HIVE

The easy approach

Training by- Sudhanshu Saxena(er_sudhanshusaxena@yahoo.com)

Agenda

In this session, you will learn about:

- Analytical OLAP - Data warehousing with Apache Hive
- What is Hive?
- Hive Query Language
- Background of Hive
- Hive Installation and Configuration
- Hive Architecture
- Hive Data Types
- Hive Data Model
- Hive Practical
- Partitions and Buckets
- Joins
- Limitations of Hive
- SQL vs. Hive

Why Another Data Warehousing System?

- Problem : Data, data and more data
  - Several TBs of data everyday
- The Hadoop Experiment:
  - Uses Hadoop File System (HDFS)
  - Scalable/Available
- Problem
  - Lacked Expressiveness
  - Map-Reduce hard to program
- Solution : HIVE

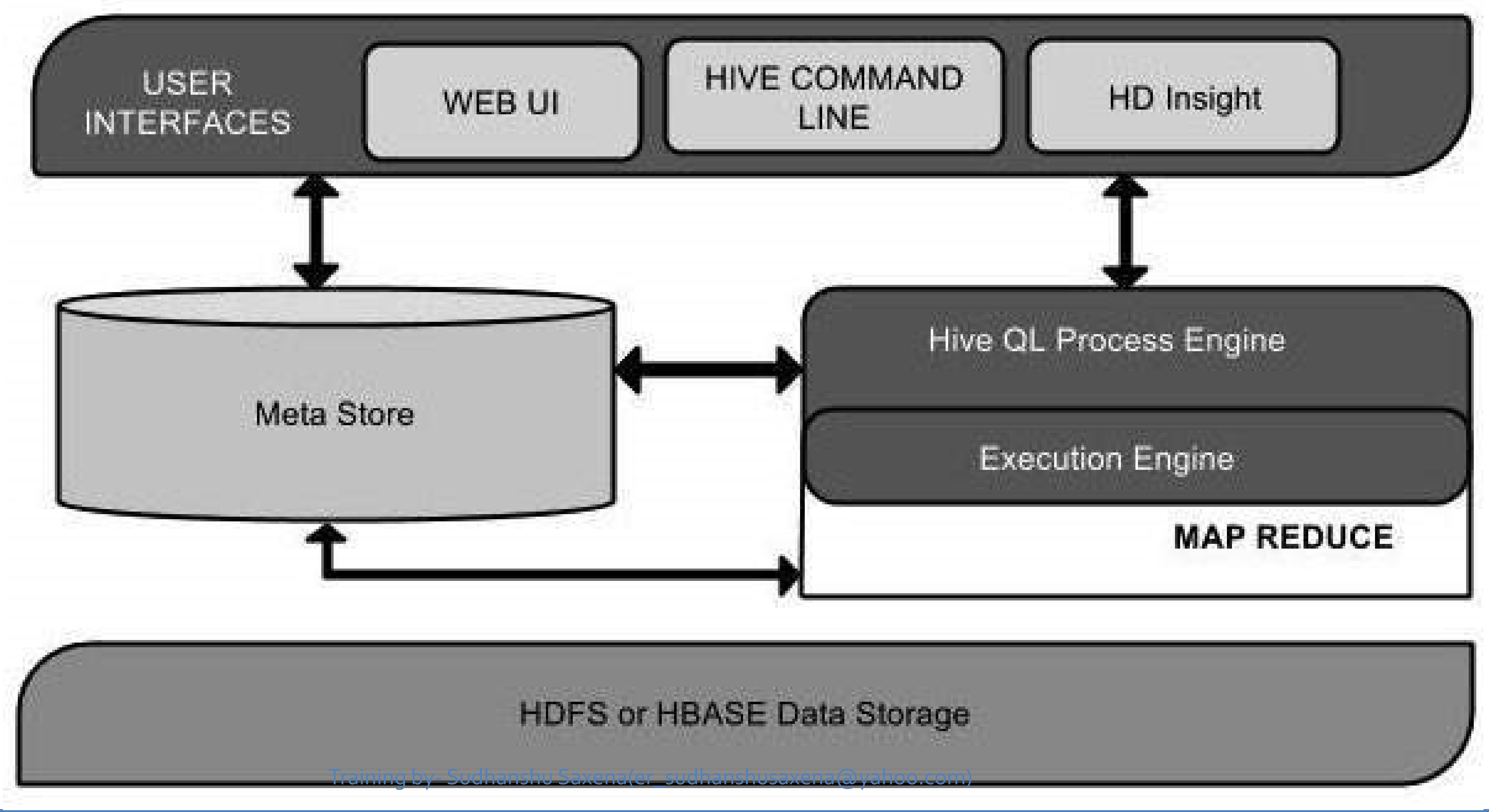
What Is Hive?

