BY: Dr. RASHMI L MALGHAN

Apache Hive

HIVE

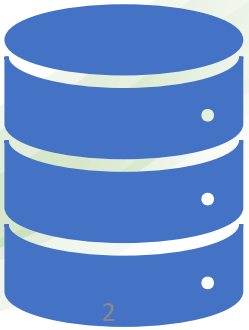
- Apache Hive is an open-source software utility **built on top of Hadoop** to provide easy **data storage** and **analysis in style of SQL**.

- Hive - Basically, a tool which we call a **data warehousing tool** is Hive. However, Hive gives **SQL queries** to perform an analysis and also an abstraction. Although, Hive it is not a database it gives you **logical abstraction over the databases and the tables**

- **It is a distributed, fault-tolerant data warehouse system** that enables analytics at a massive scale and facilitates **reading, writing, and managing** petabytes of data residing in distributed storage using SQL.

- Hive is built on top of Apache Hadoop and supports storage on S3, adls, gs etc though HDFS.
- It is not built for Online Transactional Processing (OLTP) workloads**. Limited concurrency**

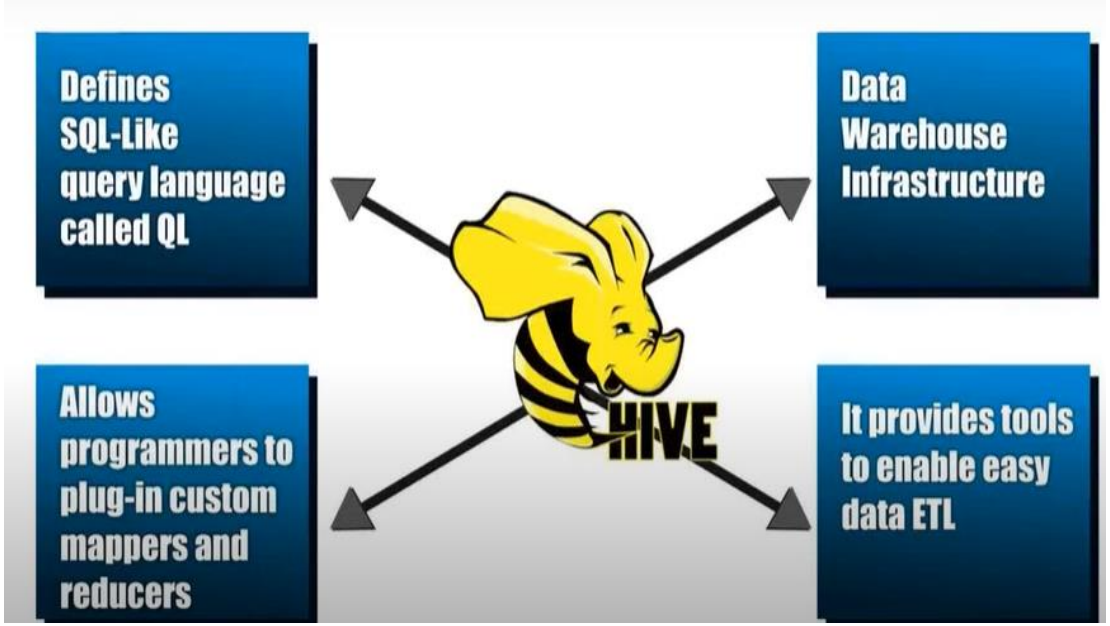
- It is designed to **enhance scalability, extensibility, performance, fault-tolerance** and loose-coupling with its input formats.
- Hive uses a language called **HiveQL**, which is similar to SQL, to allow users to express data queries, transformations, and analyses in a familiar syntax.
- HiveQL statements are compiled into MapReduce jobs, which are then executed on the Hadoop cluster to process the data.



What is HIVE?

- Data Warehousing package built on top of Hadoop
- Used for data analysis
- Targeted towards users comfortable with SQL
- It is similar to SQL and called HiveQL
- For managing and querying structured data
- Abstracts complexity of Hadoop
- No need learn java and Hadoop APIs
- Developed by Facebook and contributed to community
- Facebook analyzed several Terabytes of data everyday using Hive

Features of HIVE



•Hive supports any client application written in Java, PHP, Python, C++ or Ruby by exposing its **Thrift server**. (You can use these client – side languages embedded with SQL for accessing a database such as DB2, etc.).

•As the **metadata information of Hive is stored in an RDBMS**, it significantly **reduces the time** to perform **semantic checks** during query execution.

•Useful for people who aren't from a programming background as it **eliminates the need to write complex MapReduce program**.

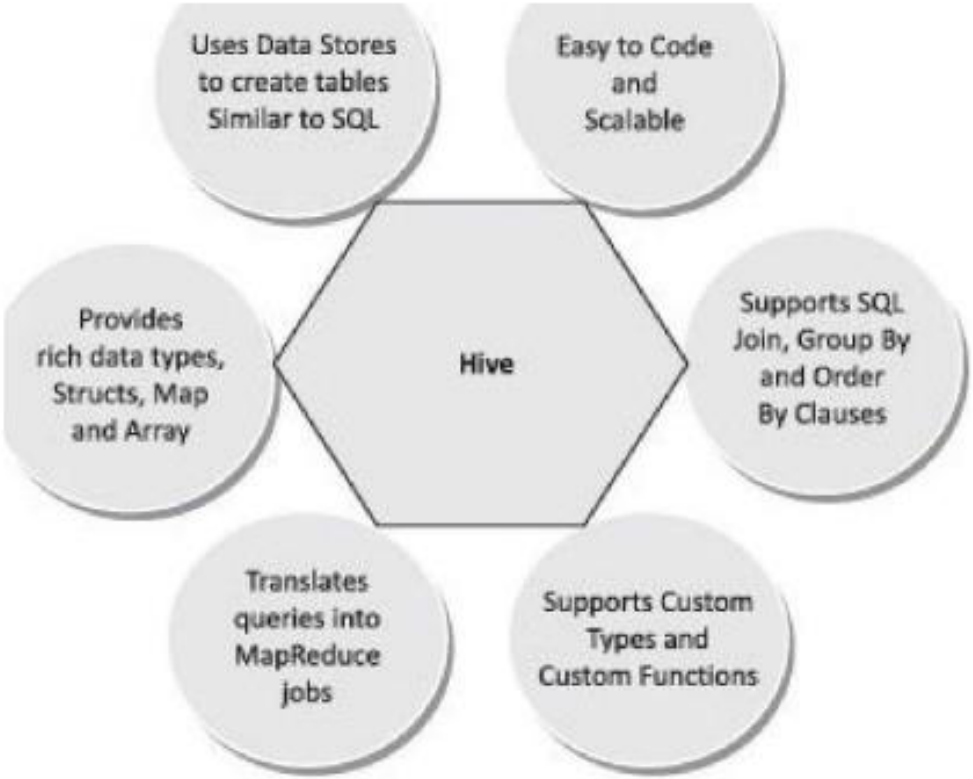
•**Extensible** and **scalable** to cope up with the growing volume and variety of data, without affecting performance of the system.

•It is as an **efficient ETL** (Extract, Transform, Load) tool.

Features of HIVE

- It provides indexes, including bitmap indexes to accelerate the queries. Index type containing compaction and bitmap index as of 0.10.
- **Metadata** storage in a **RDBMS, reduces the time** to function **semantic checks** during query execution.
- **Built in user-defined functions** (UDFs) to **manipulation of strings, dates, and other data-mining** tools. Hive is reinforced to extend the UDF set to deal with the use-cases not reinforced by predefined functions.
- **DEFLATE, BWT, snappy**, etc are the **algorithms to operation on compressed data** which is stored in Hadoop Ecosystem.
- It is built for Online Analytical Processing (OLAP).
- It delivers various types of querying language which are frequently known as Hive Query Language (HVL or HiveQL).

Hive Features…



- **Traditional relational databases** are designed for interactive queries on small to medium datasets and **do not process huge datasets** well.
- Hive instead **uses batch processing** so that it works quickly across a very large distributed database.
- It **queries data stored** in a distributed storage solution, like the **Hadoop Distributed File System (HDFS) or Amazon S3**
- Hive stores its database and table metadata in a **metastore**
- Hive includes **HCatalog**, which is a **table and storage management layer** that reads data from the Hive metastore to facilitate seamless integration between Hive, Apache Pig, and MapReduce.
- **By using the metastore, HCatalog allows Pig and MapReduce to use the same data structures as Hive,** so that the metadata doesn't have to be redefined for each engine.

Hive Characteristics:

- Capability to "Translate Queries in to MapReduce Jobs"
- This makes Hive "scalable", able to handle Datawarehouse applications and therefore suitable for the analysis of static data of an extremely large size, where the "fast – response time" is not a criterion.
- Supports web interfaces , Application API as well as web-browser clients, can access the Hive DB Server.
- Provides an SQL "Dialect" (Hive Query Language, abbreviated HIVEQL or HQL).
- Results of HiveQL query and the data load in the tables which store at Hadoop cluster at HDFS.
- Hive as data warehouse is built to manage and query only structured data which is residing under tables.
- **Tables and databases get** created first; then data gets loaded into the proper tables
- Hive supports four file formats: **ORC, SEQUENCEFILE, RCFILE** (Record Columnar File), and **TEXTFILE**
- difference between the Hive Query Language (HQL) and SQL is that **Hive executes queries on Hadoop's infrastructure instead of on a traditional database.**
- Hive supports Data Definition Language (DDL), Data Manipulation Language (DML), and User Defined Functions (UDF).

Limitations of Hive

- Hive supports Online Analytical Processing (OLAP), but not Online Transaction Processing (OLTP).
- It doesn’t support subqueries.
- It has a high latency.
- Hive tables don’t support delete or update operations.
- Hive is not capable of handling real-time data.

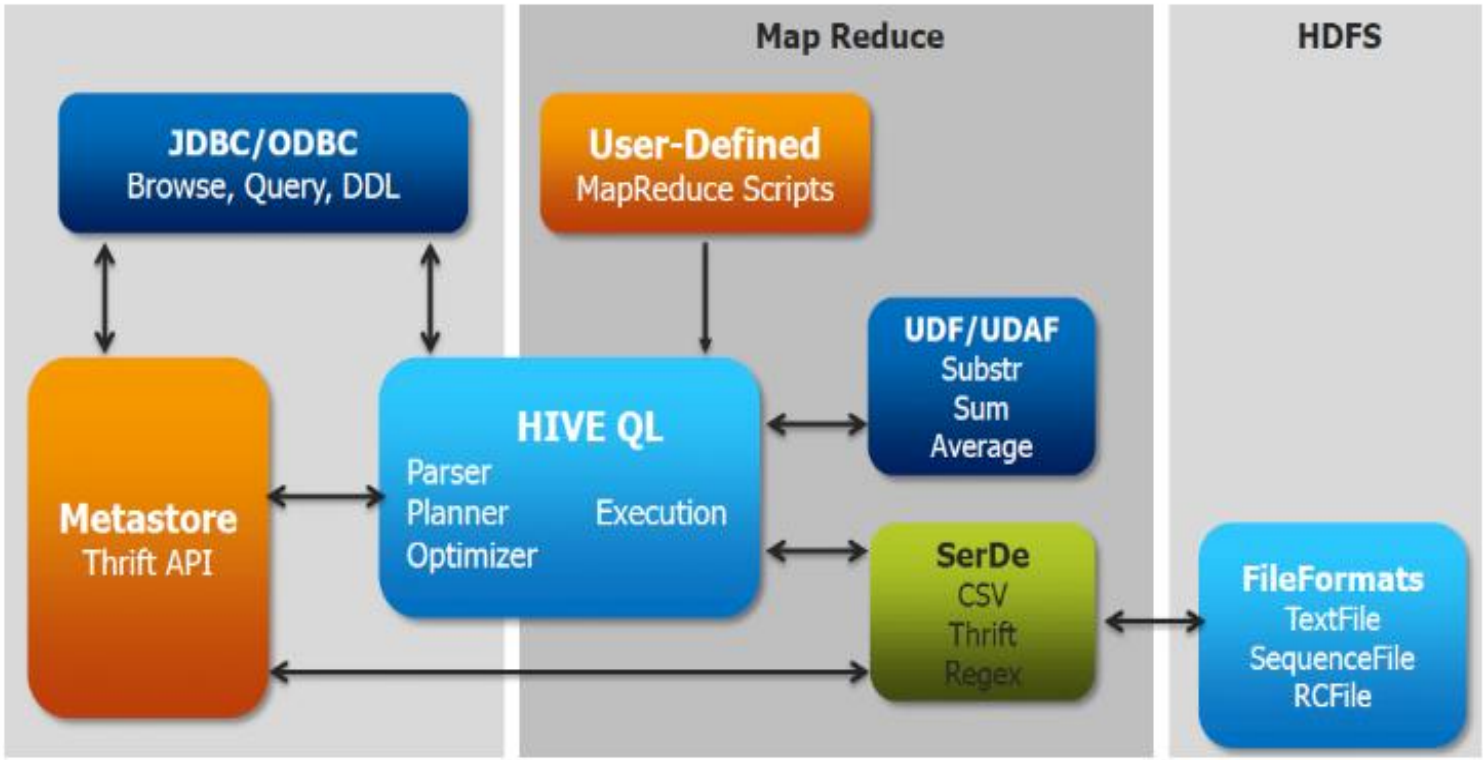
Differences between Hive and Pig

Hive	Pig
Hive is commonly used by Data Analysts.	Pig is commonly used by programmers.
It follows SQL-like queries.	It follows the data-flow language.
It can handle structured data.	It can handle semi-structured data.
It works on server-side of HDFS cluster.	It works on client-side of HDFS cluster.
Hive is slower than Pig.	Pig is comparatively faster than Hive.

Hive Vs. SQL

Feature	Apache Hive	SQL
Purpose	Batch and Interactive Query Processing	Relational Database Management System
Data Analysis	Complex Data Processing	Detailed Data Querying
Architecture	Data Warehousing Project	RDBMS-Based Programming Language
Data Types	9 Types Supported	5 Types Supported
Multitable Inserts	Supported	Not Supported
MapReduce	Supports MapReduce	No MapReduce Concept
OLTP	Not Supported	Supports OLTP
Schema Support	Supported	Used for Data Storage
Views	Read-Only Format	Updateable Views
Data Size	Can handle petabytes of data	Can only handle terabytes of data

Apache Hive Components:



Hive consists of the following major **components:**

Metastore – To store the metadata.

JDBC/ODBC – Query Compiler and Execution Engine to convert SQL queries to a sequence of MapReduce.

SerDe and ObjectInspectors – For data formats and types.

UDF/UDAF – For User Defined Functions.

Clients – Similar to MySQL command line and a web UI.

Major Components

Unit Name	Operation
User Interface	Hive is a data warehouse infrastructure software that can create interaction between user and HDFS. The user interfaces that Hive supports are Hive Web UI, Hive command line, and Hive HD Insight (In Windows server).
Meta Store	Hive chooses respective database servers to store the schema or Metadata of tables, databases, columns in a table, their data types, and HDFS mapping.
HiveQL Process Engine	HiveQL is similar to SQL for querying on schema info on the Metastore. It is one of the replacements of traditional approach for MapReduce program. Instead of writing MapReduce program in Java, we can write a query for MapReduce job and process it.
Execution Engine	The conjunction part of HiveQL process Engine and MapReduce is Hive Execution Engine. Execution engine processes the query and generates results as same as MapReduce results. It uses the flavor of MapReduce.
HDFS or HBASE	Hadoop distributed file system or HBASE are the data storage techniques to store data into file system.

Hive Architecture:

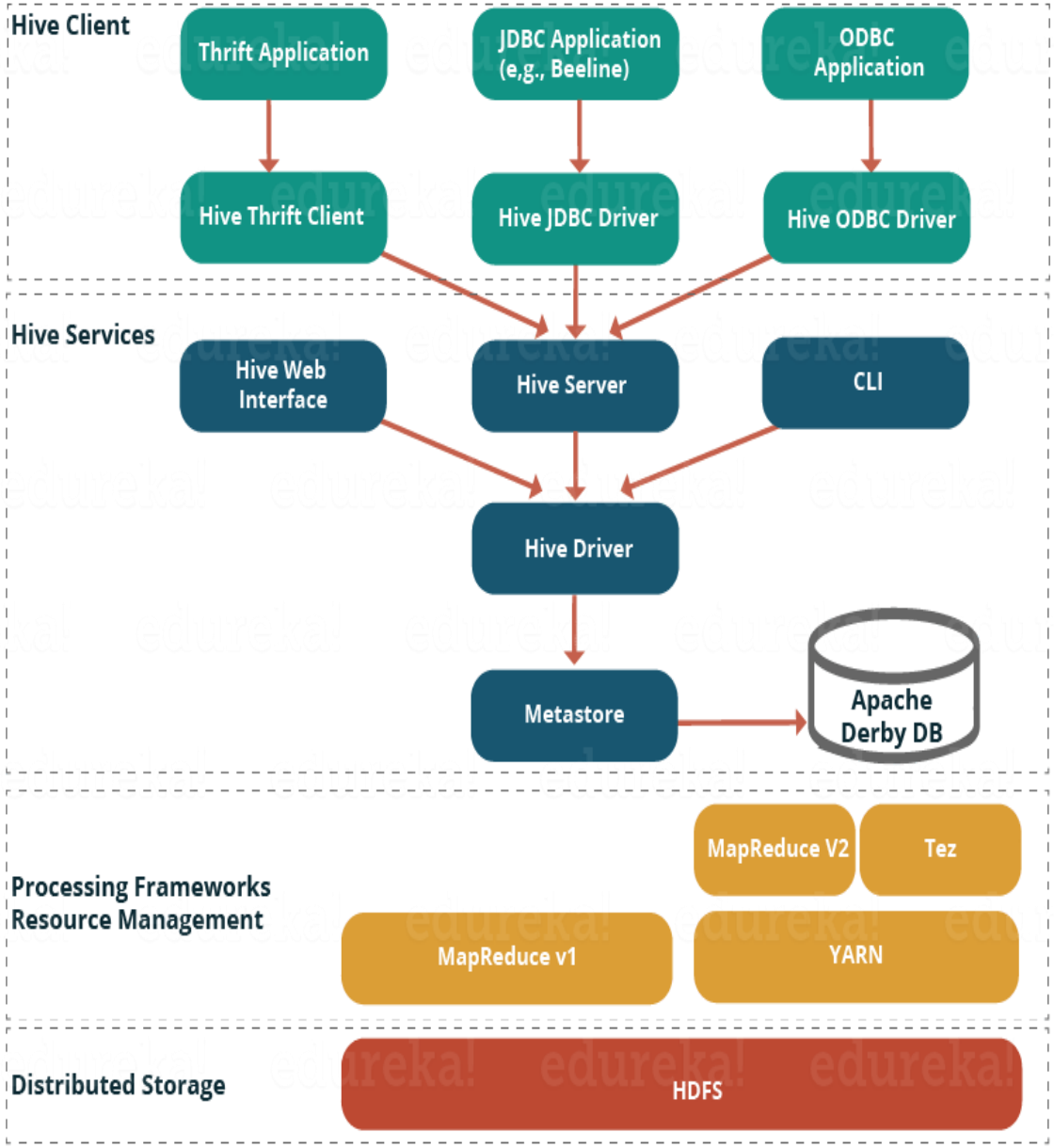
Hive Architecture can be categorized into the following components:

•**Hive Clients:** Hive supports application written in many languages like Java, C++, Python etc. using JDBC, Thrift and ODBC drivers. Hence one can always write hive client application written in a language of their choice.

•**Hive Services:** Apache Hive provides various services like CLI, Web Interface etc. to perform queries.

•**Processing framework and Resource Management:** Internally, Hive uses Hadoop MapReduce framework as execution engine to execute the queries.

•**Distributed Storage:** As Hive is installed on top of Hadoop, it uses the underlying HDFS for the distributed storage.



Hive Client

- **Thrift Server** - It is a cross-language service provider platform that serves the request from all those programming languages that supports Thrift.
- **JDBC Driver** - It is used to establish a connection between hive and Java applications. The JDBC Driver is present in the class org.apache.hadoop.hive.jdbc.HiveDriver.
- **ODBC Driver** - It allows the applications that support the ODBC protocol to connect to Hive.

Hive Services

- **Hive CLI** - The Hive CLI (Command Line Interface) is a shell where we can execute Hive queries and commands.
- **Hive Web User Interface** - The Hive Web UI is just an alternative of Hive CLI. It provides a web-based GUI for executing Hive queries and commands.
- **Hive MetaStore** - It is a central repository that stores all the structure information of various tables and partitions in the warehouse. It also includes metadata of column and its type information, the serializers and deserializers which is used to read and write data and the corresponding HDFS files where the data is stored.
- **Hive Server** - It is referred to as Apache Thrift Server. It **accepts the request from different clients** and provides it to **Hive Driver.**
- **Hive Driver** - **It receives queries** from different sources like **web UI, CLI, Thrift, and JDBC/ODBC driver**. It transfers the queries to the **compiler.**

Hive Services

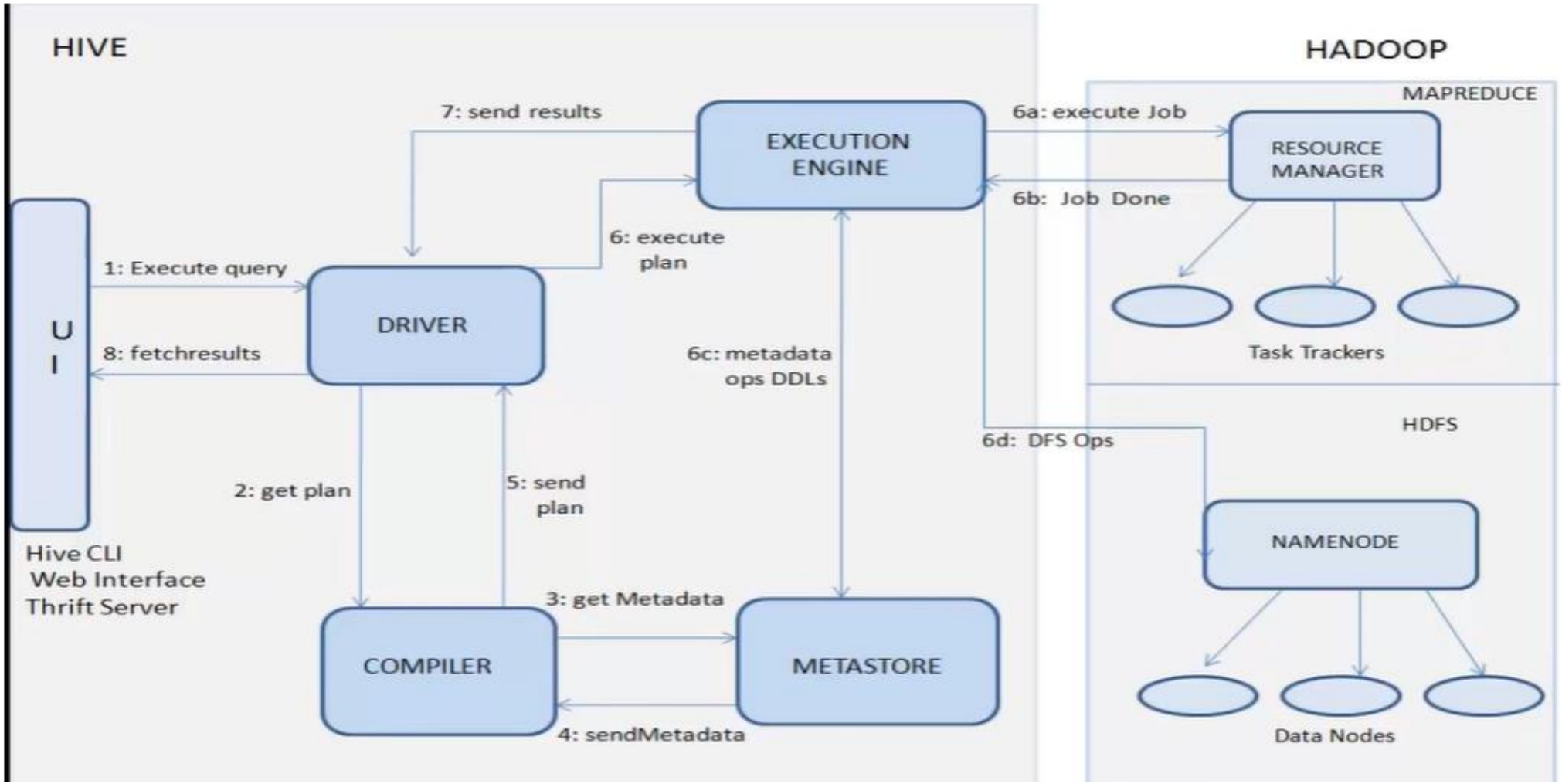
- **Hive Compiler** - The purpose of the compiler is **to parse the query and perform semantic analysis** on the different query blocks and expressions. It **converts HiveQL statements into MapReduce jobs**.

