** & path of data file is **/hbase/bulk_data.tsv.**



```
[acadgild@localhost Hbase]$ hbase org.apache.hadoop.hbase.mapreduce.ImportTsv -Dimporttsv.columns=HBASE_ROW_KEY,cf1:name,cf2:exp  bulktab
le /hbase/bulk_data.tsv
2018-08-18 11:59:30,865 WARN  [main] util.NativeCodeLoader: Unable to load native-hadoop library for your platform... using builtin-java
classes where applicable
SLF4J: Class path contains multiple SLF4J bindings.
SLF4J: Found binding in [jar:file:/home/acadgild/install/hbase/hbase-1.2.6/lib/slf4j-log4j12-1.7.5.jar!/org/slf4j/impl/StaticLoggerBinder
.class]
SLF4J: Found binding in [jar:file:/home/acadgild/install/hadoop/hadoop-2.6.5/share/hadoop/common/lib/slf4j-log4j12-1.7.5.jar!/org/slf4j/i
mpl/StaticLoggerBinder.class]
SLF4J: See http://www.slf4j.org/codes.html#multiple_bindings for an explanation.
SLF4J: Actual binding is of type [org.slf4j.impl.Log4jLoggerFactory]
2018-08-18 11:59:32,358 INFO  [main] zookeeper.RecoverableZooKeeper: Process identifier=hconnection-0x6025e1b6 connecting to ZooKeeper en
semble=localhost:2181
2018-08-18 11:59:32,389 INFO  [main] zookeeper.ZooKeeper: Client environment:zookeeper.version=3.4.6-1569965, built on 02/20/2014 09:09 G
MT
2018-08-18 11:59:32,389 INFO  [main] zookeeper.ZooKeeper: Client environment:host.name=localhost
2018-08-18 11:59:32,389 INFO  [main] zookeeper.ZooKeeper: Client environment:java.version=1.8.0_151
2018-08-18 11:59:32,389 INFO  [main] zookeeper.ZooKeeper: Client environment:java.vendor=Oracle Corporation
2018-08-18 11:59:32,389 INFO  [main] zookeeper.ZooKeeper: Client environment:java.home=/usr/java/jdk1.8.0_151/jre
2018-08-18 11:59:32,390 INFO  [main] zookeeper.ZooKeeper: Client environment:java.class.path=/home/acadgild/install/hbase/hbase-1.2.6/con
f:/usr/java/jdk1.8.0_151/lib/tools.jar:/home/acadgild/install/hbase/hbase-1.2.6:/home/acadgild/install/hbase/hbase-1.2.6/lib/activation-1
.1.jar:/home/acadgild/install/hbase/hbase-1.2.6/lib/aopalliance-1.0.jar:/home/acadgild/install/hbase/hbase-1.2.6/lib/apacheds-i18n-2.0.0-
M15.jar:/home/acadgild/install/hbase/hbase-1.2.6/lib/apacheds-kerberos-codec-2.0.0-M15.jar:/home/acadgild/install/hbase/hbase-1.2.6/lib/a
pi-asn1-api-1.0.0-M20.jar:/home/acadgild/install/hbase/hbase-1.2.6/lib/api-util-1.0.0-M20.jar:/home/acadgild/install/hbase/hbase-1.2.6/li
b/asm-3.1.jar:/home/acadgild/install/hbase/hbase-1.2.6/lib/avro-1.7.4.jar:/home/acadgild/install/hbase/hbase-1.2.6/lib/commons-beanutils-
1.7.0.jar:/home/acadgild/install/hbase/hbase-1.2.6/lib/commons-beanutils-core-1.8.0.jar:/home/acadgild/install/hbase/hbase-1.2.6/lib/comm
ons-cli-1.2.jar:/home/acadgild/install/hbase/hbase-1.2.6/lib/commons-codec-1.9.jar:/home/acadgild/install/hbase/hbase-1.2.6/lib/commons-c
ollections-3.2.2.jar:/home/acadgild/install/hbase/hbase-1.2.6/lib/commons-compress-1.4.1.jar:/home/acadgild/install/hbase/hbase-1.2.6/lib
/commons-configuration-1.6.jar:/home/acadgild/install/hbase/hbase-1.2.6/lib/commons-daemon-1.0.13.jar:/home/acadgild/install/hbase/hbase-
1.2.6/lib/commons-digester-1.8.jar:/home/acadgild/install/hbase/hbase-1.2.6/lib/commons-el-1.0.jar:/home/acadgild/install/hbase/hbase-1.2
.6/lib/commons-httpclient-3.1.jar:/home/acadgild/install/hbase/hbase-1.2.6/lib/commons-io-2.4.jar:/home/acadgild/install/hbase/hbase-1.2.
6/lib/commons-lang-2.6.jar:/home/acadgild/install/hbase/hbase-1.2.6/lib/commons-logging-1.2.jar:/home/acadgild/install/hbase/hbase-1.2.6/
lib/commons-math-2.2.jar:/home/acadgild/install/hbase/hbase-1.2.6/lib/commons-math3-3.1.1.jar:/home/acadgild/install/hbase/hbase-1.2.6/li
b/commons-net-3.1.jar:/home/acadgild/install/hbase/hbase-1.2.6/lib/disruptor-3.3.0.jar:/home/acadgild/install/hbase/hbase-1.2.6/lib/findb
```

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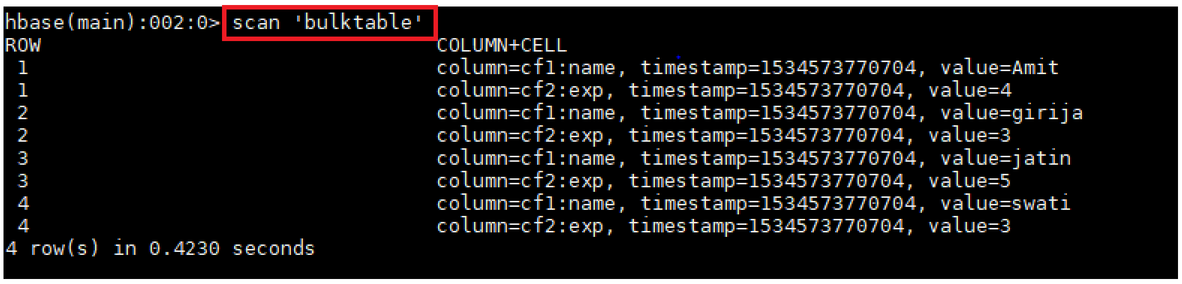
Then to check whether data got inserted from HDFS into HBase, we have fetched data from bulktable by using HBase command as **scan 'bulktable' .**

We could see that all data (4 rows) which is present in **bulk_data.tsv** file got inserted into bulktable in HBase successfully.



```
hbase(main):002:0> scan 'bulktable'
ROW                                  COLUMN+CELL
 1                                   column=cf1:name, timestamp=1534573770704, value=Amit
 1                                   column=cf2:exp, timestamp=1534573770704, value=4
 2                                   column=cf1:name, timestamp=1534573770704, value=girija
 2                                   column=cf2:exp, timestamp=1534573770704, value=3
 3                                   column=cf1:name, timestamp=1534573770704, value=jatin
 3                                   column=cf2:exp, timestamp=1534573770704, value=5
 4                                   column=cf1:name, timestamp=1534573770704, value=swati
 4                                   column=cf2:exp, timestamp=1534573770704, value=3
4 row(s) in 0.4230 seconds
```