- Developed by Facebook and a top-level Apache project
- A data warehousing infrastructure based on Hadoop
- Immediately makes data on a cluster available to non-Java programmers via SQL like queries
- Built on HiveQL (HQL), a SQL-like query language
- Interprets HiveQL and generates MapReduce jobs that run on the cluster
- Enables easy data summarization, ad-hoc reporting and querying, and analysis of large volumes of data

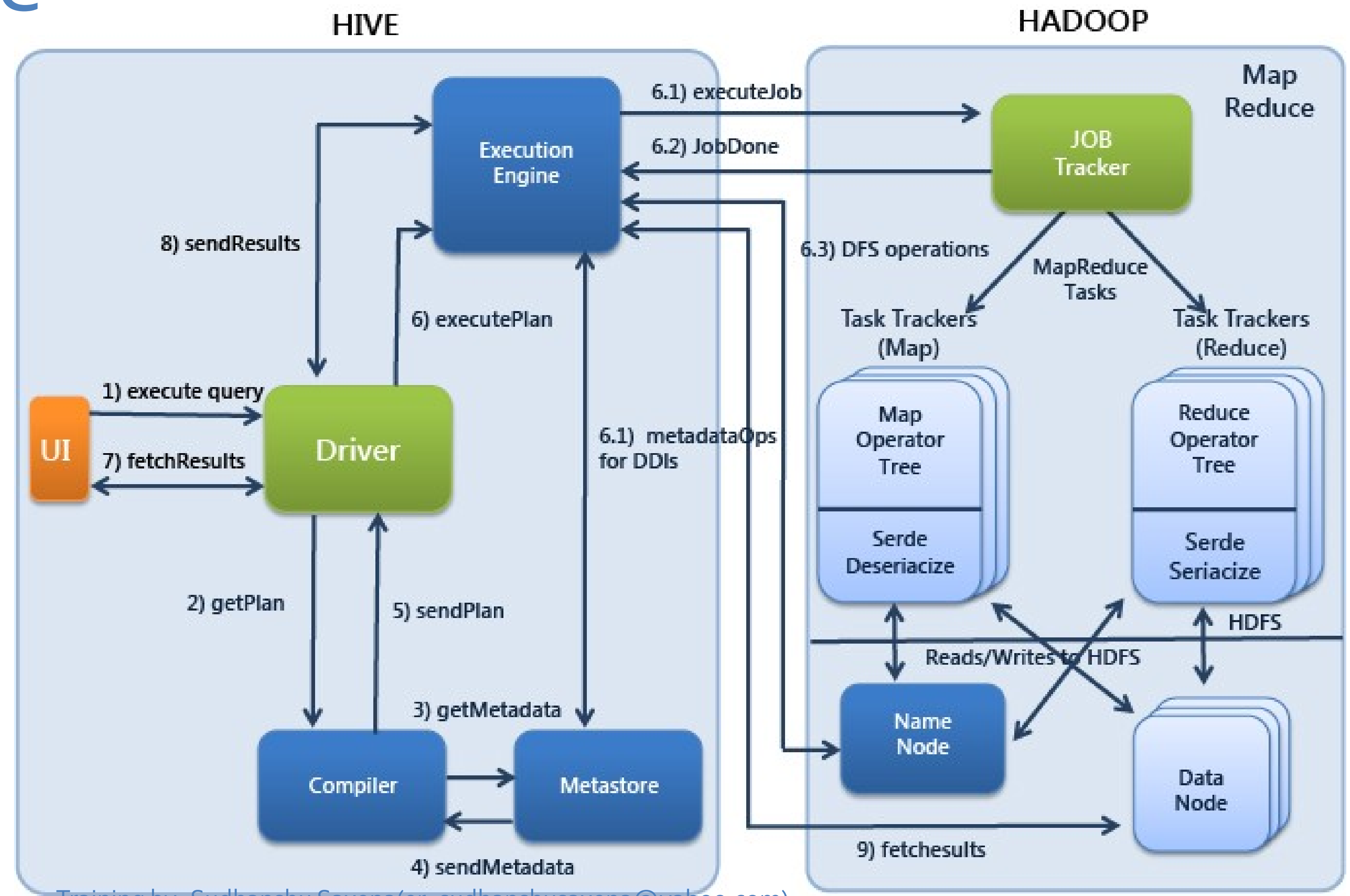
What Hive Is Not

- Hive, like Hadoop, is designed for batch processing of large datasets
- Not an OLTP or real-time system
- Latency and throughput are both high compared to a traditional RDBMS
  - Even when dealing with relatively small data (<100 MB)