- **Hive Execution Engine** - Optimizer generates the **logical plan in the form of DAG** of map-reduce tasks and HDFS tasks. In the end, the execution engine executes the incoming tasks in the order of their dependencies.

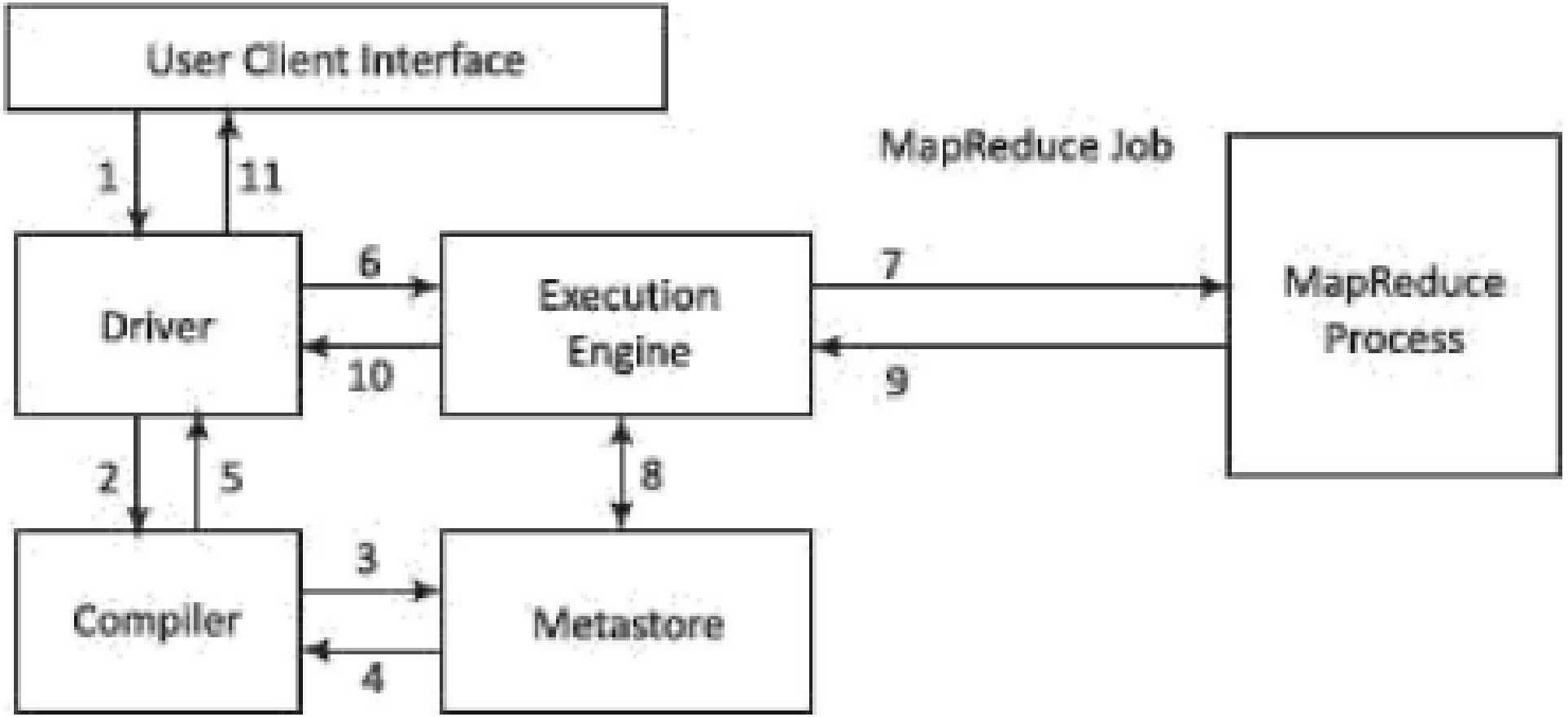
Hive makes use of the following:

- HDFS for storage
- MapReduce for execution
- Stores metadata in RDBMS

Program Execution



Dataflow Sequence & Workflow Steps:



No.	OPERATION
1	**Execute Query**: Hive interface (CLI or Web Interface) sends a query to Database Driver to execute the query.
2	**Get Plan**: Driver sends the query to query compiler that parses the query to check the syntax and query plan or the requirement of the query.
3	**Get Metadata**: Compiler sends metadata request to Metastore (of any database, such as MySQL).
4	**Send Metadata**: Metastore sends metadata as a response to compiler.
5	**Send Plan:** Compiler checks the requirement and resends the plan to driver. The parsing and compiling of the query is complete at this place.
6	**Execute Plan:** Driver sends the execute plan to execution engine.
7	**Execute Job:** Internally, the process of execution job is a MapReduce job. The execution engine sends the job to JobTracker, which is in Name node and it assigns this job to TaskTracker, which is in Data node. Then, the query executes the job.
8	**Metadata Operations:** Meanwhile the execution engine can execute the metadata operations with Metastore.
9	**Fetch Result:** Execution engine receives the results from Data nodes.
10	**Send Results:** Execution engine sends the result to Driver.
11	**Send Results:** Driver sends the results to Hive Interfaces.

Dataflow Sequence & Workflow Steps:

Hive Components:

Shell:-
Provides User interface provide an interface between user and hive. It enables user to submit queries and other operations to the system.

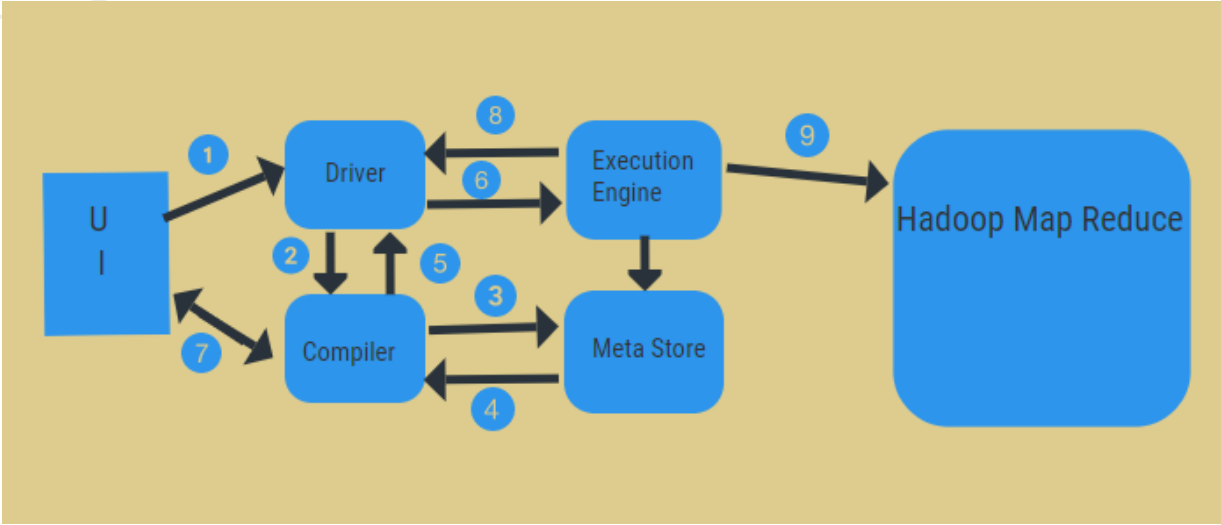
Metastore –
All the structured data or information of the different tables and partition in the warehouse containing attributes and attributes level information are stored in the metastore.

Execution Engine –
Execution of the execution plan made by the compiler is performed in the execution engine.

Compiler –
Queries are parses, semantic analysis on the different query blocks and query expression is done by the compiler.

Drivers:-
Queries of the user after the interface are received by the driver within the Hive. Concept of session handles is implemented by driver

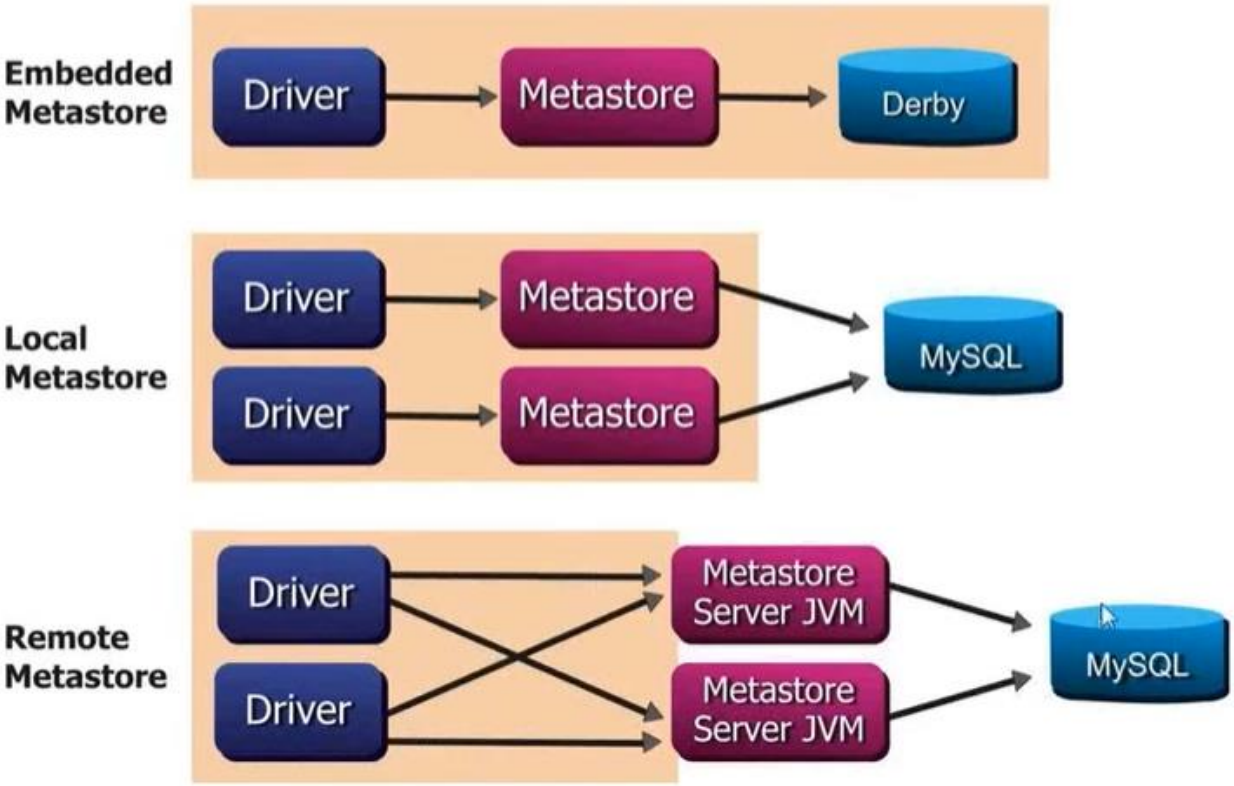
Hive Components:



The steps include:

1.execute the Query from UI
2.get a plan from the driver tasks DAG stages
3.get metadata request from the meta store
4.send metadata from the compiler
5.sending the plan back to the driver
6.Execute plan in the execution engine
7.fetching results for the appropriate user query
8.sending results bi-directionally
9.execution engine processing in HDFS with the map-reduce and fetch results from the data nodes created by the job tracker. it acts as a connector between Hive and Hadoop.

Hive Metastore:



Embedded Metastore:

It offers an embedded Derby database instance backed by the local disk for the Metastore, by default. It is what we call embedded Metastore configuration.

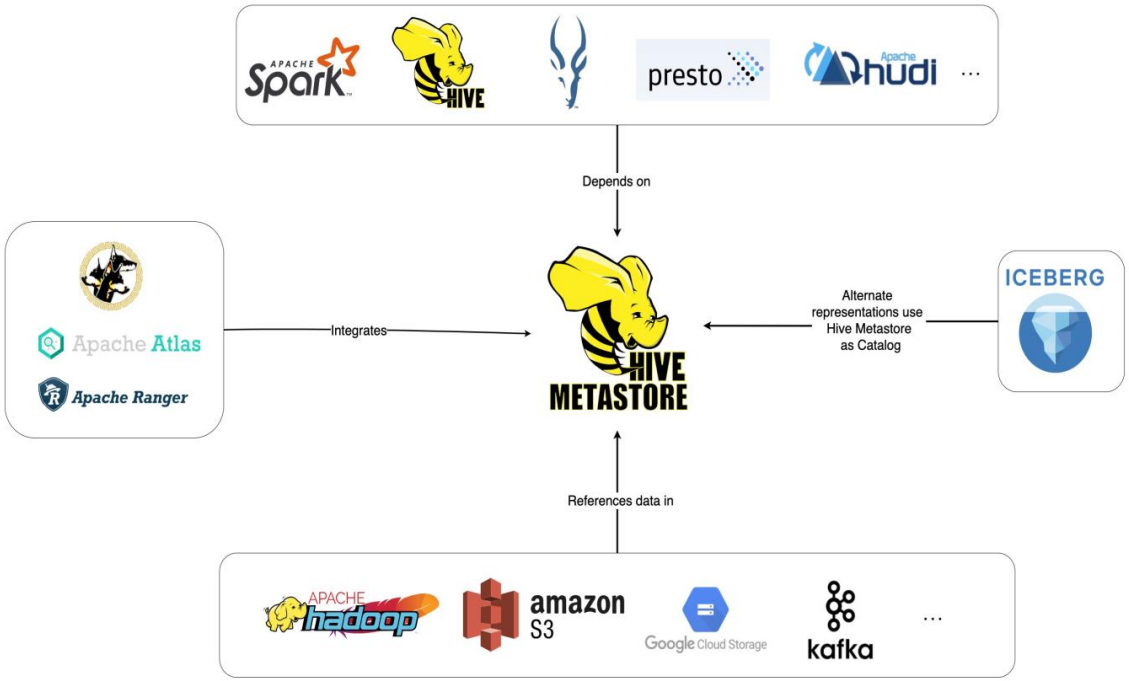
Local Metastore:

It is the Metastore service runs in the same **JVM** in which the Hive service is running and connects to a database running in a separate JVM. Either on the same machine or on a remote machine.

Remote Metastore:

In this configuration, the Metastore service runs on its own separate JVM and not in the Hive service JVM.

Hive Metastore(HMS)

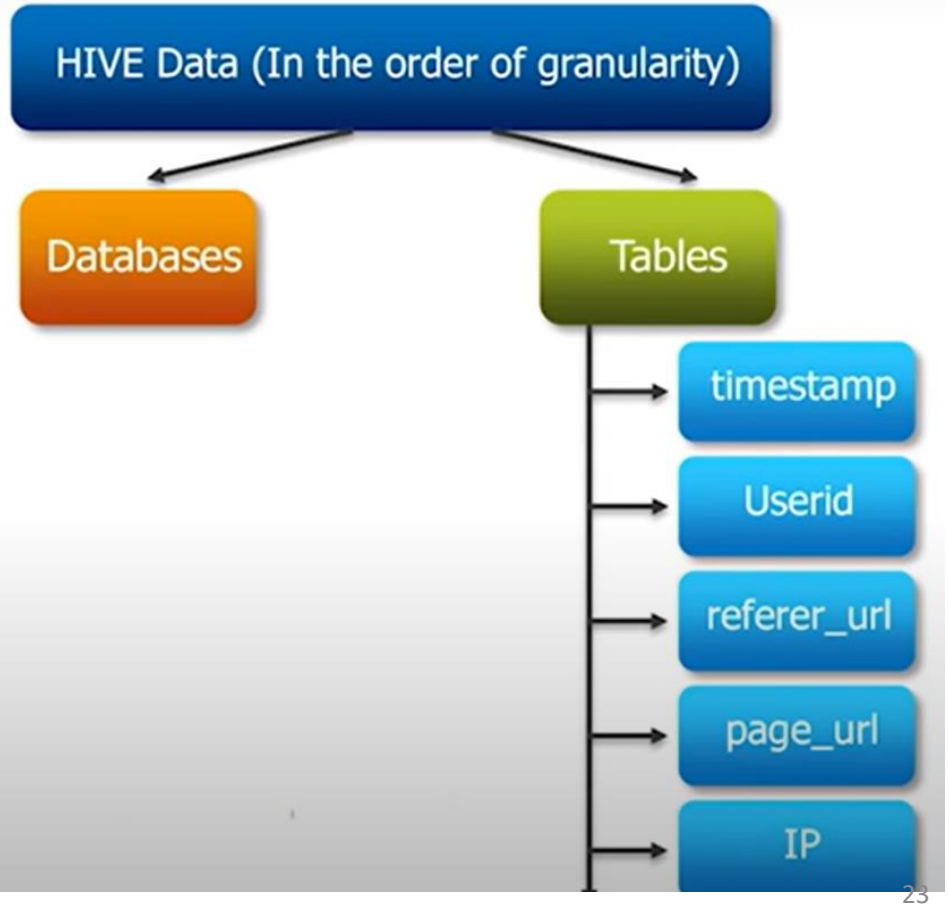


- The Hive Metastore (HMS) is a central repository of metadata for Hive tables and partitions in a relational database, and provides clients (including Hive, Impala and Spark) access to this information using the metastore service API.

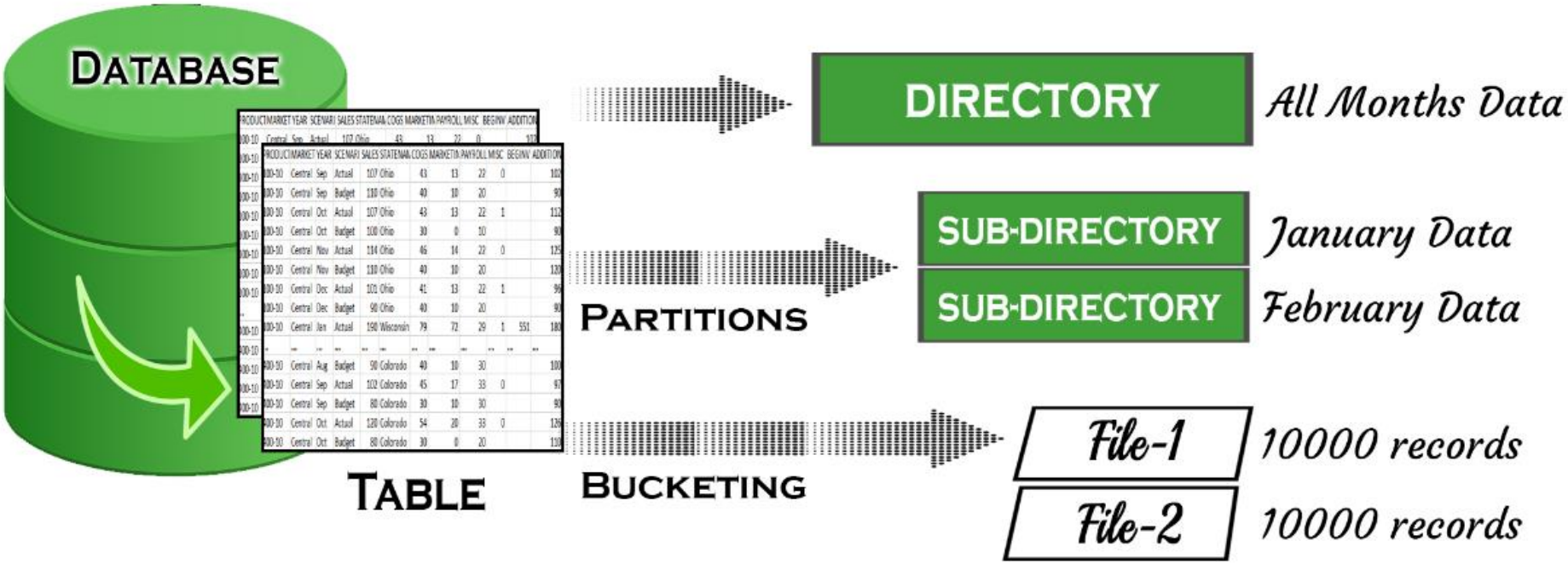
- It has become a building block for data lakes that utilize the diverse world of open-source software, such as Apache Spark and Presto. In fact, a whole ecosystem of tools, open-source and otherwise, are built around the Hive Metastore.

Hive Data Models

- ✓ Databases
  - ✓ Namespaces
- ✓ Tables
  - ✓ Schemas in namespaces
- ✓ Partitions
  - ✓ How data is stored in HDFS
  - ✓ Grouping data bases on some column
  - ✓ Can have one or more columns
- ✓ Buckets or Clusters
  - ✓ Partitions divided further into buckets bases on some other column
  - ✓ Use for data sampling



Hive Data Models



Create Database :

- **Create Database**
  - Create database retail;
- **Use Database**
  - Use retail;
- **Create table for storing transactional records**
  - Create table txnrecords(txnno INT, txndate STRING, custno INT, amount DOUBLE, category STRING, product STRING, city STRING, state String, Spendby String)
  - Row format delimited
  - Fields terminated by ',' stored as textfile

CREATE DATABASE|SCHEMA [IF NOT EXISTS] <database name>

hive> CREATE DATABASE [IF NOT EXISTS] userdb;

hive> CREATE SCHEMA userdb;

Tables:

- Apache **Hive tables** are the **same as the tables** present in a **Relational Database**.
- We can perform **filter, project, join and union operations** on tables.
- Hive stores the **metadata** in a **relational database** and not in HDFS.
- Hive has **two types of tables** which are as follows:

1. Managed Table:
Command:
CREATE TABLE <table_name> (column1 data_type, column2 data_type);
LOAD DATA INPATH <HDFS_file_location> INTO table managed_table;

2. External Table:
Command:
CREATE EXTERNAL TABLE <table_name> (column1 data_type, column2 data_type) LOCATION '<table_hive_location>';
LOAD DATA INPATH '<HDFS_file_location>' INTO TABLE <table_name>;

For *external table*, Hive is not responsible for managing the data.