Hive Architecture



Working of Hive



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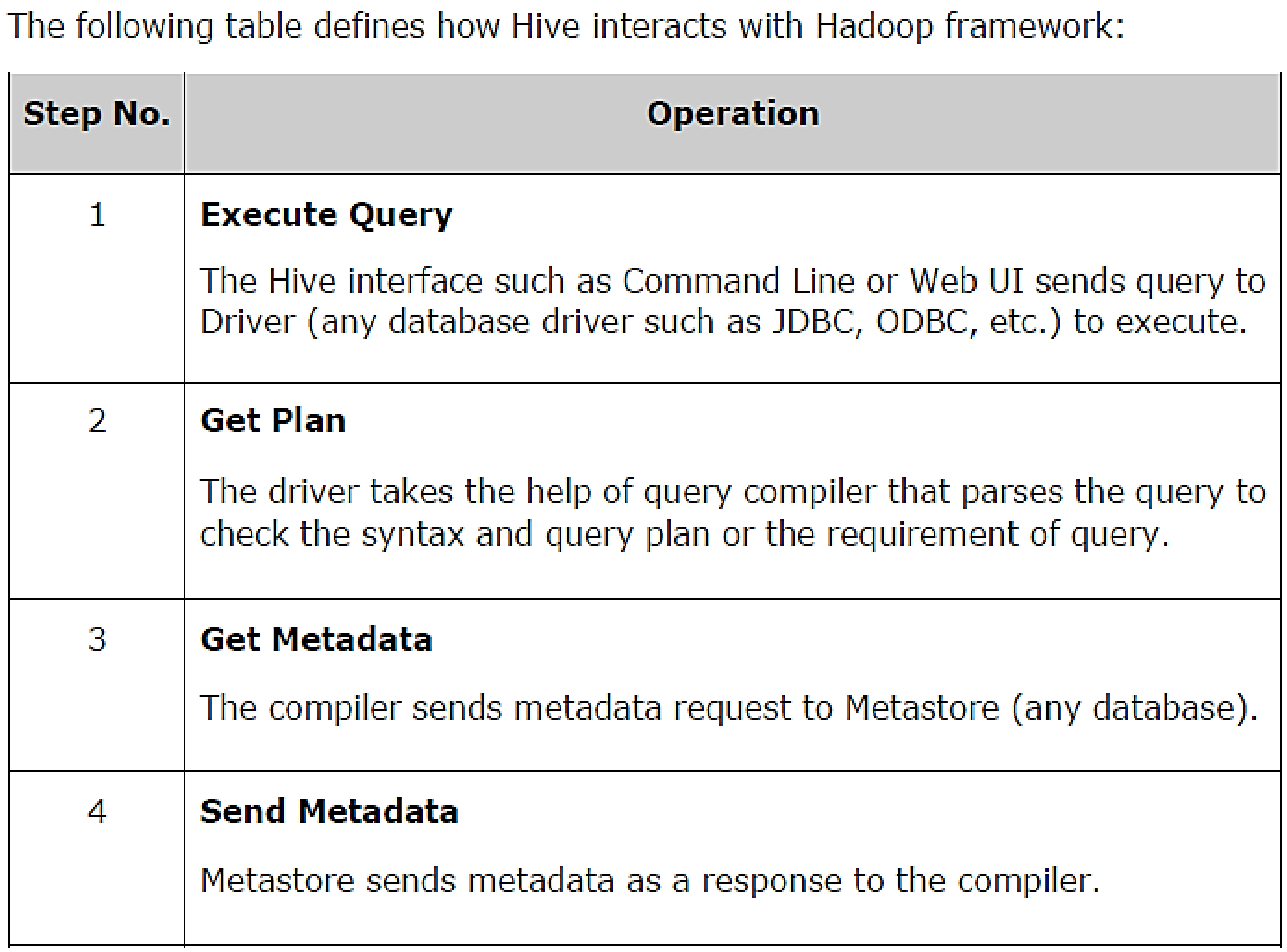
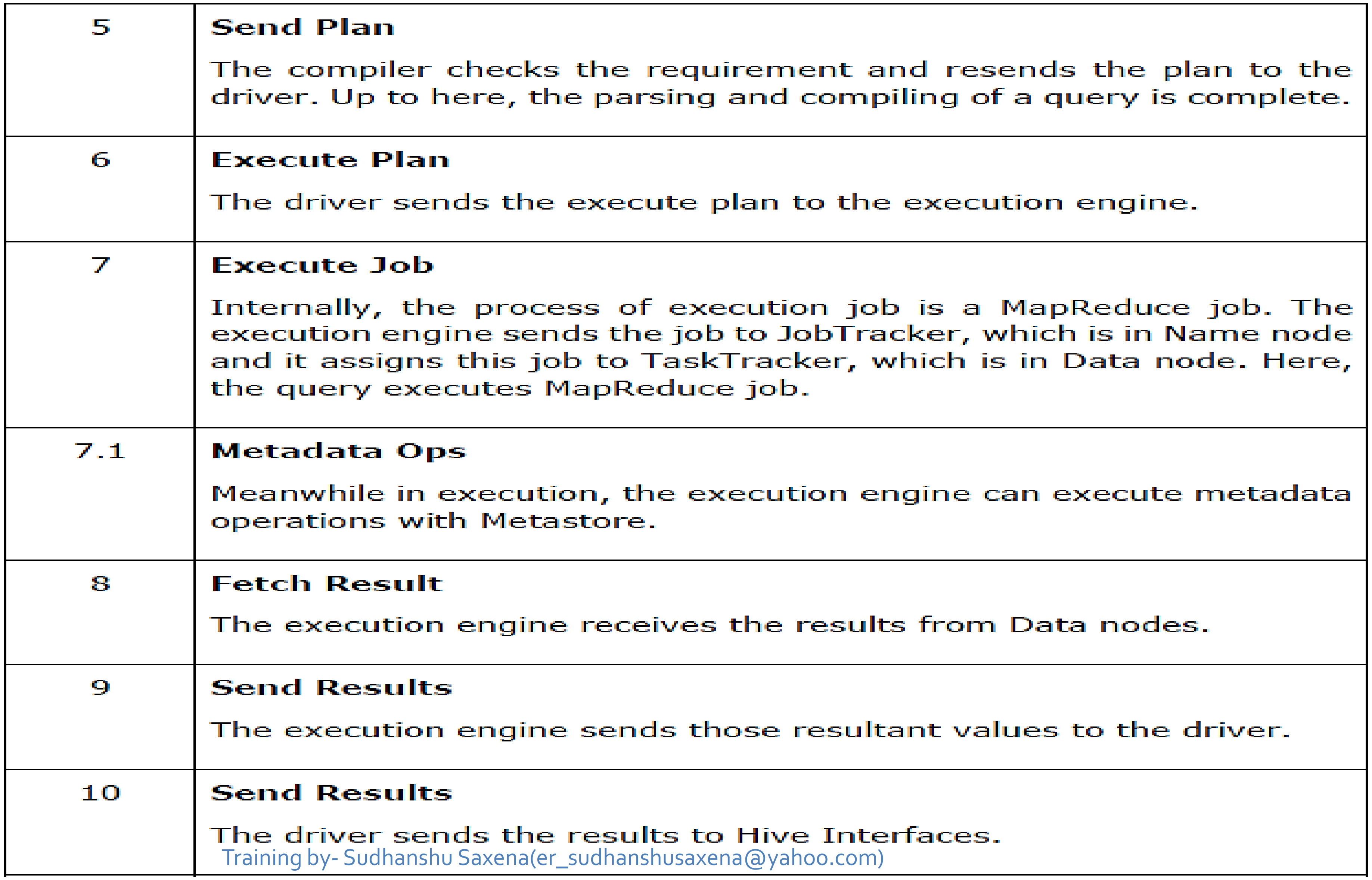