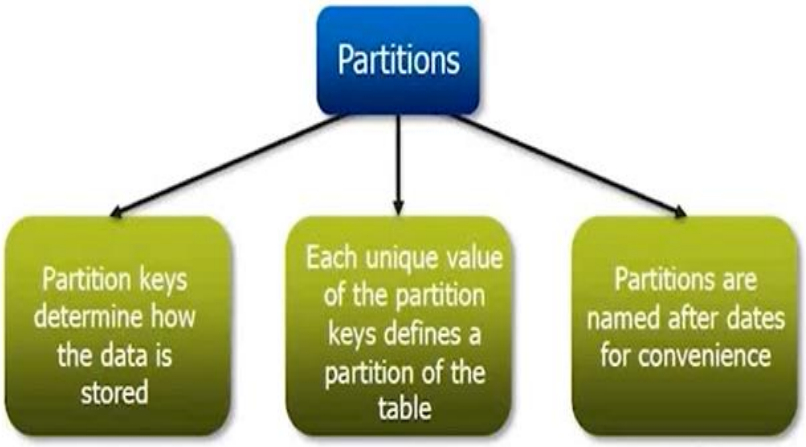
External Table

- ✓ **Create the table in another hdfs location** and not in warehouse directory
- ✓ **Not managed by hive**
  - ✓ CREATE EXTERNAL TABLE external_Table (dummy STRING)
  - ✓ LOCATION '/user/notroot/external_table';

- ✓ **Hive does not delete the table (or hdfs files) even when the tables are dropped.**
  It leaves the table untouched and only metadata about the tables are deleted.

Partition:

Partition means dividing a table into a coarse grained parts based on the value of a partition column such as a date. This make it faster to do queries on slices of the data.



- student_details containing the student information of students like student_id, name, department, year, etc. Now, if I perform partitioning based on department column, the information of all the students belonging to a particular department will be stored together in that very partition.

- Partition: is used to group similar data types together based on column or partition key.
- Hive organizes tables into partitions.
- In other words, we can say that partition is used to create a sub-directory in the table directory.
- Each table can have one or more partition keys to identify a particular partition.
- Partitioning is used in Hive to reduce the query latency. Instead of scanning the entire tables, it scans only the relevant partitions and corresponding datasets.

Dynamic Partitioning (Columns - values know – Execution Time)

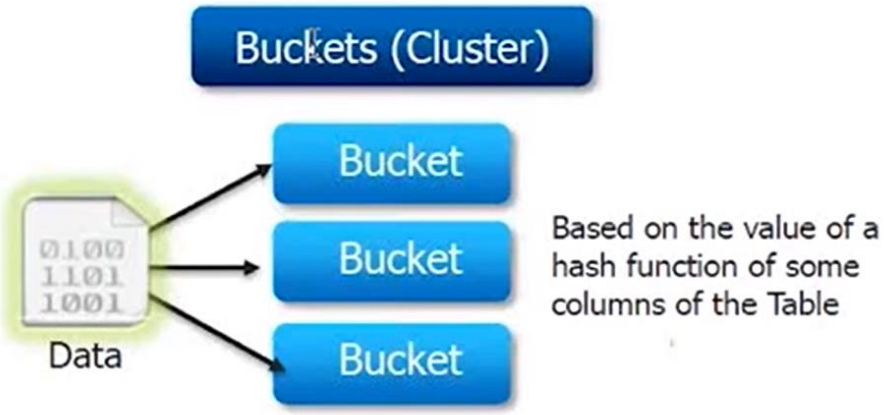
- A partitioning is called dynamic partitioning while loading the data into the Hive table. In other words, we can say that dynamic partitioning values for partition columns in the runtime.
- **Dynamic partitioning is used in the following cases:**
- While we Load data from an existing non-partitioned table, it is used to improve the sampling. Thus it decreases the query latency.
- While we do not know all the values of the partitions beforehand, so, finding these partition values manually from a huge dataset is a tedious task.

Hive Data Model :

Name	Description
Database	Namespace for tables
Tables	Similar to tables in RDBMS Support filter, projection, join and union operations The table data stores in a directory in HDFS
Partitions	Table can have one or more partition keys that tell how the data stores
Buckets	Data in each partition further divides into buckets based on hash of a column in the table. Stored as a file in the partition directory.

Buckets:

- ✓ Buckets give extra structure to the data that may be used for more efficient queries.
  - ✓ A join of two tables that are bucketed on the same columns – including the join column can be implemented as a Map Side Join.
  - ✓ Bucketing by user ID means we can quickly evaluate a user based query by running it on a randomized sample of the total set of users.



Bucketing & Reasoning:

- Bucketing is the concept of breaking data down into ranges, which are known as buckets.
- Bucketing is mainly a data organizing technique.
- It is similar to partitioning in Hive with an added functionality that it divides large datasets into more manageable parts known as buckets.
- The partitioning into buckets can give extra structure to the data to use for more efficient queries.
- The range for a bucket is determined by the hash value of one or more columns in the dataset.

- Reasons:

There are two main reasons for performing bucketing to a partition:

•We perform bucketing to a partition because a map side join requires the data belonging to a unique join key to be present in the same partition.

•Bucketing facilitates us to decrease the query time, and it also makes the sampling process more efficient.

Optimization: Indexing

- Indexing in Hive is a Hive query optimization technique.
- It is mainly used to speed up the access of a column or set of columns in a Hive database.
- With the use of the index, the Hive database system does not need to read all rows in the table, especially that one has selected.

Hive Data Model:

Partitions:

Command:

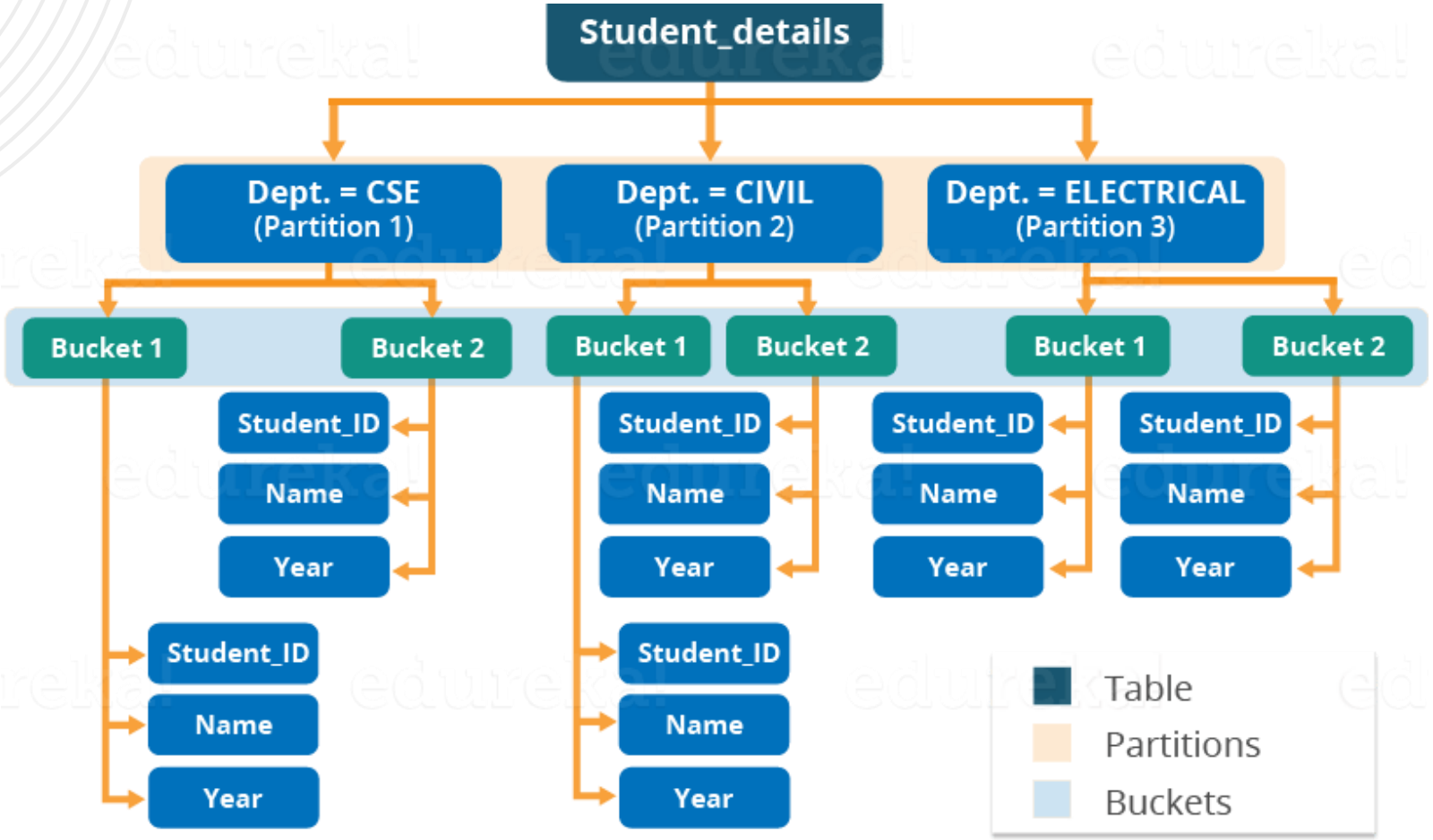
CREATE TABLE table_name (column1 data_type, column2 data_type) PARTITIONED BY (partition1 data_type, partition2 data_type,....);

Hive organizes tables into partitions for grouping similar type of data together based on a column or partition key. Each Table can have one or more partition keys to identify a particular partition. This allows us to have a faster query on slices of the data.

Buckets:

Commands:

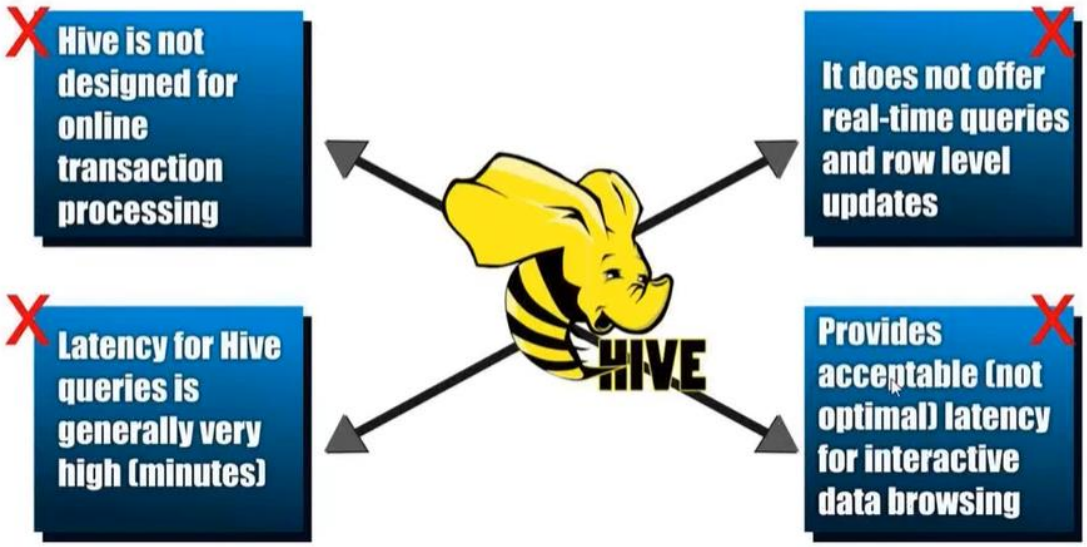
CREATE TABLE table_name PARTITIONED BY (partition1 data_type, partition2 data_type,....) CLUSTERED BY (column_name1, column_name2, ...) SORTED BY (column_name [ASC|DESC], ...)] INTO num_buckets BUCKETS;


Student_details
Dept. = CSE
(Partition 1)
Dept. = CIVIL
(Partition 2)
Dept. = ELECTRICAL
(Partition 3)
Bucket 1
Bucket 2
Bucket 1
Bucket 2
Bucket 1
Bucket 2
Student_ID
Name
Year
Student_ID
Name
Year
Student_ID
Name
Year
Student_ID
Name
Year
Student_ID
Name
Year
Student_ID
Name
Year
Table
Partitions
Buckets

MODES OF HIVE

- **Local Mode**
- **MapReduce Mode**
  - In Hive, the Map reduce mode is used in the following conditions:
  - To perform on a large amount of data sets and query going to execute in a parallel way .
  - When Hadoop has multiple data nodes and is distributed across different nodes, we should use this mode.
  - To achieve better performance.

Limitation of Hive:



- Hive Does not provide update, alter and deletion of records in the database.
- Not developed for "Unstructured Data"
- Not designed for "Real Time Queries".
- Performs the partition always from the last column.
- OLTP: No. Because Hive does not provide insert and update at the row level, it is not suitable for the OLTP system.

Hive Data Types :

- Hive Defines various primitive, complex, string, date/time, collection data types and file formats.
- For handling & Storing different data formats.
- Table 1: Gives primitive, string , date/time and complex Hive data types & its description.

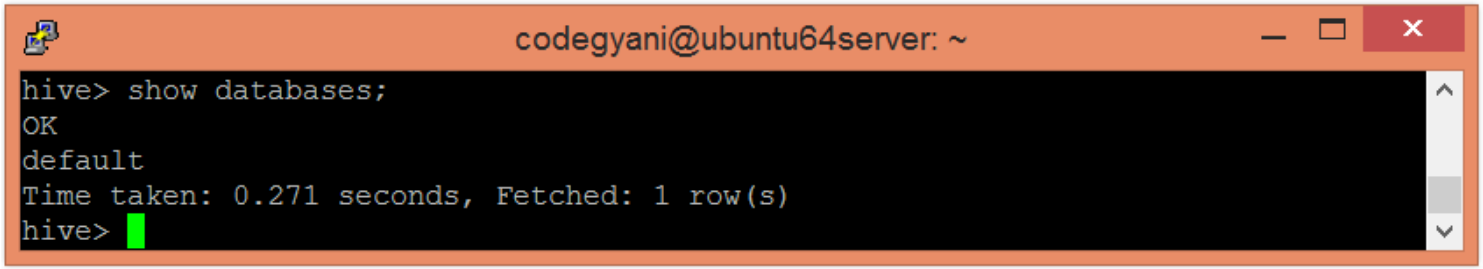
Table 1: Primitive, Sting, Date/time datatypes

Data Type Name	Description
TINYINT	1 byte signed integer. Postfix letter is Y.
SMALLINT	2 byte signed integer. Postfix letter is S.
INT	4 byte signed integer
BIGINT	8 byte signed integer. Postfix letter is L.
FLOAT	4 byte single-precision floating-point number
DOUBLE	8 byte double-precision floating-point number
BOOLEAN	True or False
TIMESTAMP	UNIX timestamp with optional nanosecond precision. It supports java.sql.Timestamp format "YYYY-MM-DD HH:MM:SS.fffffffff"
DATE	YYYY-MM-DD format
VARCHAR	1 to 65355 bytes. Use single quotes (' ') or double quotes (" ")
CHAR	255 bytes
DECIMAL	Used for representing immutable arbitrary precision. DECIMAL (precision, scale) format

Hive - Create Database

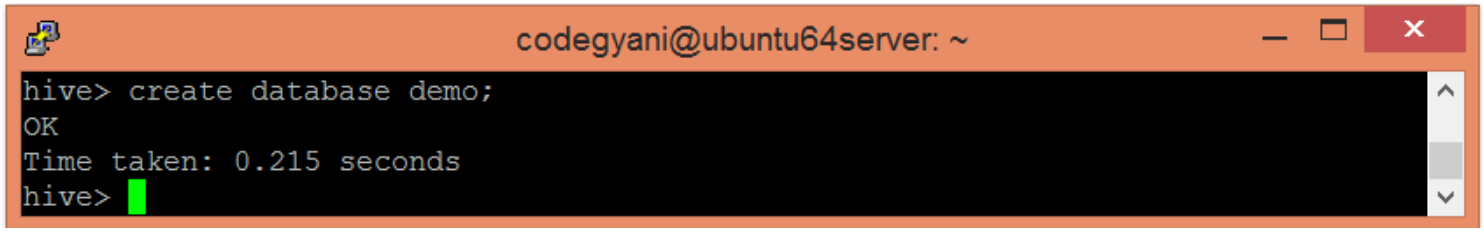
- In Hive, the database is considered as a **catalog or namespace of tables**. So, we can maintain **multiple tables within a database** where a **unique name is assigned to each table**. Hive also provides a **default database** with a name **default**.
- check the list of existing databases, follow the below command: -

hive> show databases;



- Let's create a new database by using the following command: -

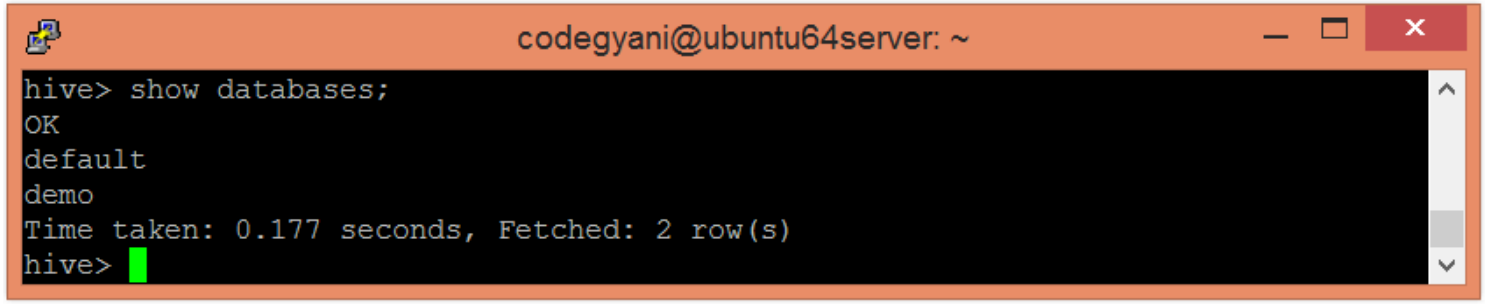
hive> create database demo;



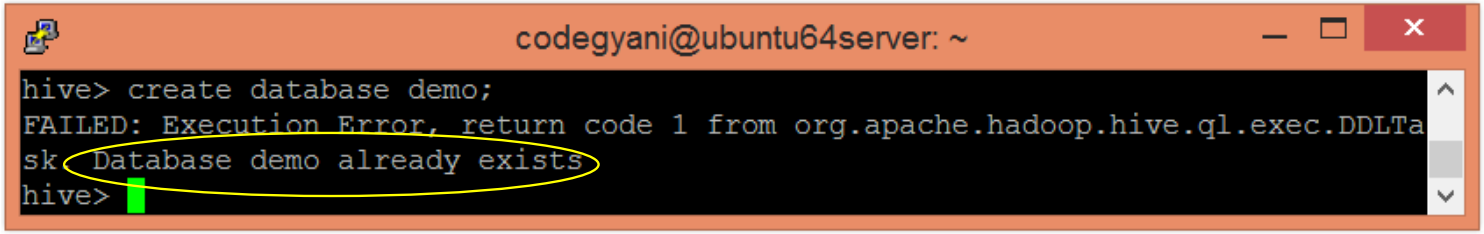
Hive - Create Database

- Let's check the existence of a newly created database.

  hive> show databases;



- Each database must contain a **unique name**. If we create **two databases with the same name**, the following error generates: -



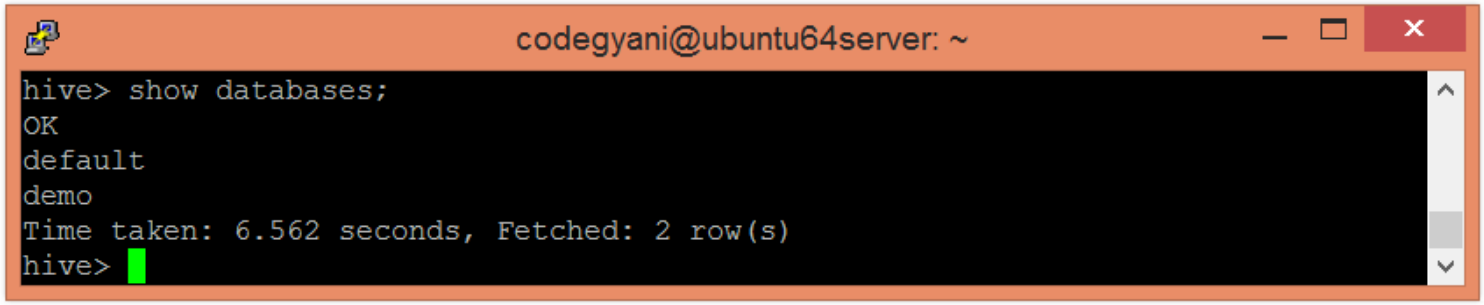
- If we want to suppress the warning generated by Hive on creating the database with the same name, follow the below command: -

  hive> create a database if not exists demo;

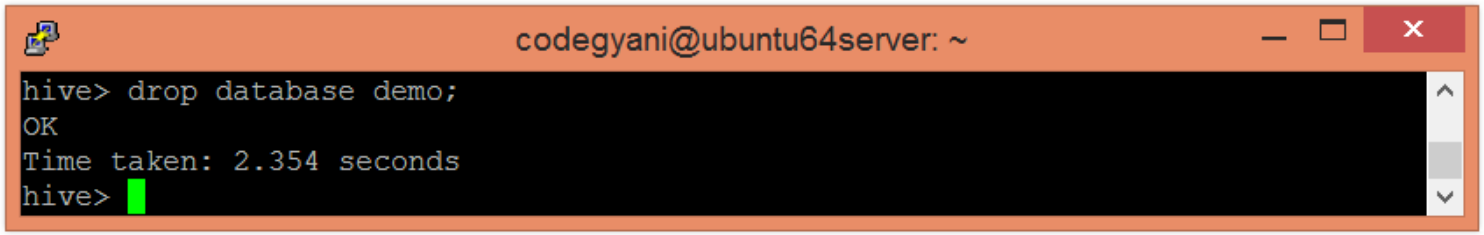
Hive - Drop Database

•check the list of existing databases by using the following command: -

hive> show databases;

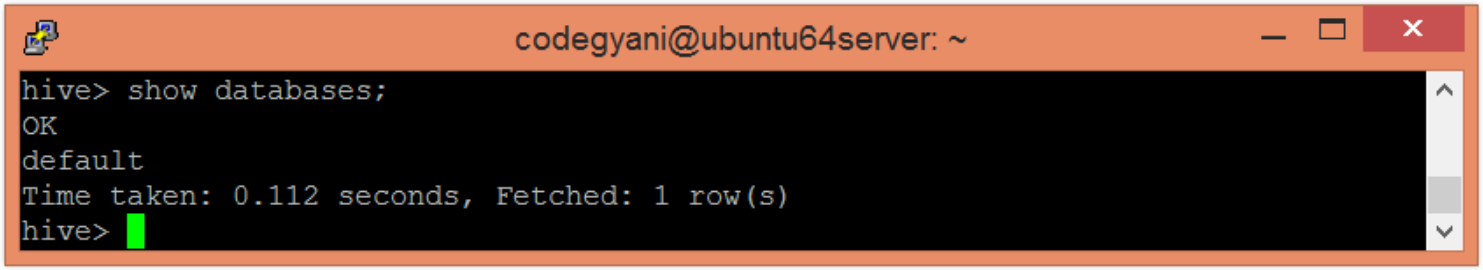


hive> drop database demo;

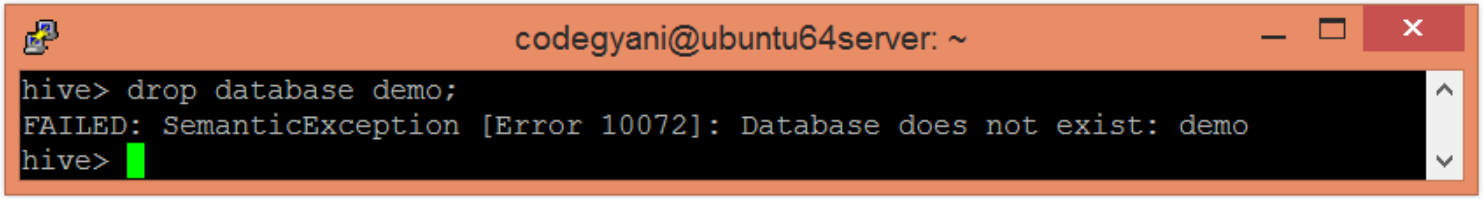


Let's check whether the database is dropped or not.

hive> show databases;



- If we try to drop the database that doesn't exist, the following error generates:



- if we want to suppress the warning generated by Hive on creating the database with the same name, follow the below command:-

  hive> drop database if exists demo;

- In Hive, it is **not allowed to drop the database that contains the tables** directly. In such a case, we **can drop the database either by dropping tables first** or use **Cascade keyword** with the command.