The following table defines how Hive interacts with Hadoop framework:

Step No.	Operation
1	**Execute Query** The Hive interface such as Command Line or Web UI sends query to Driver (any database driver such as JDBC, ODBC, etc.) to execute.
2	**Get Plan** The driver takes the help of query compiler that parses the query to check the syntax and query plan or the requirement of query.
3	**Get Metadata** The compiler sends metadata request to Metastore (any database).
4	**Send Metadata** Metastore sends metadata as a response to the compiler.

Working of Hive



5	**Send Plan** The compiler checks the requirement and resends the plan to the driver. Up to here, the parsing and compiling of a query is complete.
6	**Execute Plan** The driver sends the execute plan to the 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. Here, the query executes MapReduce job.
7.1	**Metadata Ops** Meanwhile in execution, the execution engine can execute metadata operations with Metastore.
8	**Fetch Result** The execution engine receives the results from Data nodes.
9	**Send Results** The execution engine sends those resultant values to the driver.
10	**Send Results** The driver sends the results to Hive Interfaces.

Data Model- Tables

- Tables
  - Analogous to tables in relational DBs.
  - Each table has corresponding directory in HDFS.
  - Example
    - Page view table name – pvs
    - HDFS directory
      - /wh/pvs
- Example:

  CREATE TABLE t1(ds string, ctry float, li list<map<string, struct<p1:int, p2:int>>);

Data Model - Partitions

- Partitions
  - Analogous to dense indexes on partition columns
  - Nested sub-directories in HDFS for each combination of partition column values.
  - Allows users to efficiently retrieve rows
  - Example
    - Partition columns: ds, ctry
    - HDFS for ds=20120410, ctry=US
      - /wh/pvs/ds=20120410/ctry=US
    - HDFS for ds=20120410, ctry=IN
      - /wh/pvs/ds=20120410/ctry=IN

Data Hierarchy

- Hive is organised hierarchically into:
  - Databases: namespaces that separate tables and other objects
  - Tables: homogeneous units of data with the same schema
    - Analogous to tables in an RDBMS
  - Partitions: determine how the data is stored
    - Allow efficient access to subsets of the data
  - Buckets/clusters
    - For subsampling within a partition
    - Join optimization

HiveQL

- HiveQL / HQL provides the basic SQL-like operations:
  - Select columns using SELECT
  - Filter rows using WHERE
  - JOIN between tables
  - Evaluate aggregates using GROUP BY
  - Store query results into another table
  - Download results to a local directory (i.e., export from HDFS)
  - Manage tables and queries with CREATE, DROP, and ALTER

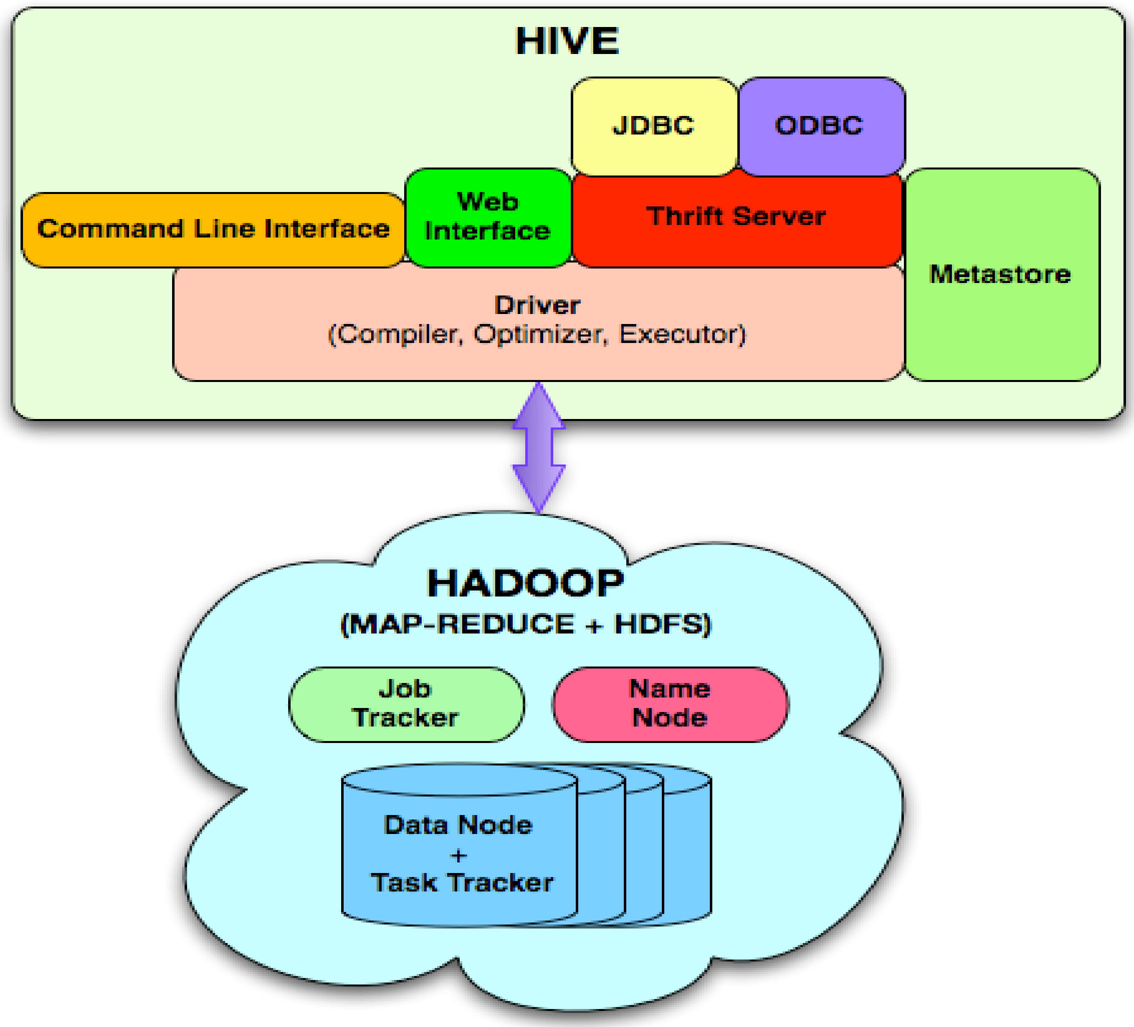
Primitive Data Types

Type	Comments
TINYINT, SMALLINT, INT, BIGINT	1, 2, 4 and 8-byte integers
BOOLEAN	TRUE/FALSE
FLOAT, DOUBLE	Single and double precision real numbers
STRING	Character string
TIMESTAMP	Unix-epoch offset *or* datetime string
DECIMAL	Arbitrary-precision decimal
BINARY	Opaque; ignore these bytes