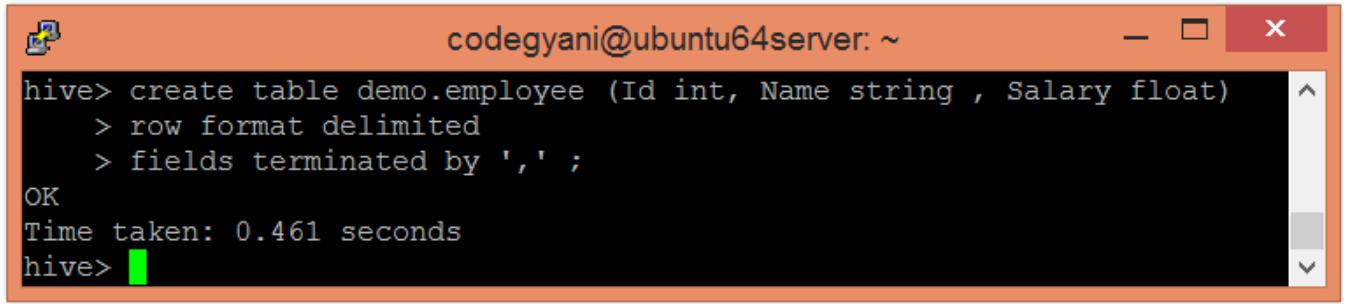
  hive> drop database if exists demo cascade;

Hive - Create Table

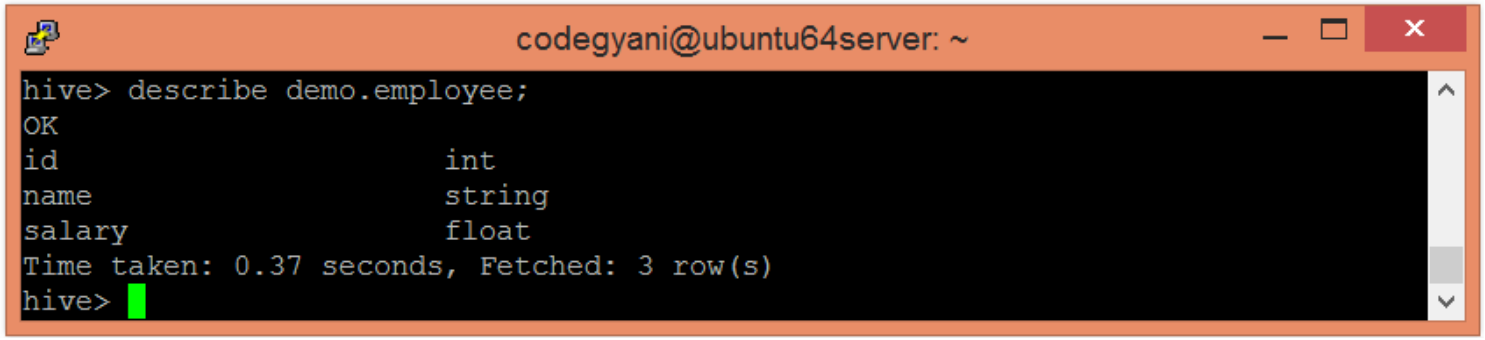
- In Hive, we can create a table by using the **conventions similar to the SQL**. It supports a wide range of flexibility where the data files for tables are stored. It provides two types of table: -

- create an internal/managed table by using the following command:-

hive> create table demo.employee (Id int, Name string , Salary float)
row format delimited
fields terminated by ',' ;

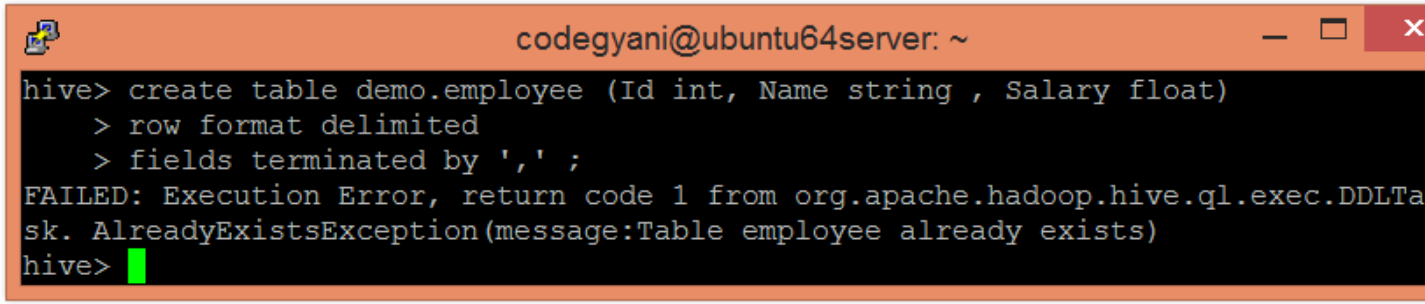


- The **metadata** of the created table by using the following command:-

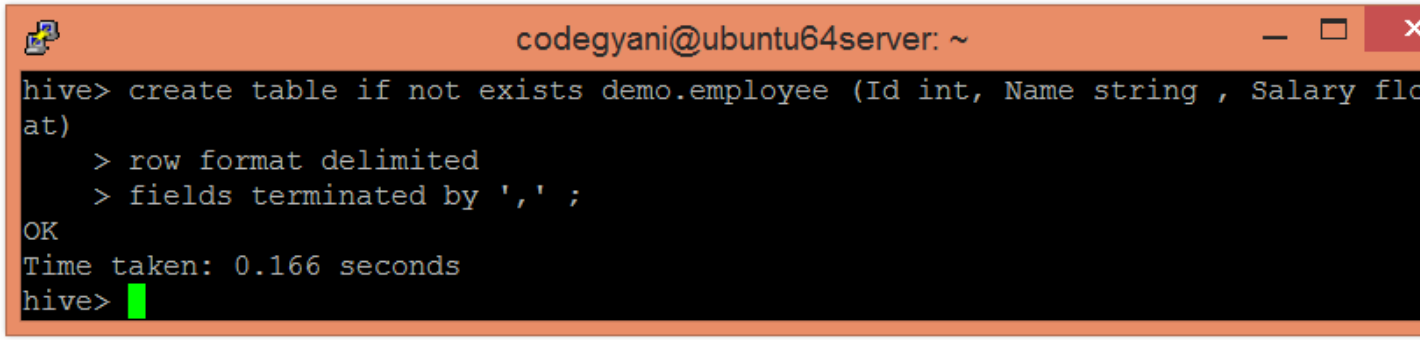


Hive - Create Table

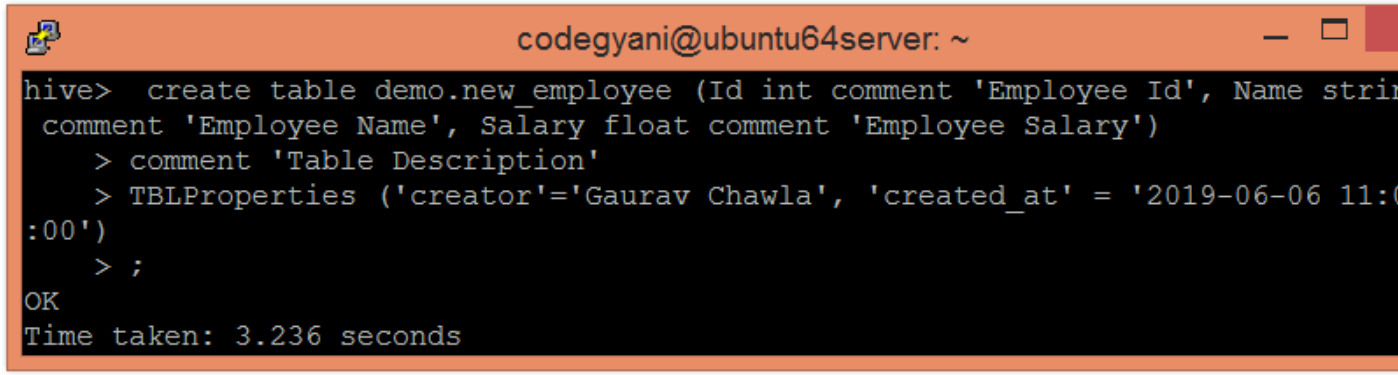
- Let's see the result when we try to create the existing table again.



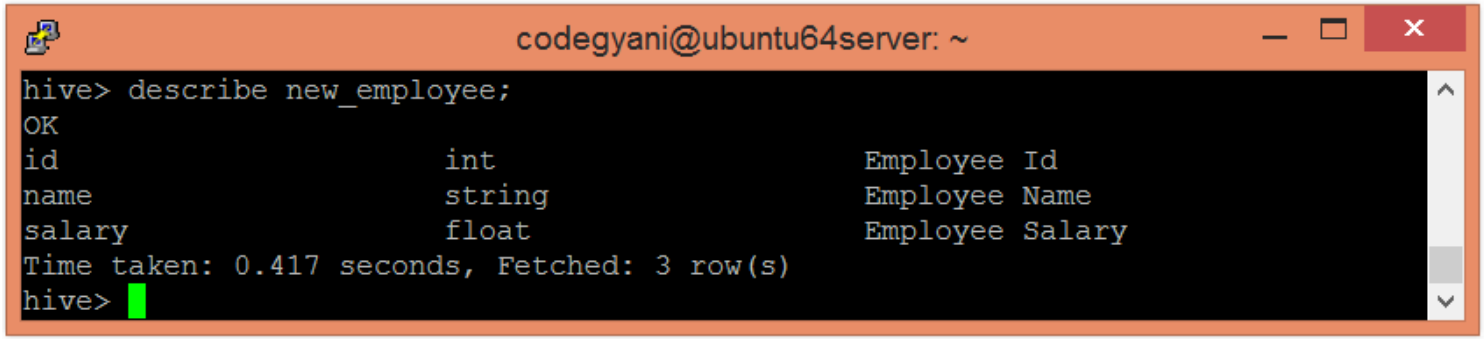
- In such a case, the exception occurs. If we want to ignore this type of exception, we can use if not exists command while creating the table.



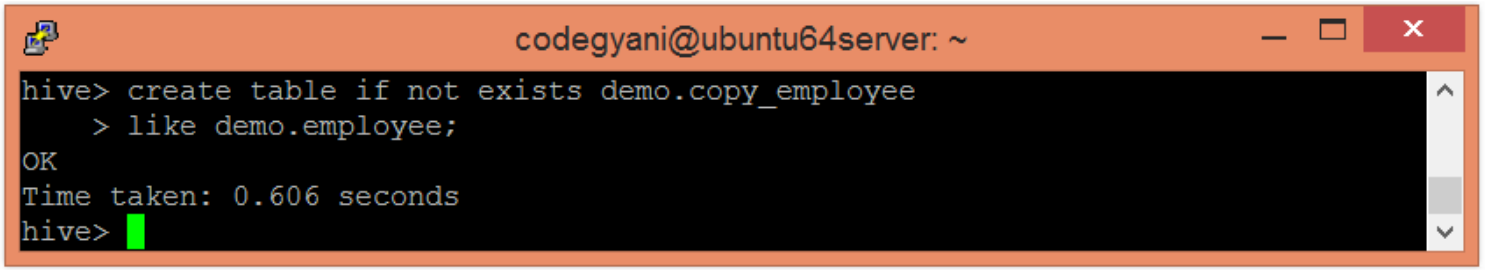
•While creating a table, we can add the comments to the columns and can also define the table properties.



hive> describe new_employee;



- Hive allows creating a new table by using the schema of an existing table.

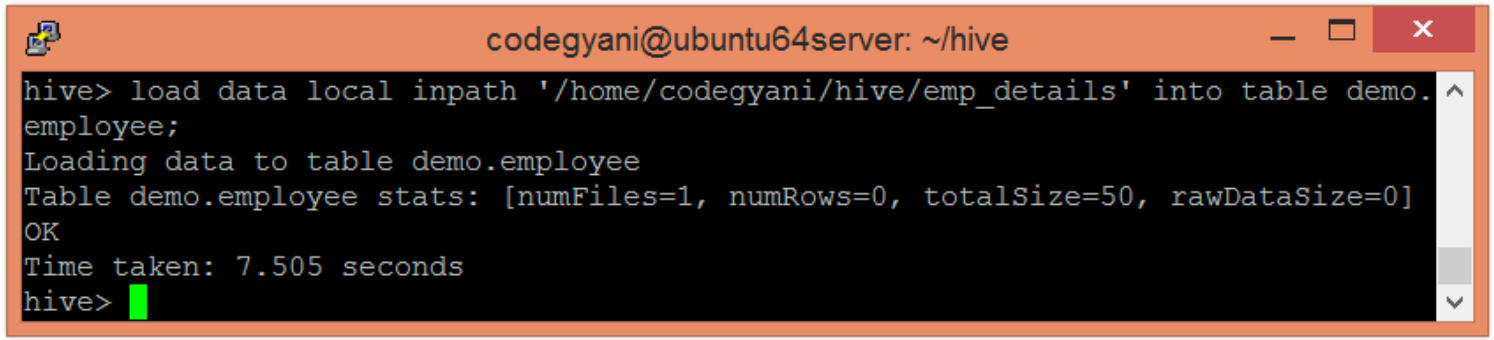


Hive - Load Data

Once the **internal table has been created**, the next step is to load the data into it. So, in Hive, we can easily load data from any file to the database.

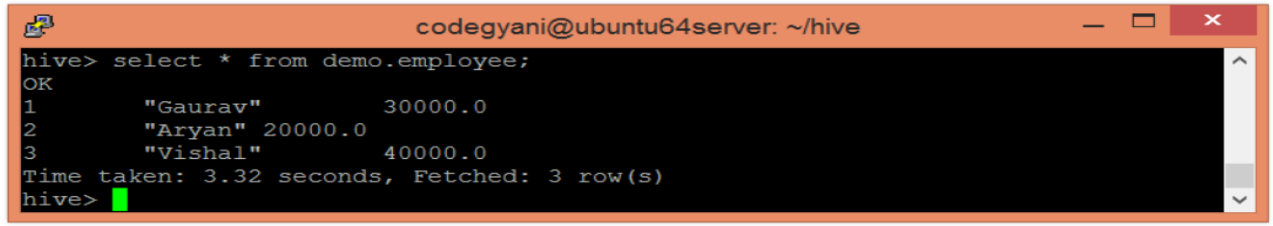
- Let's load the data of the file into the database by using the following command: -

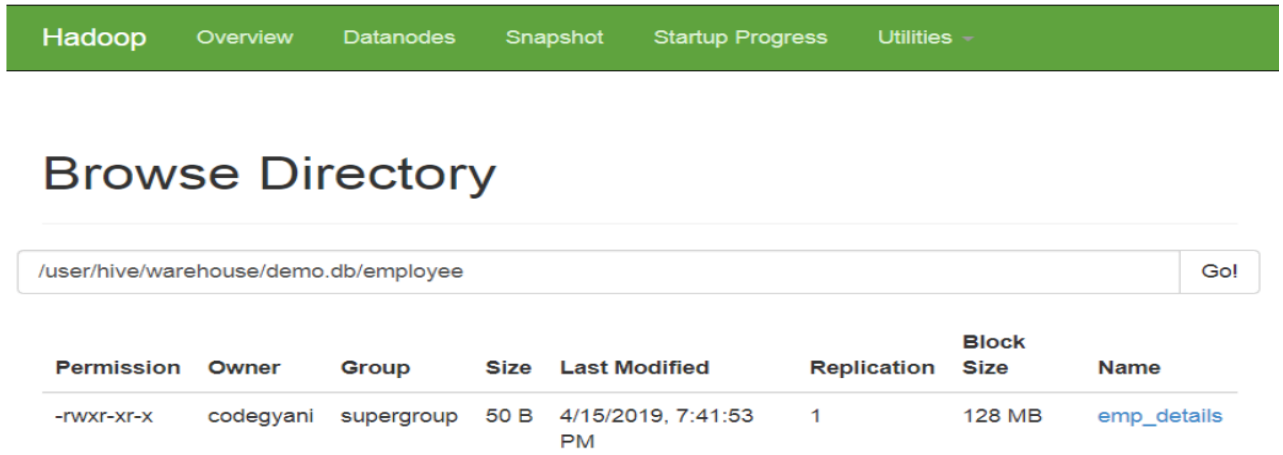
- Here, **emp_details** is the file name that contains the data.



- If we want to add more data into the current database, execute the same query again by just updating the new file name.

load data local inpath '/home/codegyani/hive/emp_details1' into table demo.employee;





External Table

To create an external table, follow the below steps: -

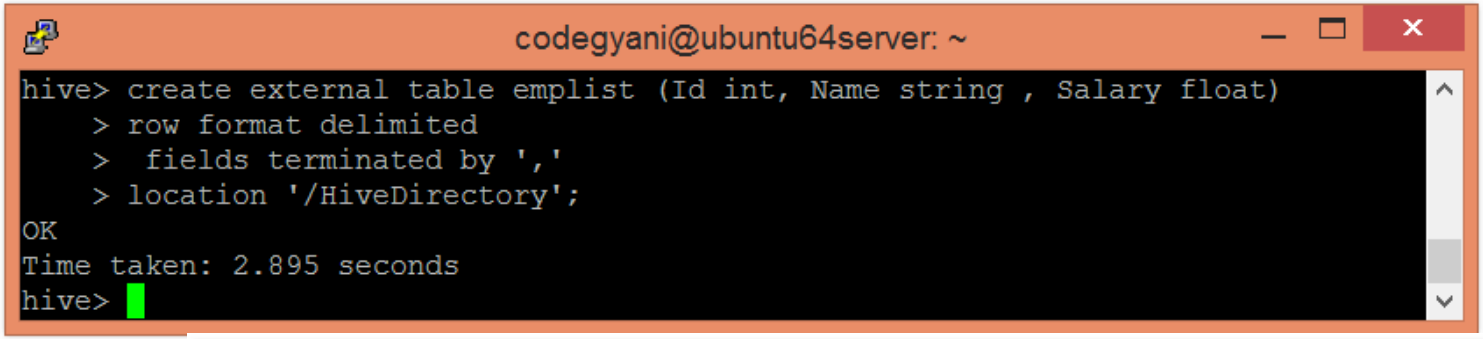
•Let's create a directory on HDFS by using the following command: -

hdfs dfs -mkdir /HiveDirectory

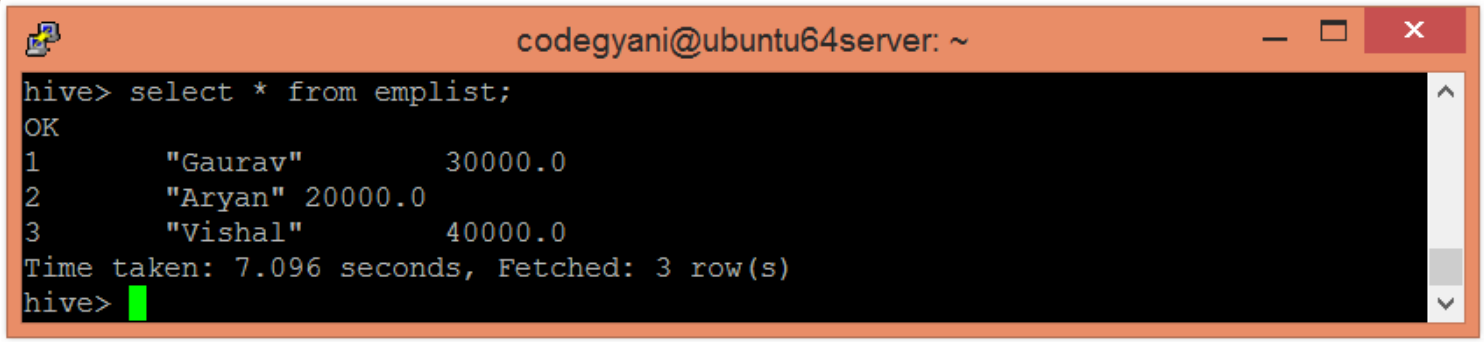
•Now, store the file on the created directory.