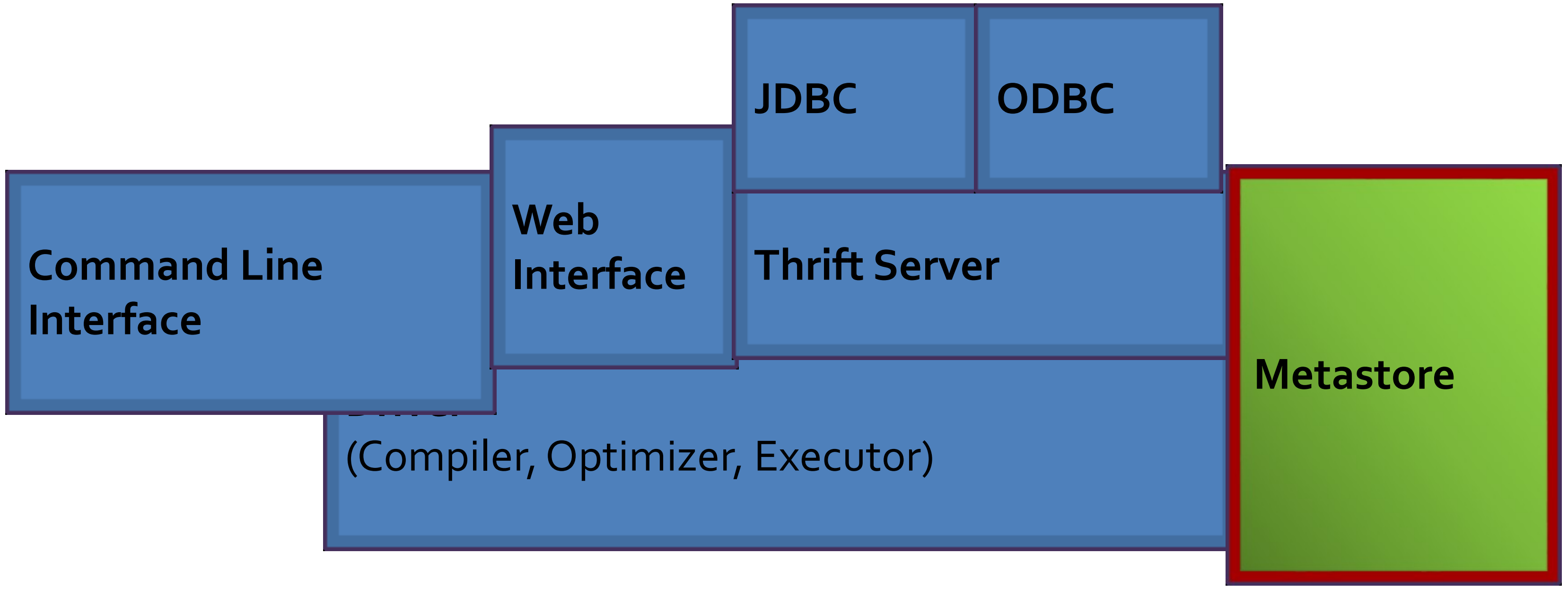
Complex Data Types

Type	Comments
STRUCT	A collection of elements If S is of type STRUCT {a INT, b INT}: S.a returns element a
MAP	Key-value tuple If M is a map from 'group' to GID: M['group'] returns value of GID
ARRAY	Indexed list If A is an array of elements ['a','b','c']: A[o] returns 'a'