hdfs dfs -put hive/emp_details /HiveDirectory

•Let's create an external table using the following command: -

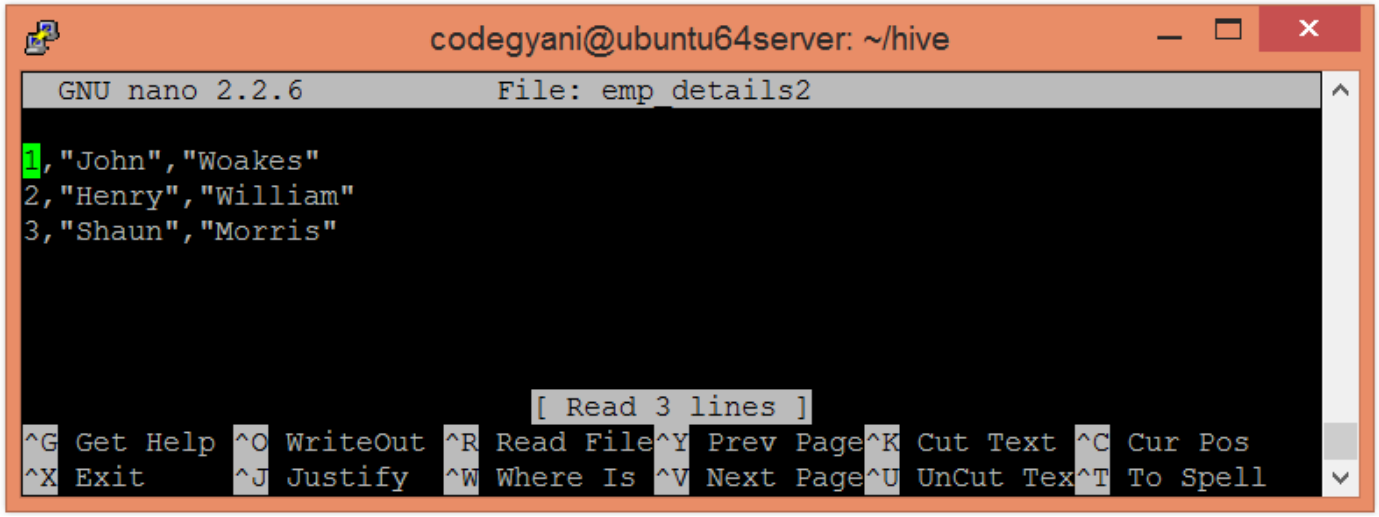


- Now, we can use the following command to retrieve the data: -

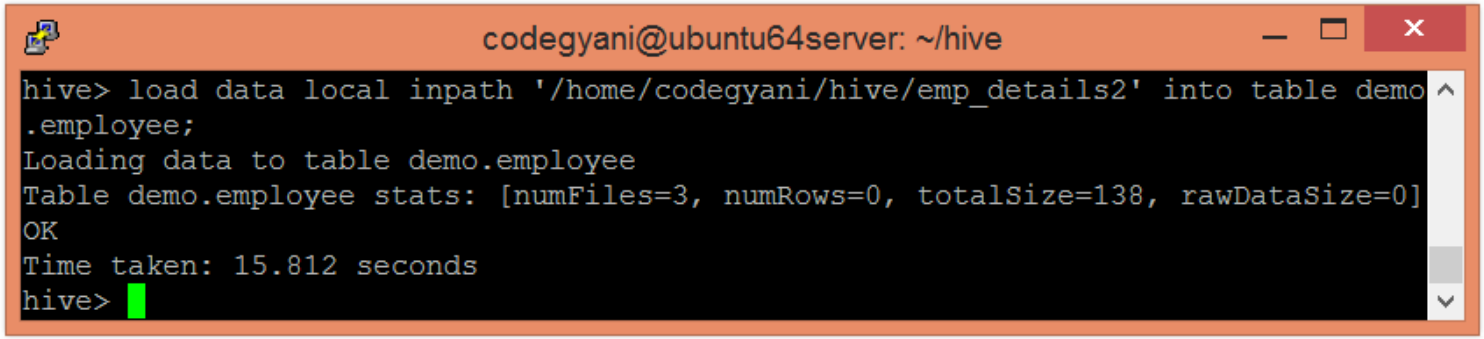


- In Hive, if we try to **load unmatched data** (i.e., **one or more column data doesn't match the data type of specified table columns**), it will not throw any exception. However, it stores the Null value at the position of **unmatched tuple**.

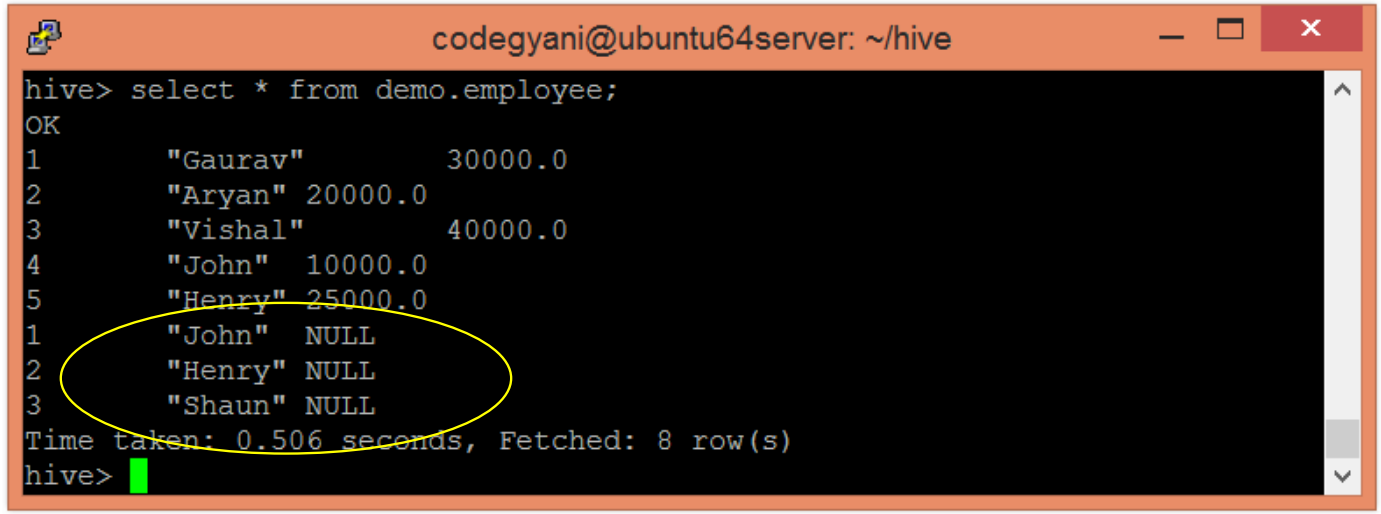
- Let's add one more file to the current table. This file contains the unmatched data.



- load the data into the table.



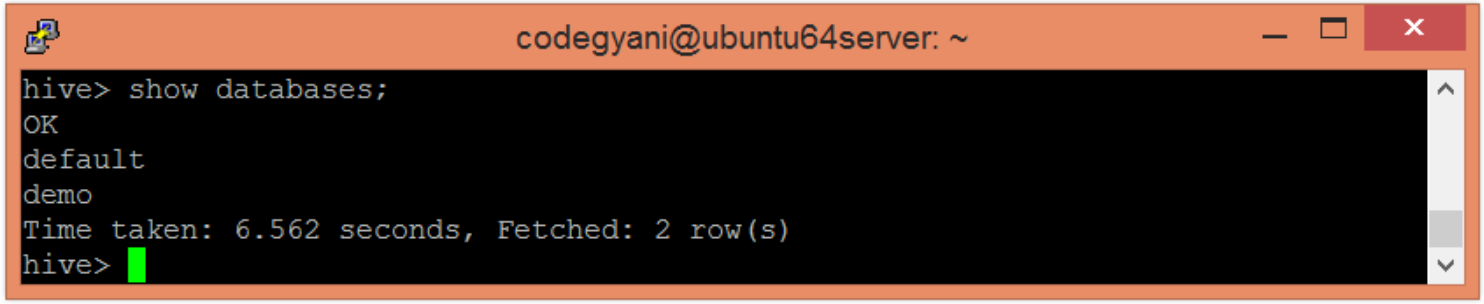
- Null values at the position of unmatched data.



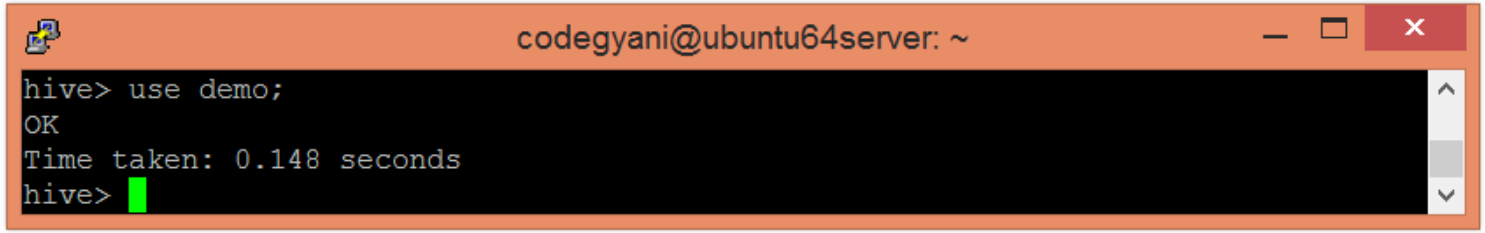
Hive - Drop Table

Hive facilitates us to drop a table by using the SQL drop table command. Let's follow the below steps to drop the table from the database.

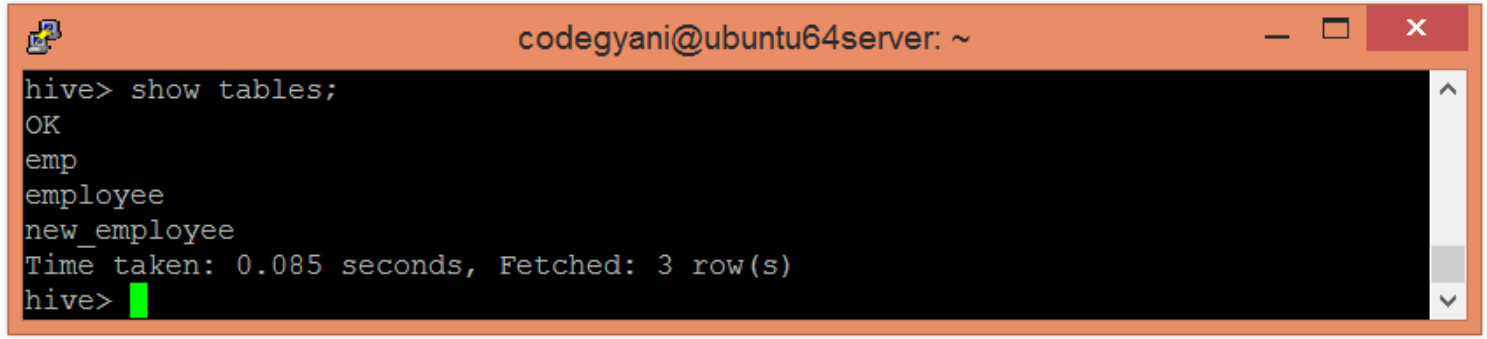
- check the list of existing databases by using the following command: -



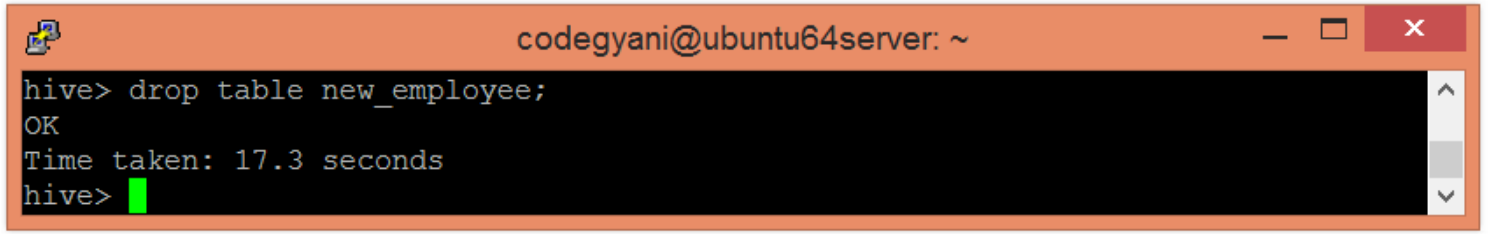
- select the **database from which we want to delete the table**



- check the list of **existing tables** in the corresponding database.

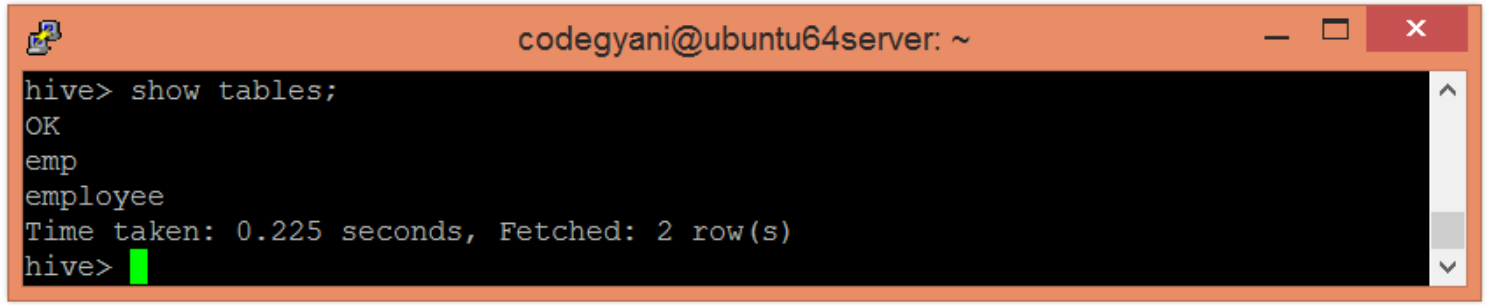


- drop the table by using the following command:



- check whether the table is dropped or not.

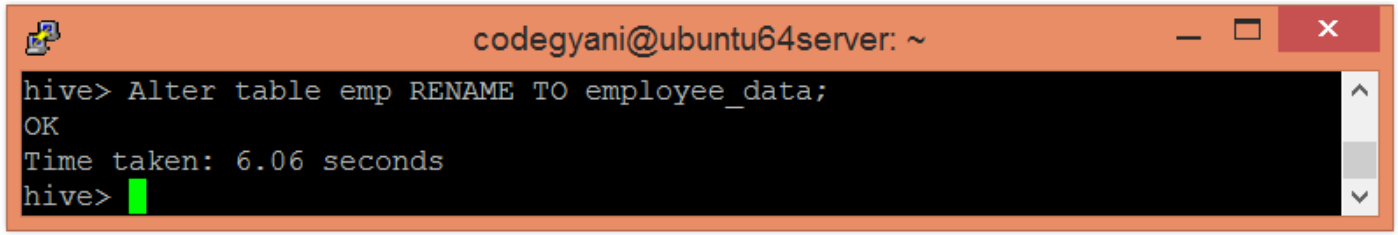
- As we can see, the table **new_employee** is not present in the list. Hence, the table is dropped successfully.



Hive - Alter Table

In Hive, we can perform modifications in the existing table **like changing the table name, column name, comments, and table properties. It provides SQL like commands to alter the table.**

- change the name of the table by using the following command



- In Hive, we can **add one or more columns** in an existing table by using the following signature:

  Alter table employee_data add columns (age int);

- change the name of the column by using the following command: -

  Alter table employee_data change name first_name string;

- **alter table employee_data replace columns(id string, first_name string, age int);**

Partitioning in Hive

The partitioning in Hive can be executed **in two ways** -

- Static partitioning
- Dynamic partitioning

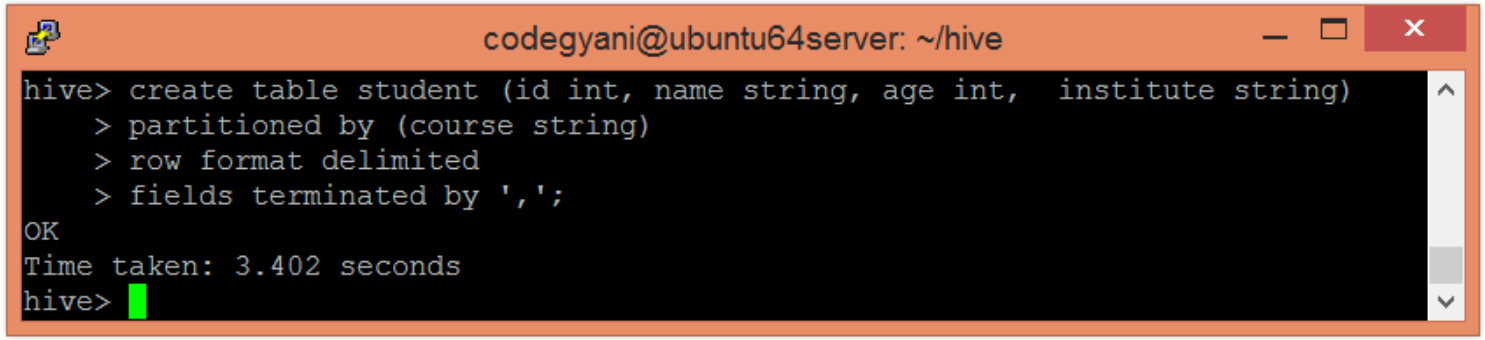
- In static or manual partitioning, it is required to **pass the values of partitioned columns manually** while **loading the data into the table**. Hence, the data file doesn't contain the partitioned columns.

Example of Static Partitioning

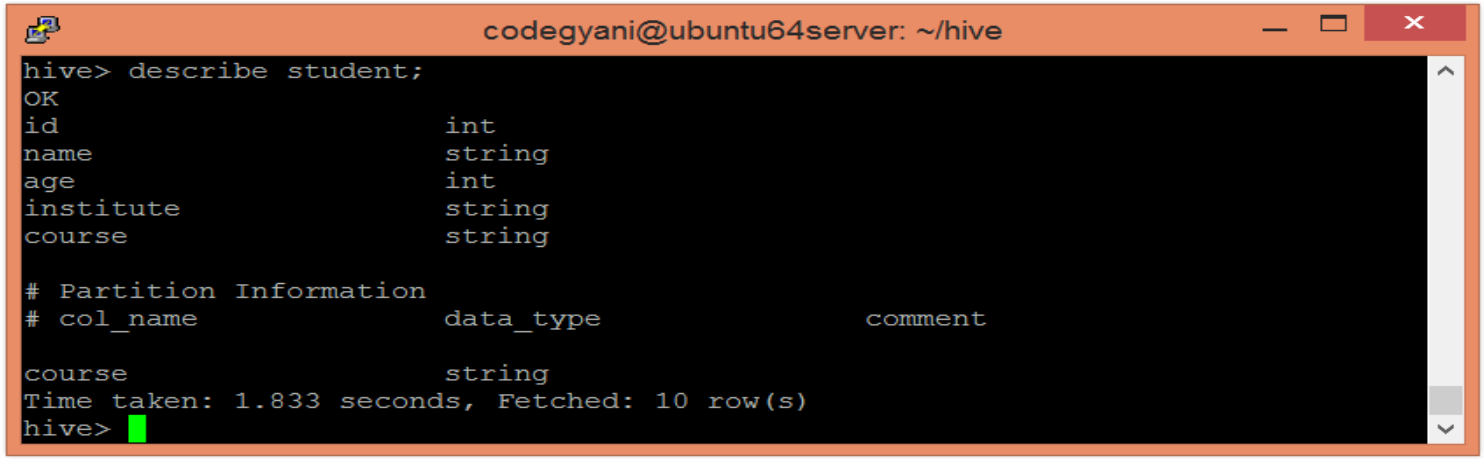
First, select the database in which we want to create a table.

hive> use test;

- Create the table and provide the partitioned columns by using the following command



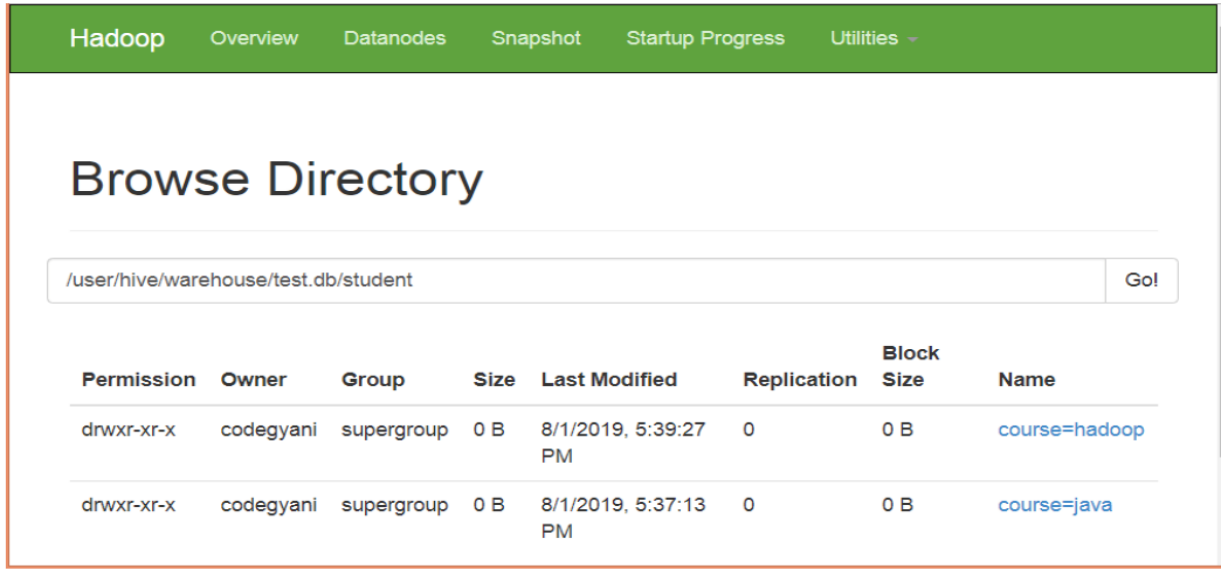
- Let's retrieve the information associated with the table.



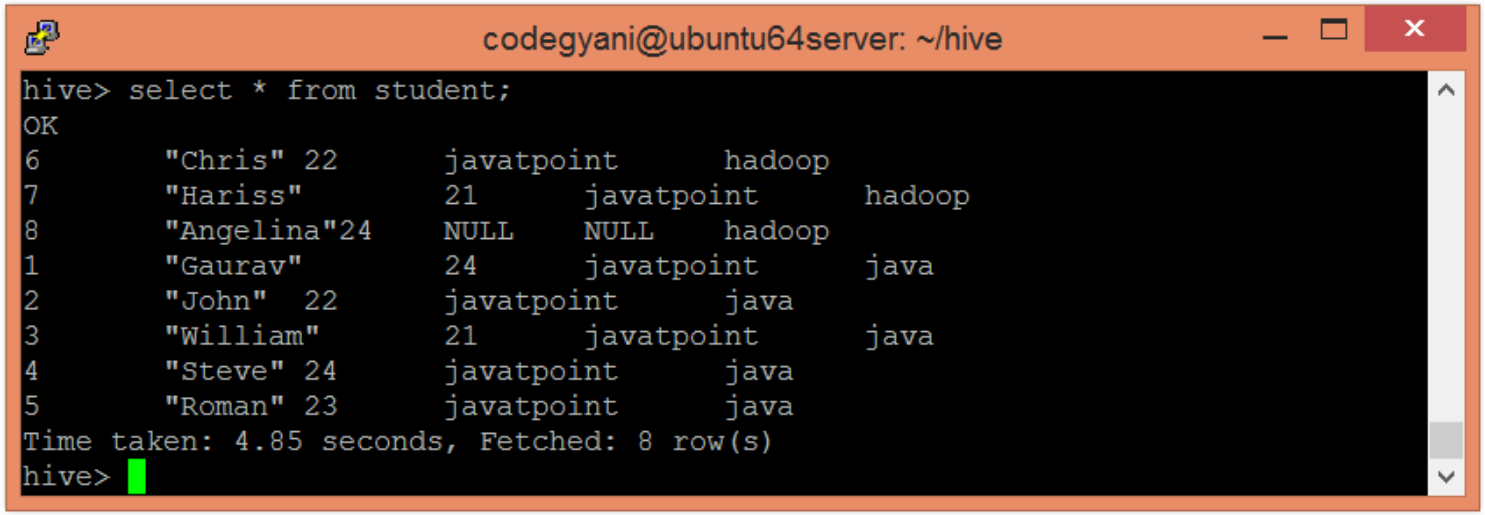
- Load the data into the table and pass the values(key) of partition columns with it by using the following command: -
- Here, we are **partitioning the students of an institute based on courses.**

- Load the data of **another file into the same table** and pass the values of partition columns with it by using the following command: -

- In the following screenshot, we can see that the **table student is divided into two categories.**

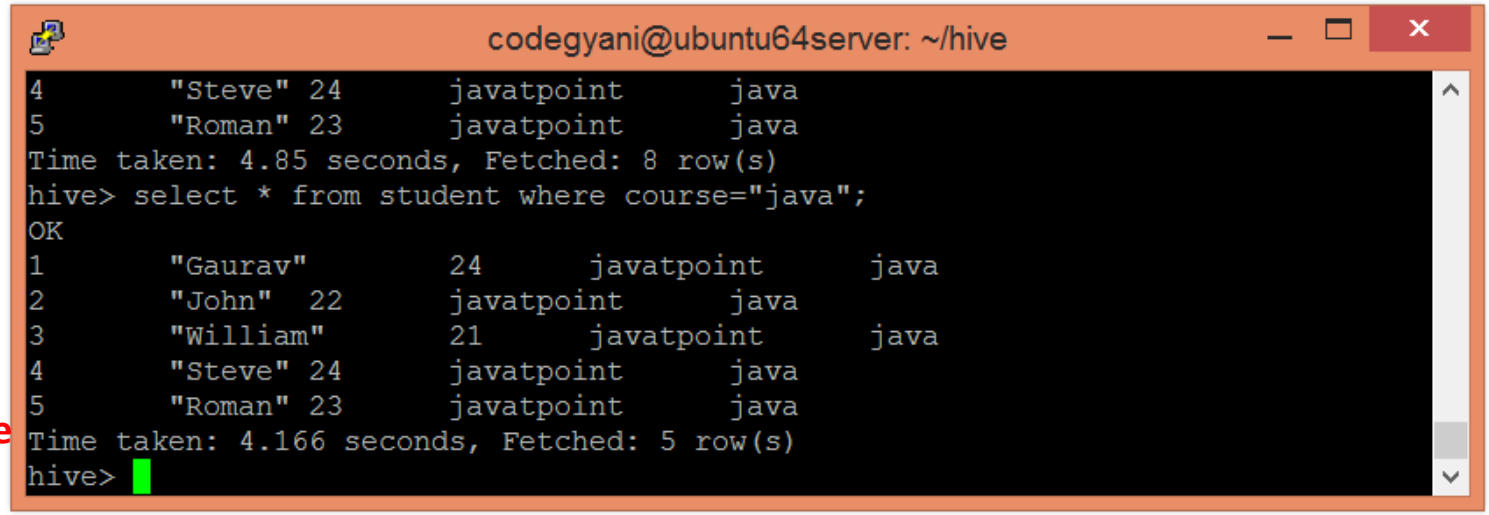


- Let's retrieve the entire data of the table by using the following command



- try to retrieve the data based on **partitioned columns** by using the following command: -

- In this case, we are **not examining the entire data**. Hence, this approach **improves query response time.**



Dynamic Partitioning

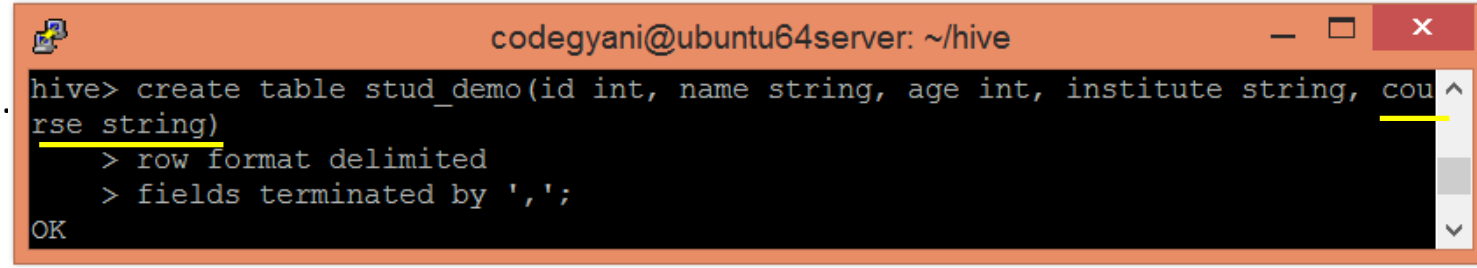
In dynamic partitioning, the **values of partitioned columns exist within the table**. So, it is not required to pass the values of partitioned columns manually.

- First, select the **database** in which we **want to create a table**.

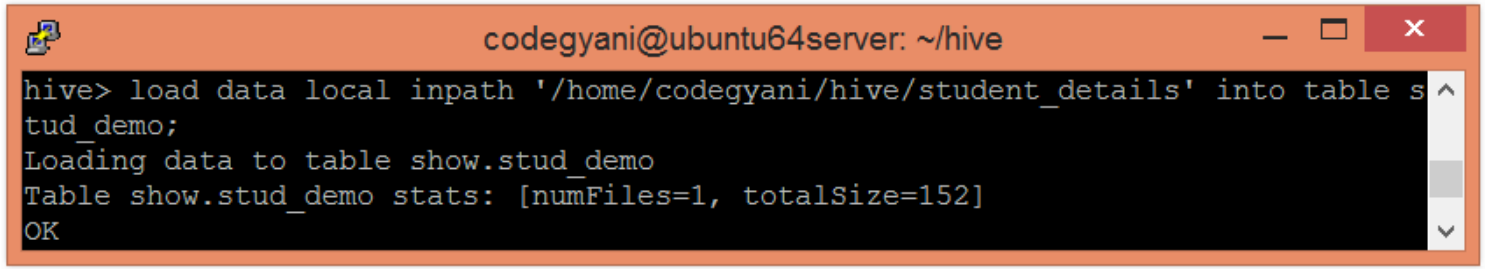
- **Enable the dynamic partition** by using the following commands: -

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

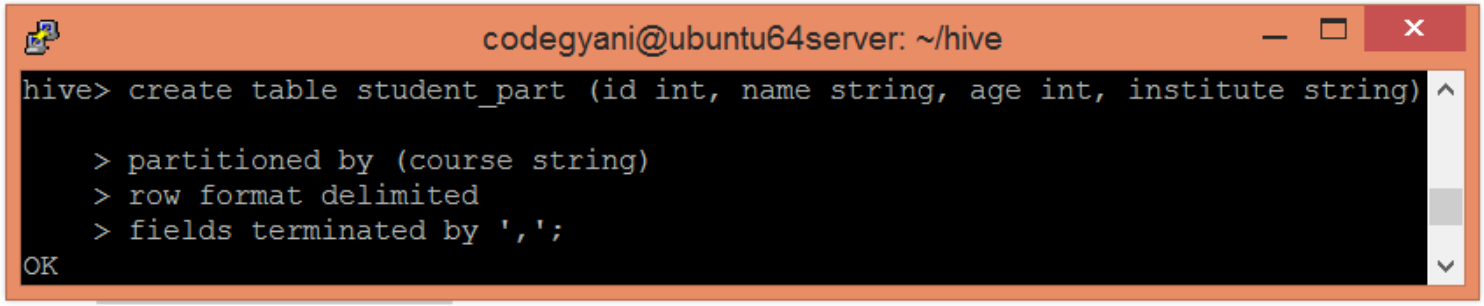
•Create a **dummy table** to store the data.



- Now, load the data into **dummy** table.



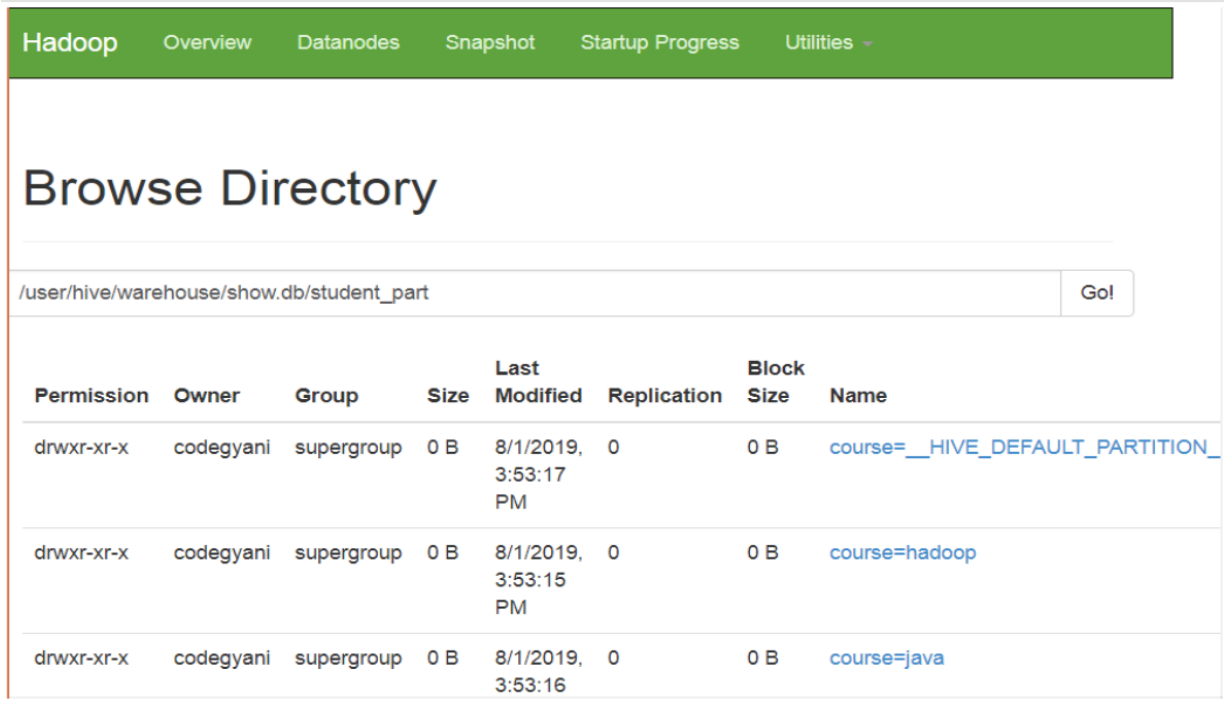
- Create a **partition table** by using the following command



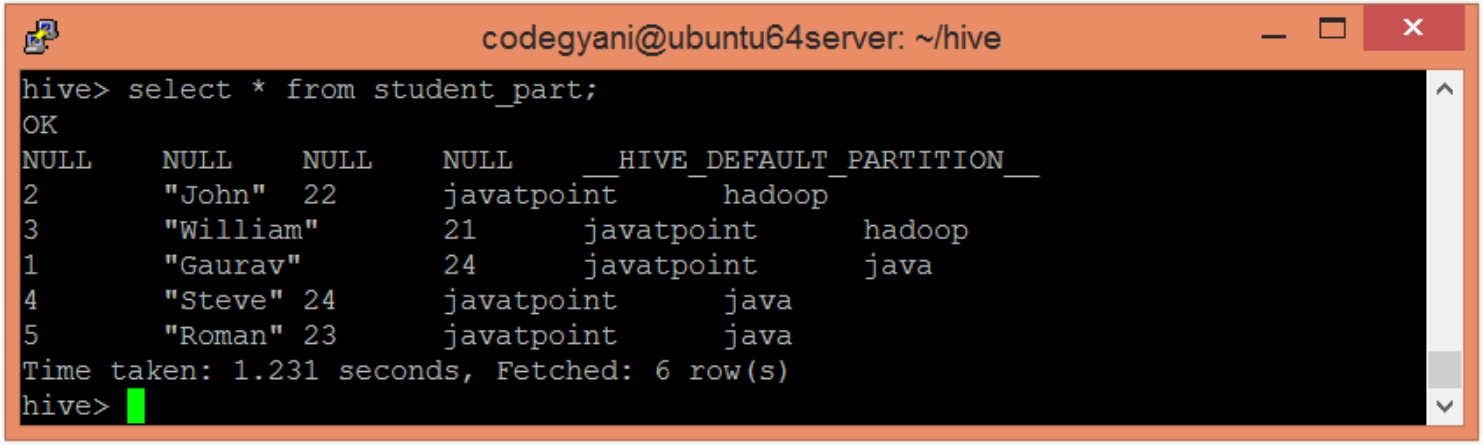
- Now, **insert the data of dummy table into the partition table.**

→ hive> insert into student_part
partition(course)
select id, name, age, institute, course
from stud_demo;

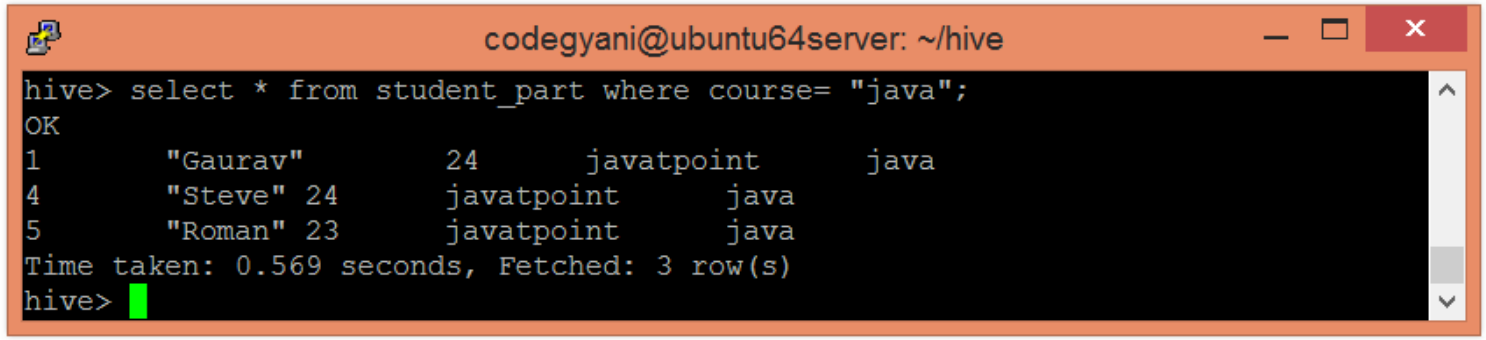
- In the following screenshot, we can see that the table **student_part is divided into two categories**.



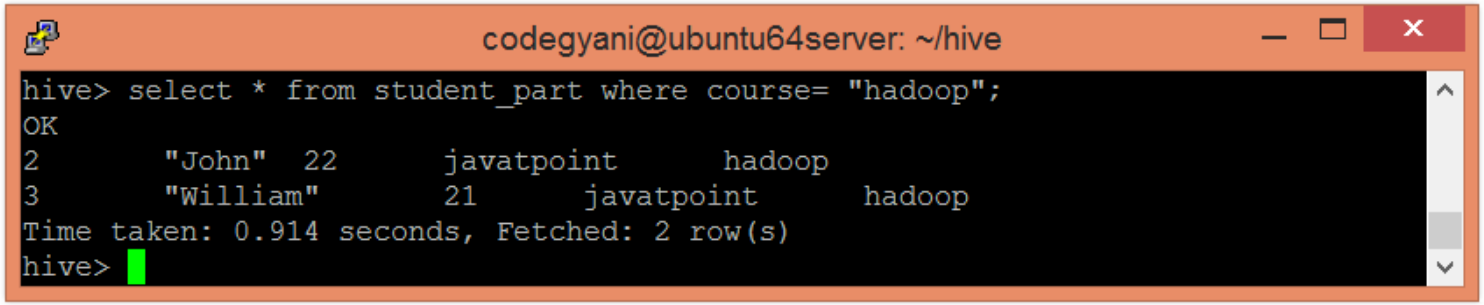
- Let's retrieve the entire data of the table by using the following command



- Now, try to retrieve the data based on partitioned columns by using the following command:



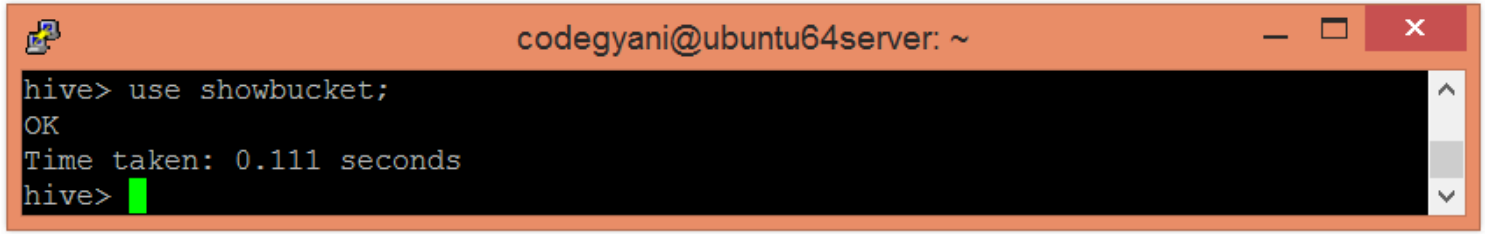
- Let's also retrieve the data of another partitioned dataset by using the following command



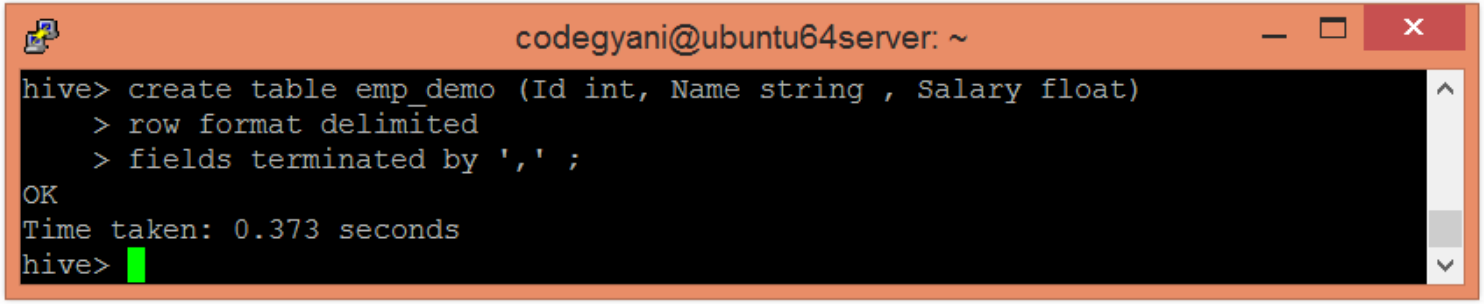
Bucketing in Hive

- The bucketing in Hive is a data organizing technique. It is similar to partitioning in Hive with an added functionality that it divides large datasets into more manageable parts known as buckets.

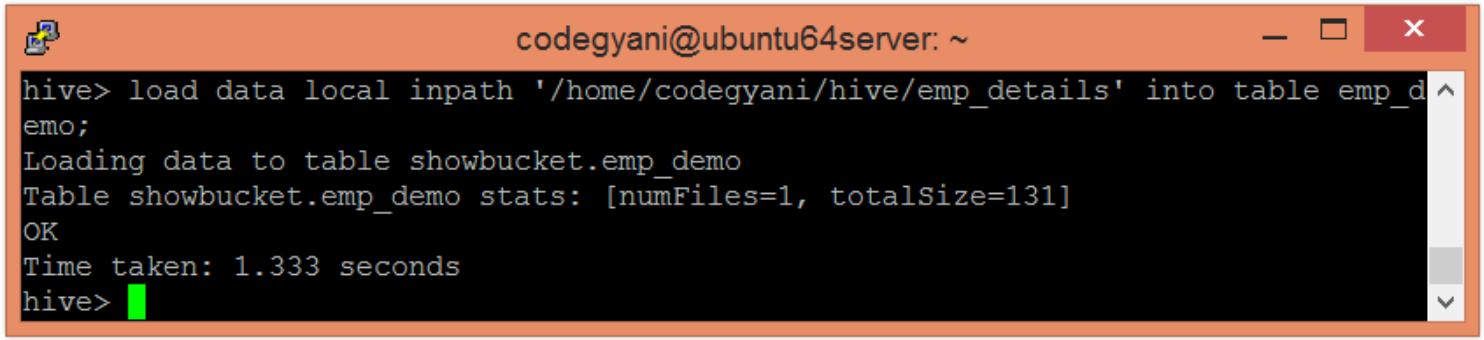
- First, select the database in which we want to create a table.



- Create a dummy table to store the data.



- Now, load the data into the table.



Bucketing in Hive

- Enable the bucketing by using the following command → **hive> set hive.enforce.bucketing = true;**

- Create a bucketing table by using the following command:

```
codegyani@ubuntu64server: ~
hive> create table emp_bucket(Id int, Name string , Salary float)
    > clustered by (Id) into 3 buckets
    > row format delimited
    > fields terminated by ',' ;
OK
Time taken: 0.308 seconds
hive>
```

- Now, insert the data of dummy table into the bucketed table.

hive> insert overwrite table emp_bucket select * from emp_demo;

- Here, we can see that the data is divided into three buckets.

Hadoop Overview Datanodes Snapshot Startup Progress Utilities

Browse Directory

/user/hive/warehouse/showbucket.db/emp_bucket Go!

Permission	Owner	Group	Size	Last Modified	Replication	Block Size	Name
-rwxr-xr-x	codegyani	supergroup	56 B	8/2/2019, 4:11:20 AM	1	128 MB	000000_0
-rwxr-xr-x	codegyani	supergroup	53 B	8/2/2019, 4:11:20 AM	1	128 MB	000001_0
-rwxr-xr-x	codegyani	supergroup	54 B	8/2/2019, 4:11:20 AM	1	128 MB	000002_0

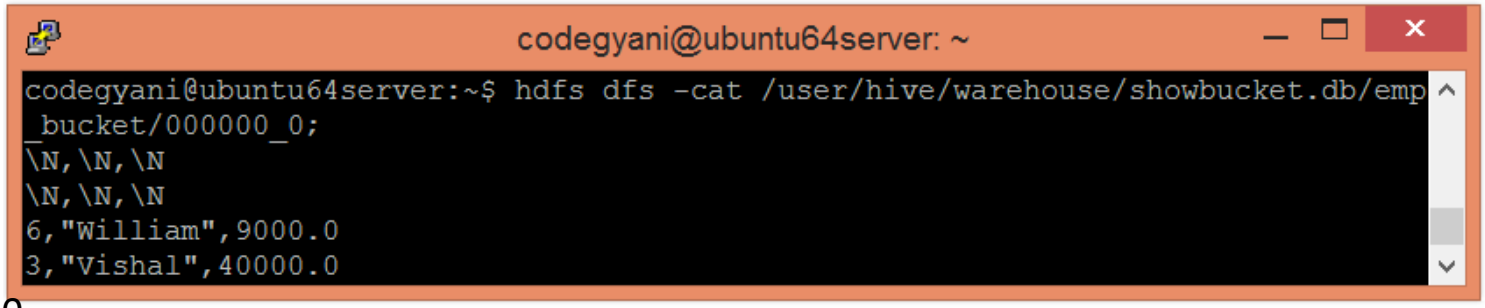
•Let's retrieve the data of bucket 0.

According to hash function :

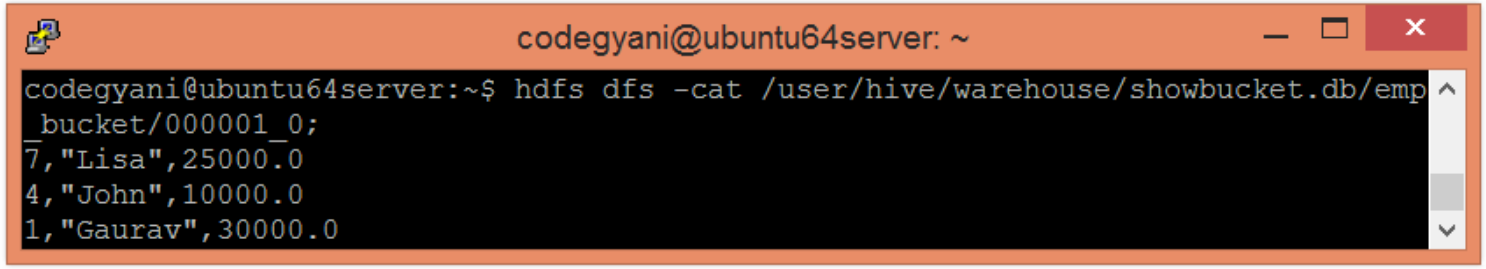
6%3=0

3%3=0

So, these columns stored in bucket 0.



- Let's retrieve the data of bucket 1



According to hash function :

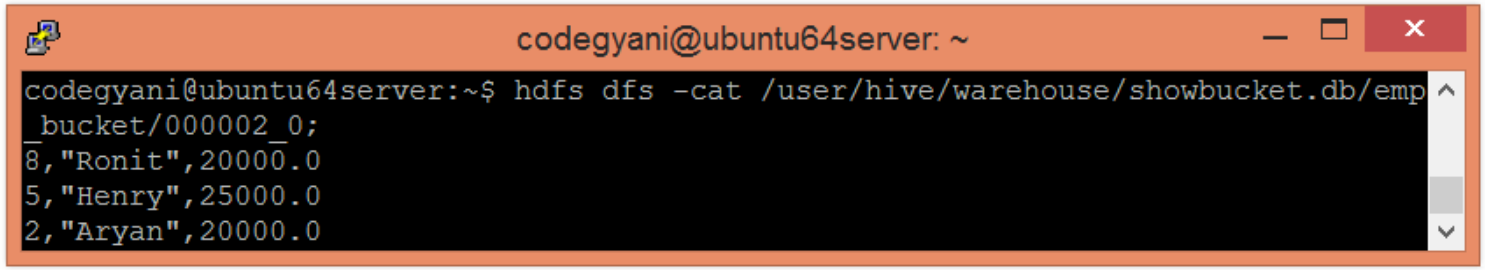
7%3=1

4%3=1

1%3=1

So, these columns stored in bucket 1.

- Let's retrieve the data of bucket 2.



According to hash function :

8%3=2

5%3=2

2%3=2

So, these columns stored in bucket 2.

File Formats & Descriptions:

File Format	Description
Text file	The default file format, and a line represents a record. The delimiting characters separate the lines. Text file examples are CSV, TSV, JSON and XML
Sequential file	Flat file which stores binary key-value pairs, and supports compression.
RCFile	Record Columnar file
ORCFILE	ORC stands for Optimized Row Columnar which means it can store data in an optimized way than in the other file formats

Hive Text File Format

- Hive **Text file format is a default storage format**.

- You can use the text format to **interchange** the data with **other client application.**

- Create a TEXT file by add **storage option** as 'STORED AS TEXTFILE' at the end of a Hive CREATE TABLE command.

Hive Text File Format Examples

Below is the Hive CREATE TABLE command with storage format specification:

Create table textfile_table (column_specs) stored as textfile;

Hive Sequence File Format

- Sequence files are Hadoop flat files which stores values in **binary key-value pairs.**
- The sequence files are **in binary format** and these files are **able to split.**
- The main **advantages** of using sequence file is to **merge two or more files** into one file.
- Create a sequence file by add storage option as 'STORED AS SEQUENCEFILE' at the end of a Hive CREATE TABLE command.

Hive Sequence File Format Example

Below is the Hive CREATE TABLE command with storage format specification:

Create table sequencefile_table (column_specs) stored as sequencefile;

Hive RC File Format

- RCFile **is row columnar file format.**
- This is another form of Hive file format which **offers high row level compression rates.**
- If you have requirement to **perform multiple rows at a time** then you can use RCFile format.
- The RCFile are very much similar to the sequence file format. This file format also stores the data as key-value pairs.
- Create RCFile by specifying 'STORED AS RCFILE' option at the end of a CREATE TABLE Command:

Hive RC File Format Example

Below is the Hive CREATE TABLE command with storage format specification:

Create table RCfile_table (column_specs) stored as rcfile;

Hive RC File Format

RC files partitions the table first horizontly, and then verticly to serialize the data

Table 9.1 A table with four columns

C1	C2	C3	C4
11	12	13	14
21	22	23	24
31	32	33	34
41	42	43	44
51	52	53	54

Table 9.2 Table with two row groups

Row Group 1			
C1	C2	C3	C4
11	12	13	14
21	22	23	24
31	32	33	34

Row Group 2			
C1	C2	C3	C4
41	42	43	44
51	52	53	54

Table 9.3 Table in RCFile Format

Row Group 1	Row Group 2
11, 21, 31;	41, 51;
12, 22, 32;	42, 52;
13, 23, 33;	43, 53;
14, 24, 34;	44, 54;

Hive ORC File Format

- The ORC file stands for **Optimized Row Columnar** file format.
- The ORC file format provides a **highly efficient way to store data in Hive table**.
- This file system was actually designed to **overcome limitations of the other Hive file formats.**
- The Use of **ORC files improves performance** when **Hive is reading, writing, and processing data from large tables.**
- Due to their columnar storage format, they can **efficiently skip over irrelevant columns** when executing queries, leading to faster query performance.

Create ORC file by specifying '**STORED AS ORC**' option at the end of a CREATE TABLE Command.

Hive ORC File Format Examples

Below is the Hive CREATE TABLE command with storage format specification:

Create table orc_table (column_specs) stored as orc;

Hive Parquet File Format

- Parquet is a **column-oriented binary file format**.
- The parquet is **highly efficient for the types of large-scale queries**.
- Parquet is especially good for **queries scanning particular columns** within a particular table.
- The Parquet table uses compression **Snappy, gzip**; currently **Snappy by default**.

Create Parquet file by specifying 'STORED AS PARQUET' option at the end of a CREATE TABLE Command.

Hive Parquet File Format Example

Below is the Hive CREATE TABLE command with storage format specification:

Create table parquet_table (column_specs) stored as parquet;

Hive Parquet File Sample

File: C:\Users\ \Downloads\yellow_tripdata_2022-01.parquet

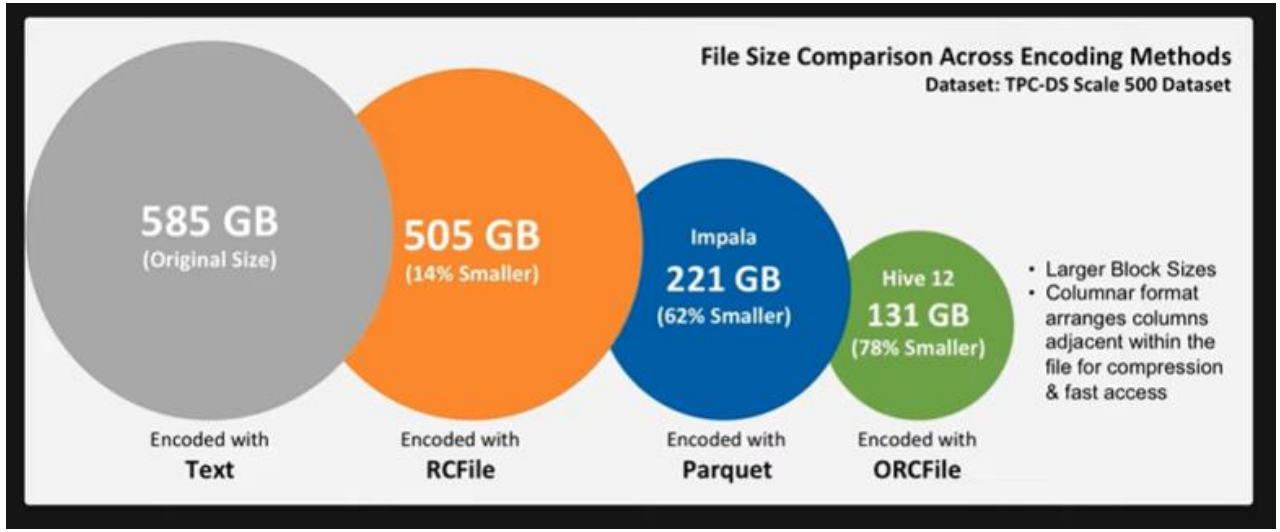
File Edit Tools Help

Filter Query (?): WHERE (tip_amount * 100) / fare_amount > 60 Execute Clear Record Offset: 0 Record Count: 1000

VendorID	fare_amount	tip_amount	tpep_pickup_datetime	tpep_dropoff_datetime	passenger_count	trip_distance	RatecodeID	store_and_f
2	21	15	2022-01-01 00:55:48.000	2022-01-01 01:14:24.000	1	6.67	1	N
1	7.5	20	2022-01-01 00:37:13.000	2022-01-01 00:44:46.000	1	1.9	1	N
1	5.5	4	2022-01-01 00:57:44.000	2022-01-01 01:02:34.000	0	0.9	1	N
2	4	10	2022-01-01 00:15:46.000	2022-01-01 00:17:41.000	2	0.6	1	N
2	5.5	15	2022-01-01 00:23:02.000	2022-01-01 00:28:20.000	1	0.75	1	N
1	3.5	3	2022-01-01 00:48:11.000	2022-01-01 00:50:08.000	1	0.4	1	N
2	5.5	5	2022-01-01 00:28:57.000	2022-01-01 00:34:16.000	1	0.67	1	N
2	6	4	2022-01-01 00:15:47.000	2022-01-01 00:21:18.000	1	1.27	1	N
1	6	20	2022-01-01 00:10:22.000	2022-01-01 00:15:53.000	2	1.2	1	N
2	3	2.04	2022-01-01 00:25:52.000	2022-01-01 00:27:12.000	1	0.26	1	N

Memory usage of different file types

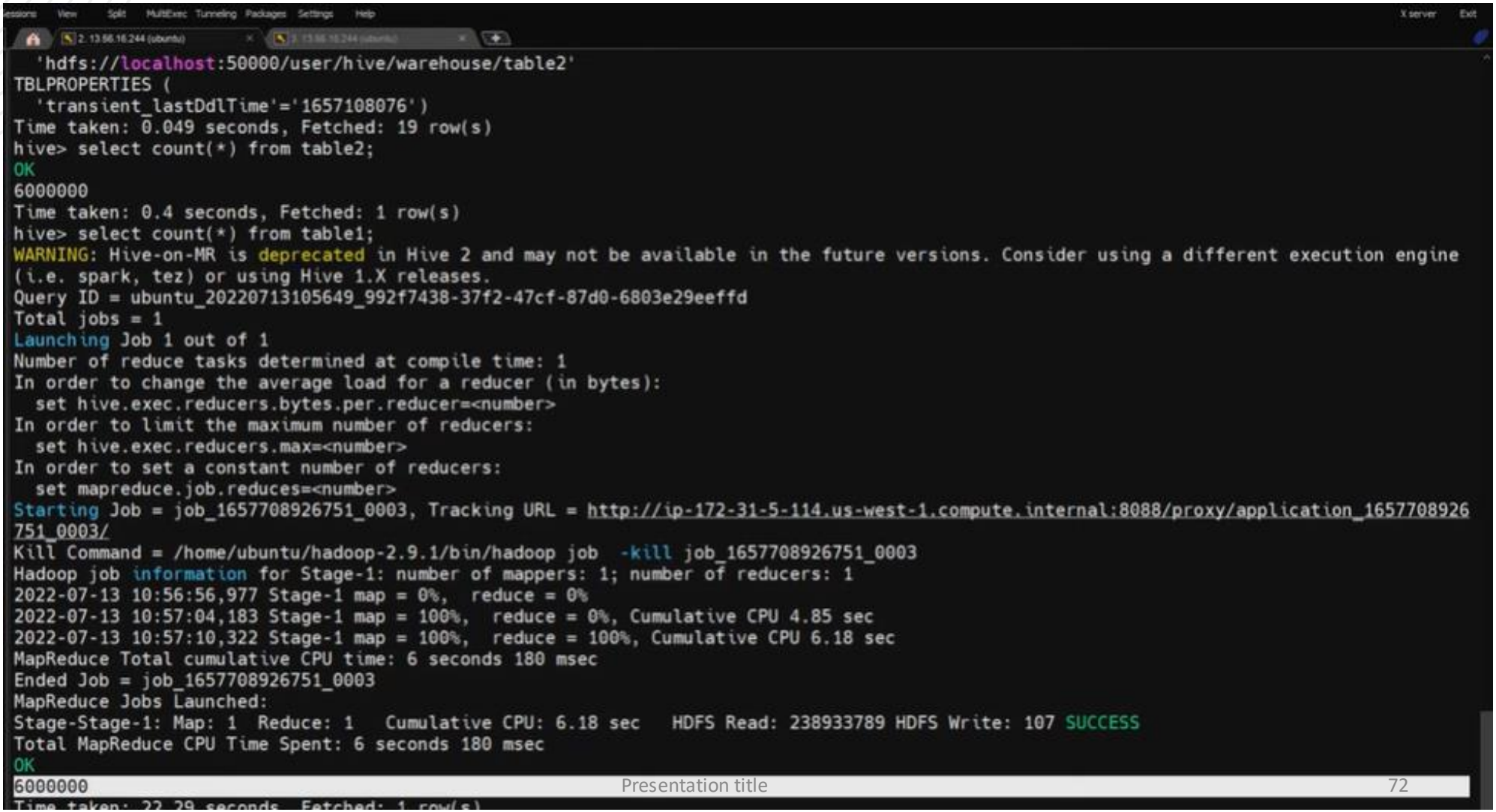
- ORC using “Columnar Format of Storage” .
- Columnar oriented storage is always faster than row-oriented storage.



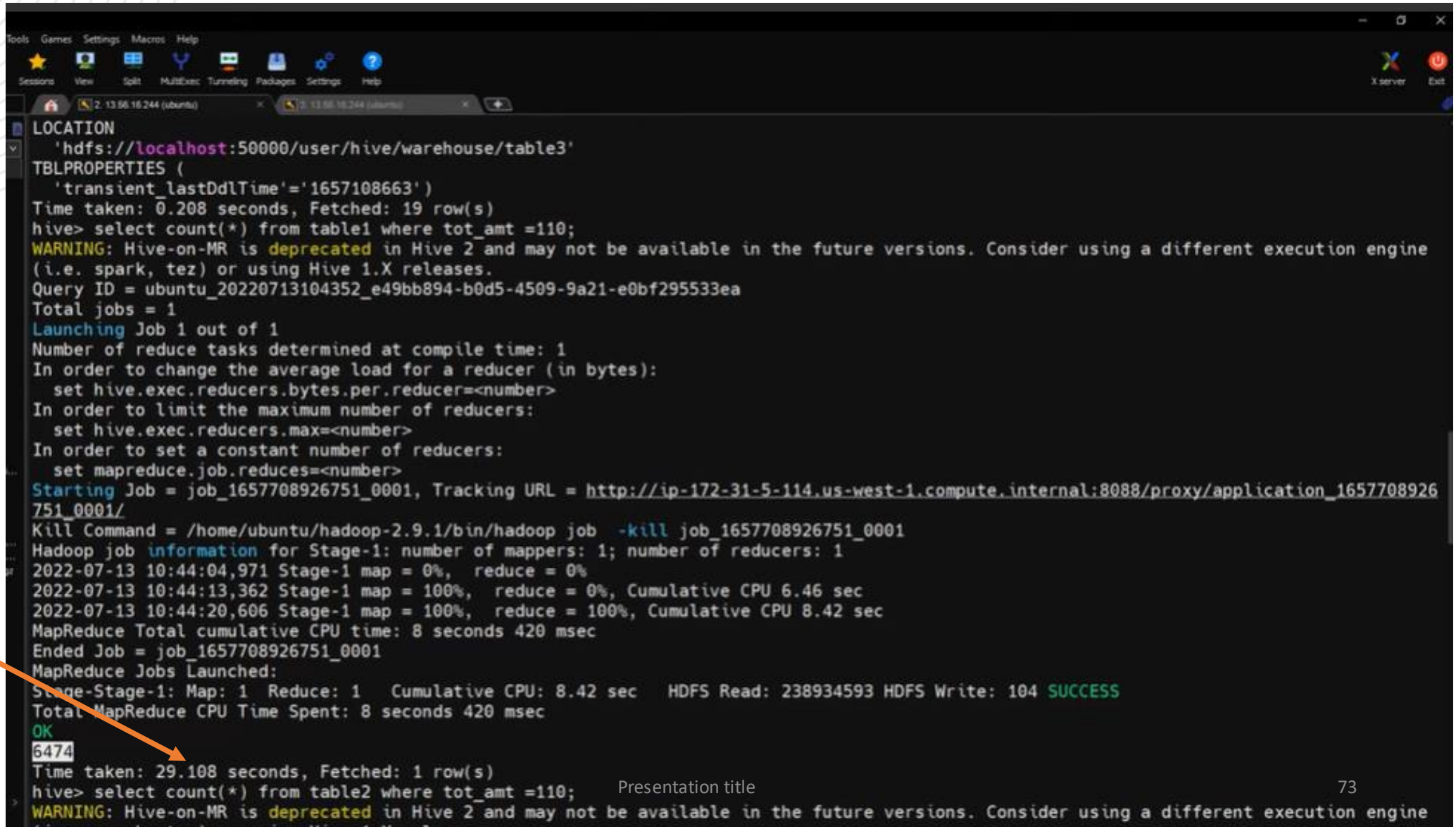
Example (File Format): Time Difference & volume of Data

```
create table table1(pid INT, pname STRING, drug STRING,gender STRING,tot_amt INT) row format delimited fields
terminated by ',' stored as textfile;

load data local inpath '/home/ubuntu/data_301.txt' into table table1;
load data local inpath '/home/ubuntu/data_301.txt' into table table1;


show create table table1;


================================

create table table2(pid INT, pname STRING, drug STRING,gender STRING,tot_amt INT)row format delimited fields
terminated by ',' STORED AS orc ;

insert overwrite table table2 select * from table1;

show create table table2;

select count(*) from table1 where tot_amt =110;
select count(*) from table2 where tot_amt =110;
```

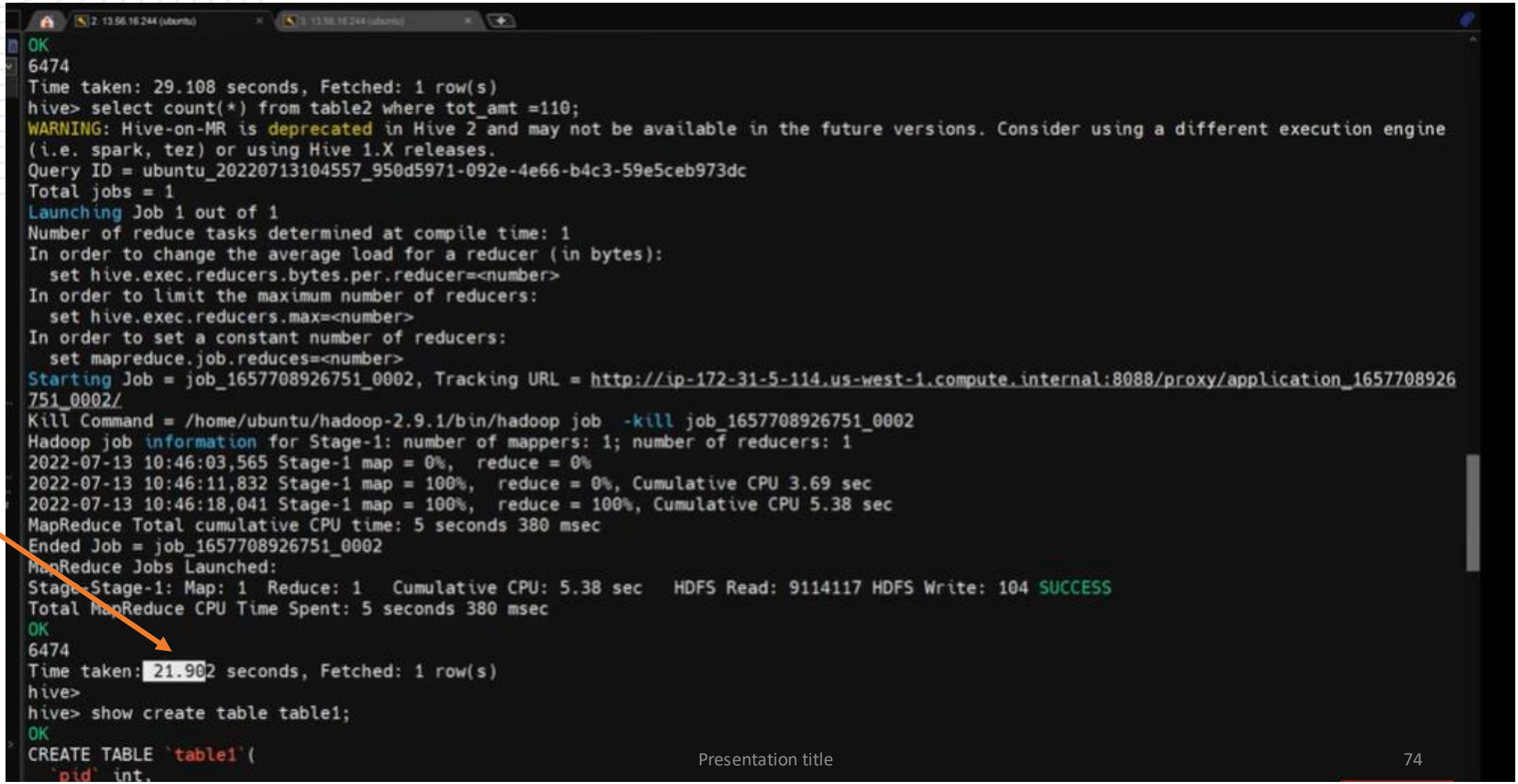
Table 1: Text Format (60lakh count)



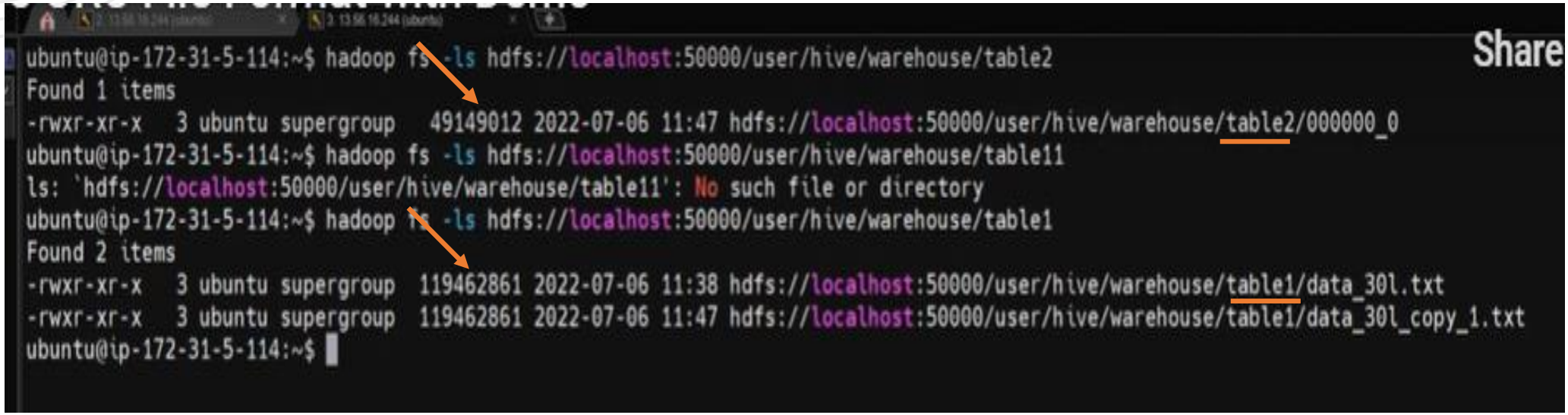
Text File Format:



ORC : Time Difference



Volume Compression of Text & ORC File Formats:



- 119462861 * 2 = 238,925,722 (Text format) [Table 1]
- 49149012 (ORC Format) [Table 2]

Apache Hive Command Line Options

Hive Command Line Option	Description
-d,–define <key=value>	Variable substitution to apply to Hive commands. e.g. -d A=B or –define A=B
-e <quoted-query-string>	Execute SQL from command line. e.g. -e 'select * from table1'
-f <filename>	Execute SQL from file. e.g. -f '/home/sql_file.sql'
-H,–help	Print Hive help information. Usually, print all command line options.

- SQL queries written in a file should be saved with .hql extension
- Silent Mode: without showing any progress or output information apart from the result set itself.

Hive Command Line Options Usage Examples

Execute query using hive command line options

```
$ hive -e 'select * from test';
```

Execute query using hive command line options in silent mode

```
$ hive -S -e 'select * from test'
```

Dump data to the file in silent mode

```
$hive -S -e 'select col from tab1' > a.txt
```

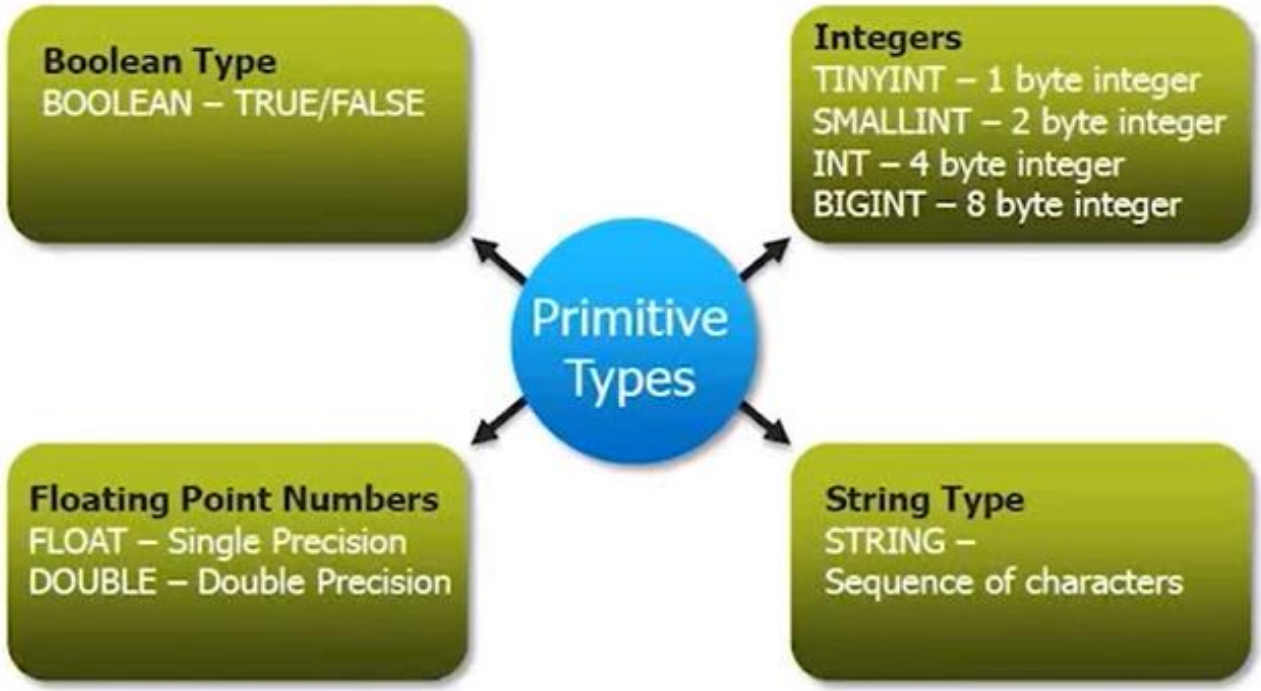
HIVE V/S RDBMS

SL.NO	Characteristics	HIVE	RDBMS
1	Record Leve Queries	No Update & Delete	Insert, Update & Delete
2	Transaction Support	No	Yes
3	Latency	Minutes or more	In fraction of seconds
4	Data Size	Petabytes	Terabytes
5	Data Per Query	Petabytes	Gigabytes
6	Query Language	HiveQL	SQL
7	Support JDB/ODBC	Limited	Full

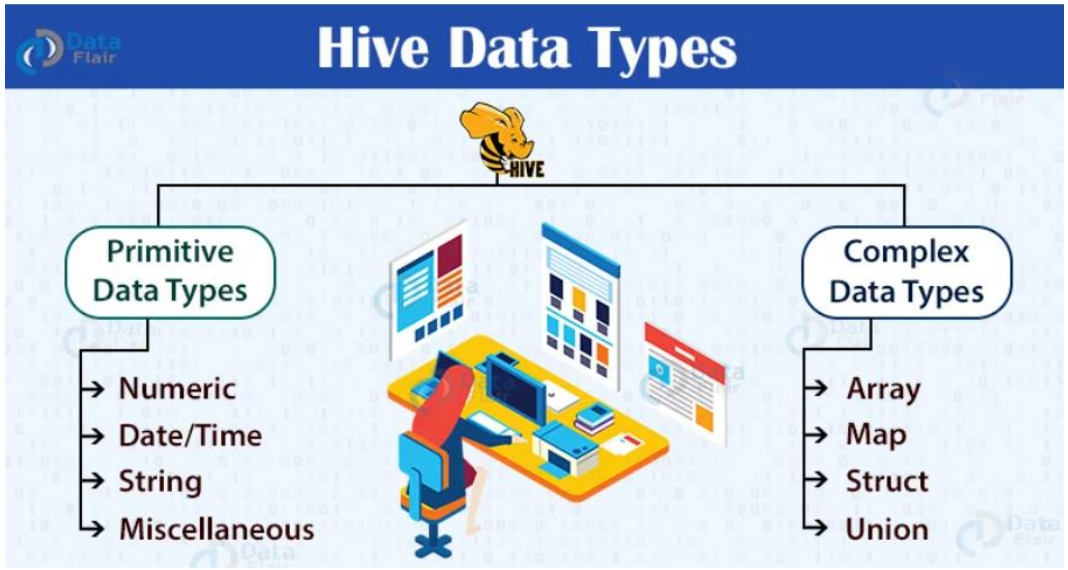
RDBMS V/S HIVE

- ✓ **Schema on Read vs Schema on Write**
  - ✓ **Hive does not verifies the data when it is loaded**, but rather when a query is issued.
  - ✓ Schema on read makes for a **very fast initial load**, since the data does not have to be read, parsed and serialized to disk in the database's internal format. The load operation is just a file copy or move.
- ✓ **No Updates, Transactions and Indexes.**

Data Types - Hive



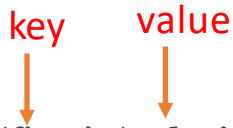
Collection Data Types:



Name	Description
STRUCT	Similar to 'C' struc, a collection of fields of different data types. An access to field uses dot notation. For example, struct ('a', 'b')
MAP	A collection of key-value pairs. Fields access using [] notation. For example, map ('key1', 'a', 'key2', 'b')
ARRAY	Ordered sequence of same types. Accesses to fields using array index. For example, array ('a', 'b')

- Map in Hive is a collection of key-value pairs, where the fields are accessed using array notations of keys (e.g., [‘key’]).

- **map<primitive_type, data_type>**



- **Example:** ‘first’ -> ‘John’, ‘last’ -> ‘Deo’, represented as map(‘first’, ‘John’, ‘last’, ‘Deo’). Now ‘John’ can be accessed with map[‘first’].

- STRUCT in Hive is similar to the STRUCT in C language. It is a record type that encapsulates a set of named fields, which can be any primitive data type.

- We can access the elements in STRUCT type using DOT (.) notation.

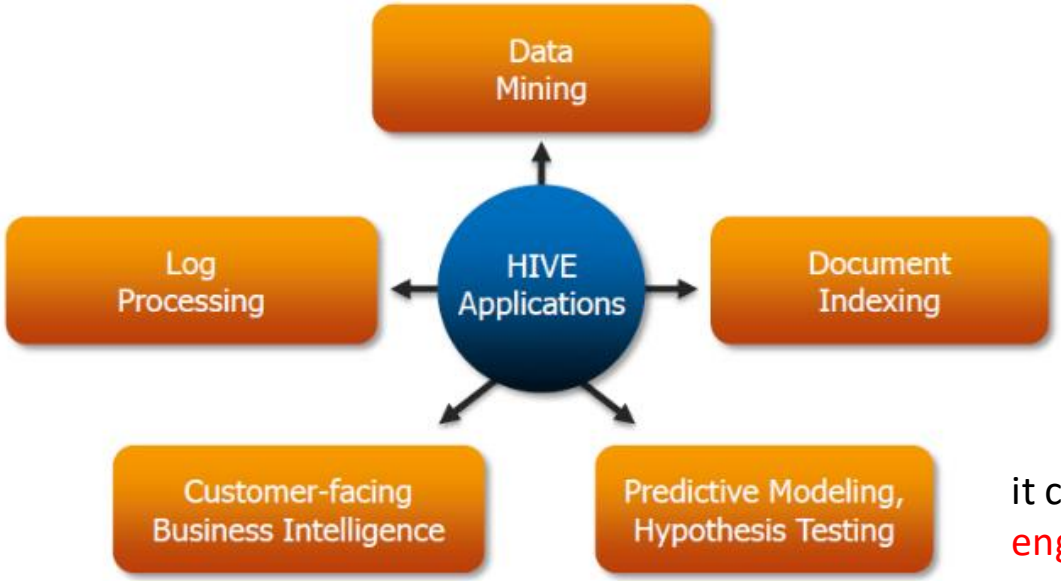
- STRUCT <col_name : data_type [COMMENT col_comment], ...>
- Example: For a column c3 of type STRUCT {c1 INTEGER; c2 INTEGER}, the c1 field is accessed by the expression c3.c1.

Built In Functions:

Return Type, Syntax & Description

BIGINT	round(double a)	Returns the rounded BIGINT (8 Byte integer) value of the 8 Byte double-precision floating point number a
BIGINT	floor(double a)	Returns the maximum BIGINT value that is equal to or less than the double.
BIGINT	ceil(double a)	Returns the minimum BIGINT value that is equal to or greater than the double.
double	rand(), rand(int seed)	Returns a random number (double) that distributes uniformly from 0 to 1 and that changes in each row. Integer seed ensured that random number sequence is deterministic.
string	concate(string str1, string str2, ...)	Returns the string resulting from concatenating str1 with str2, ...
string	substr(string str, int start)	Returns the substring of str starting from a start position till the end of string str.
string	substr(string str, int start, int length)	Returns the substring of str starting from the start position with the given length.
string	upper(string str), ucase (string str)	Returns the string resulting from converting all characters of str to upper case.
string	lower(string str), lcase(string str)	Returns the string resulting from converting all characters of str to lower case.
string	trim(string str)	Returns the string resulting from trimming spaces from both ends. trim ('12A34 56') returns '12A3456'
string	ltrim(string str); rtrim(string str)	Returns the string resulting from trimming spaces (only one end, left or right hand side or right-handside spaces trimmed). ltrim('12A34 56') returns '12A3456' and rtrim(' 12A34 56 ') returns '12A3456'.

Apache Hive – Applications



- Data Mining (If u want to identify Buying behaviour)
- Predictive Modeling (To enhance performance)
- Document Indexing
- Custom Facing UI

it can play a crucial role in the data preparation and feature engineering stages of the predictive modeling pipeline

Apache Hive Use Case – Facebook:

Facebook – Use Case

- **Objective – To store & process large amount of data.**
- **In 2007** , FB used **“Hadoop”** – To store and process the generated data. ETL (Via Python)
- But In Hadoop – **Programming became difficult**, as Hadoop default based is map reduce (java based), to **execute small query larger codes need to be written** (Structured Data type).
- As a solution, **Hive was developed by FB.**

- FB Stats: RDBMS was not suitable
- Hadoop usage Started
- 500 B/Day
- 70k Queries /Day
- 300 Million Photos /Day

Hive QL:

- HiveQL: Querying the large dataset which reside in the HDFS environment.
- HiveQL script commands enable data definition, data manipulation and query processing.
- Supports a large base of SQL users who are acquainted with SQL to "Extract information from data warehouse"

HiveQL : Data Definition Language

HiveQL database commands for data definition for DBs and Tables are CREATE DATABASE, SHOW DATABASE (list of all DBs), CREATE SCHEMA, CREATE TABLE. Following are HiveQL commands which create a table:

CREATE [TEMPORARY] [EXTERNAL] TABLE [IF NOT EXISTS] [<database name>.] <table name>

[(<column name> <data type> [COMMENT <column comment>], ...)]

[COMMENT <table comment>]

[ROW FORMAT <row format>]

[STORED AS <file format>]

DELIMITED	Specifies a delimiter at the table level for structured fields. This is default. Syntax: FIELDS TERMINATED BY, LINES TERMINATED BY
SERDE	Stands for Serializer/Deserializer. SYNTAX: SERDE 'serde.class.name'

Commands: DDL

- Commands : CREATE DATABASE, SHOW DATABASE, CREATE SCHEMA, CREATE TABLE

How do you create a database named toys_companyDB and table named toys_tbl?

SOLUTION

```
$HIVE_HOME/binhive – service cli
hive>set hive.cli.print.current.db=true;
hive> CREATE DATABASE toys_companyDB
hive>USE toys_companyDB
hive (toys_companyDB)> CREATE TABLE toys_tbl (
>puzzle_code STRING,
>pieces SMALLINT
>cost FLOAT);
hive (toys_company)> quit;
&ls/home/binadmin/Hive/warehouse/toys_companyDB.db
```

Partition: Reducing Query Processing Time

Assume that following file contains toys_tbl.

```
/table/toy_tbl/file1
Category, id, name, price
Toy_Airplane, 10725, Lost Temple, 1.25
Toy_Airplane, 31047, Propeller Plane, 2.10
Toy_Airplane, 31049, Twin Spin Helicopter, 3.45
Toy_Train, 31054, Blue Express, 4.25
Toy_Train, 10254, Winter Holiday Toy_Train, 2.75
```

A table *toy_tbl* contains many values for categories of toys. Query is required to identify all toy_airplane fields. Give reasons why partitioning reduces query processing time.

SOLUTION

Here, a table named toy_tbl contains several toy details (category, id, name and price). Suppose it is required to identify all the airplanes. A query searches the whole table for the required information. However, if a partition is created on the toy_tbl, based on category and stores it in a separate file, then it will reduce the query processing time.

Let the data partitions into two files, file 2 and file 3, using category.

```
/table/toys/toy_airplane/file2
toy_airplane, 10725, Lost Temple, TP, 1.25
toy_airplane, 31047, Propeller Plane, 2.10
toy_airplane, 31049, Lost Temple, 3.45
/table/toys/toy_train/file3
Toy_Train, 31054, Blue Express, 4.25
Toy_Train, 10254, Winter Holiday Toy_Train, 2.75
```

Partition : Advantages & Limitations

Advantages of Partition

1. Distributes execution load horizontally.
2. Query response time becomes faster when processing a small part of the data instead of searching the entire dataset.

Limitations of Partition

1. Creating a large number of partitions in a table leads to a large number of files and directories in HDFS, which is an overhead to NameNode, since it must keep all metadata for the file system in memory only.
2. Partitions may optimize some queries based on Where clauses, but they may be less responsive for other important queries on grouping clauses.
3. A large number of partitions will lead to a large number of tasks (which will run in separate JVM) in each MapReduce job, thus creating a lot of overhead in maintaining JVM start up and tear down (A separate task will be used for each file). The overhead of JVM start up and tear down can exceed the actual processing time in the worst case.

Bucketing:

A table *toy_tbl* contains many values for categories of toys. Assume the number of buckets to be
created = 5. Assume a table for `Toy_Airplane` of product code 10725.

1. How will the bucketing enforce?
2. How will the bucketed table partition `toy_airplane_10725` create five buckets?
3. How will the bucket column load into `toy_tbl`?
4. How will the bucket data display?

SOLUTION

#Enforce bucketing

```
set hive.enforce.bucketing=true;
```

#Create bucketed Table for toy_airplane of product code 10725 and create cluster of 5 buckets

```
CREATE TABLE IF NOT EXISTS
toy_airplane_10725(ProductCategory STRING,
ProductId INT, ProductName STRING, PrdocutMfgDate
YYYY-MM-DD, ProductPrice_US$ FLOAT) CLUSTERED BY
(Price) into 5 buckets;
```

Load data to bucketed table.

```
FROM toy_airplane_10725 INSERT OVERWRITE TABLE
toy_tbl SELECT ProductCategory, ProductId,
ProductName, PrdocutMfgDate, ProductPrice;
```

- To display the contents for Price_US$ selected for the ProductId from the second bucket.

Pres

```
SELECT DISTINCT ProductId FROM toy_tbl_buckets
TABLE FOR 10725(BUCKET 2 OUT OF 5 ON Price_US$);
```

Arithmetic Operators in Hive

Operators	Description
A + B	This is used to add A and B.
A - B	This is used to subtract B from A.
A * B	This is used to multiply A and B.
A / B	This is used to divide A and B and returns the quotient of the operands.
A % B	This returns the remainder of A / B.
A | B	This is used to determine the bitwise OR of A and B.
A & B	This is used to determine the bitwise AND of A and B.
A ^ B	This is used to determine the bitwise XOR of A and B.
~A	This is used to determine the bitwise NOT of A.

hive> select id, name, salary + 50 from employee;

hive> select id, name, salary - 50 from employee;

hive> select id, name, (salary * 10) /100 from employee;

Relational Operators in Hive

Operator	Description
A=B	It returns true if A equals B, otherwise false.
A <> B, A !=B	It returns null if A or B is null; true if A is not equal to B, otherwise false.
A<B	It returns null if A or B is null; true if A is less than B, otherwise false.
A>B	It returns null if A or B is null; true if A is greater than B, otherwise false.
A<=B	It returns null if A or B is null; true if A is less than or equal to B, otherwise false.
A>=B	It returns null if A or B is null; true if A is greater than or equal to B, otherwise false.
A IS NULL	It returns true if A evaluates to null, otherwise false.
A IS NOT NULL	It returns false if A evaluates to null, otherwise true.

hive> select * from employee where salary >= 25000;

hive> select * from employee where salary < 25000;

Aggregate Functions in Hive

In Hive, the aggregate function returns a single value resulting from computation over many rows. Let''s see some commonly used aggregate functions: -

Return Type	Operator	Description
BIGINT	count(*)	It returns the count of the number of rows present in the file.
DOUBLE	sum(col)	It returns the sum of values.
DOUBLE	sum(DISTINCT col)	It returns the sum of distinct values.
DOUBLE	avg(col)	It returns the average of values.
DOUBLE	avg(DISTINCT col)	It returns the average of distinct values.
DOUBLE	min(col)	It compares the values and returns the minimum one form it.
DOUBLE	max(col)	It compares the values and returns the maximum one form it.

HIVE V/S HBASE

Hive	HBase
Hive is a query engine.	Hbase is data storage mainly for unstructured data.
Hive allows most of the SQL queries.	HBase does not allow SQL queries.
Hive is mainly used for batch processing.	Hbase is mainly used for transactional processing.
Hive is not real-time processing.	HBase is real-time processing.
Hive is only used for analytical queries.	HBase is used for real-time querying.
Hive runs on the top of MapReduce.	HBase runs on the top of HDFS (Hadoop distributed file system).
Hive is not a full database. It is a data warehouse framework	HBase supports the NoSQL database.
Hive provides SQL features to Spark/Hadoop data.	HBase is used to store and process Hadoop data in real-time.
Hive has a schema model.	HBase is free from the schema model.
Hive is made for high latency operations.	HBase is made for low-level latency operations.
Hive is not suited for real-time querying.	HBase is used for real-time querying of Big Data.


Thank you