System Architecture and Components



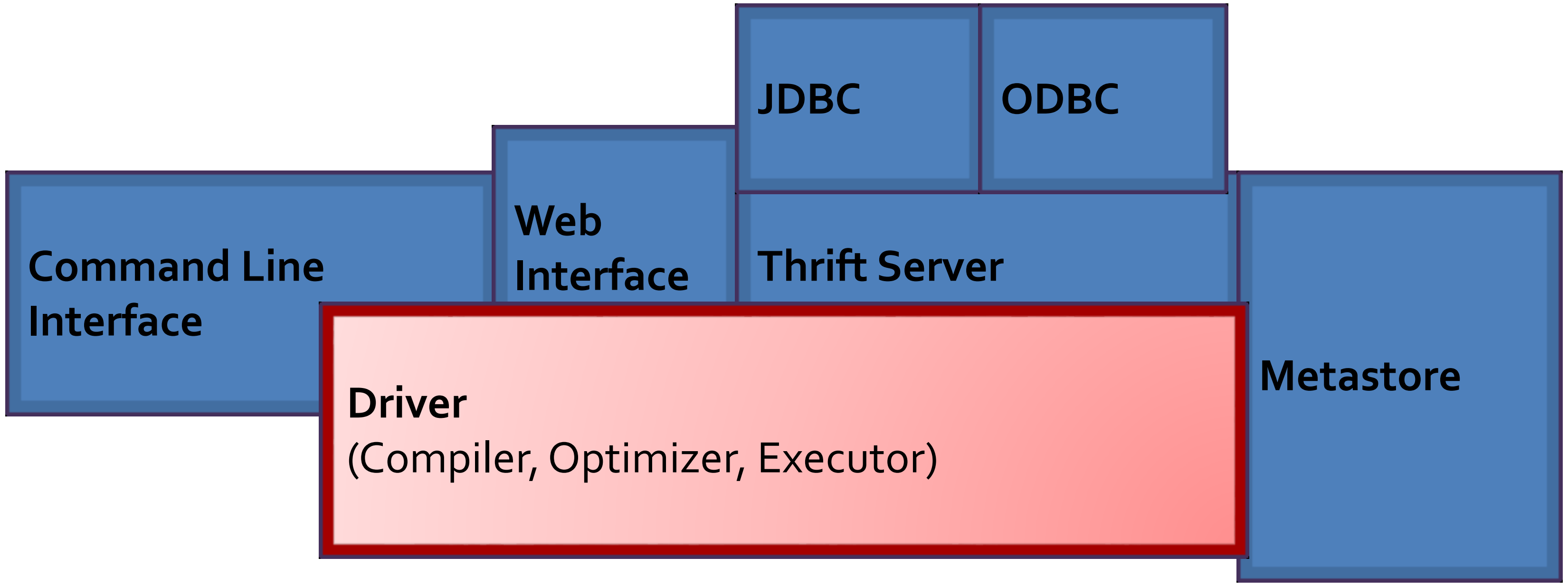
System Architecture and Components



Metastore

- The component that store the system catalog and meta data about tables, columns, partitions etc.
- Stored on a traditional RDBMS

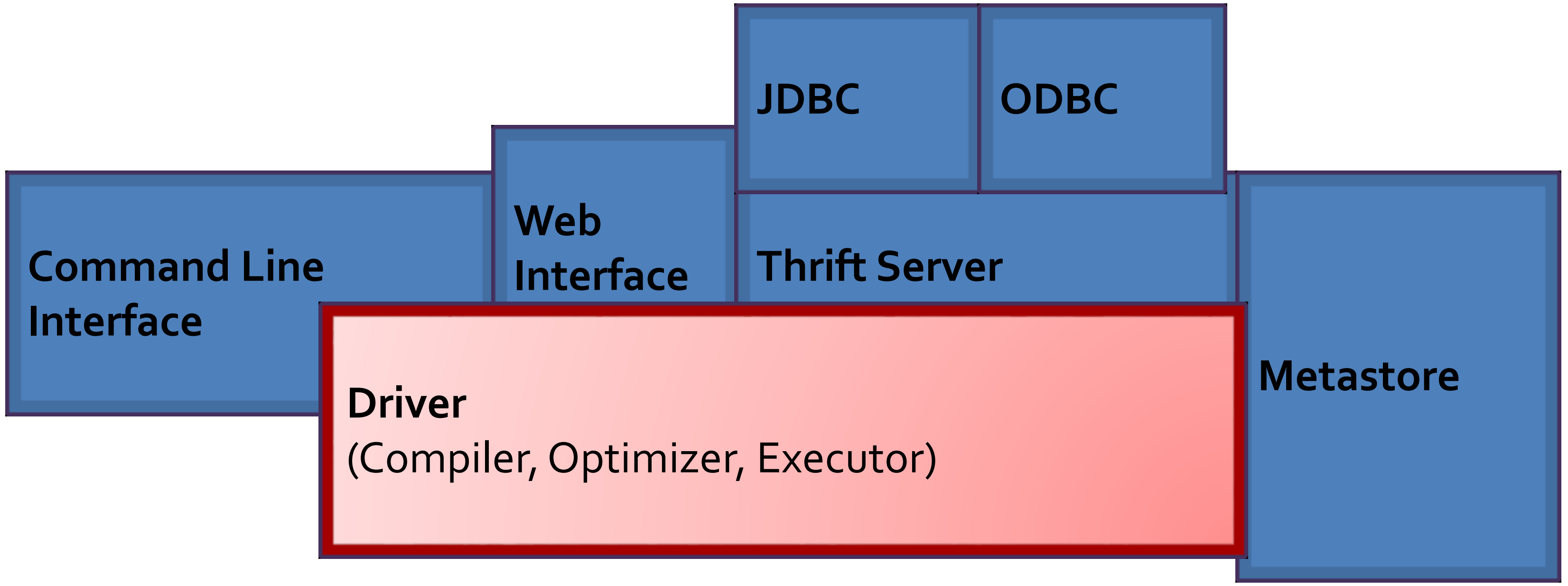
System Architecture and Components



- Driver

  The component that manages the lifecycle of a HiveQL statement as it moves through Hive. The driver also maintains a session handle and any session statistics.

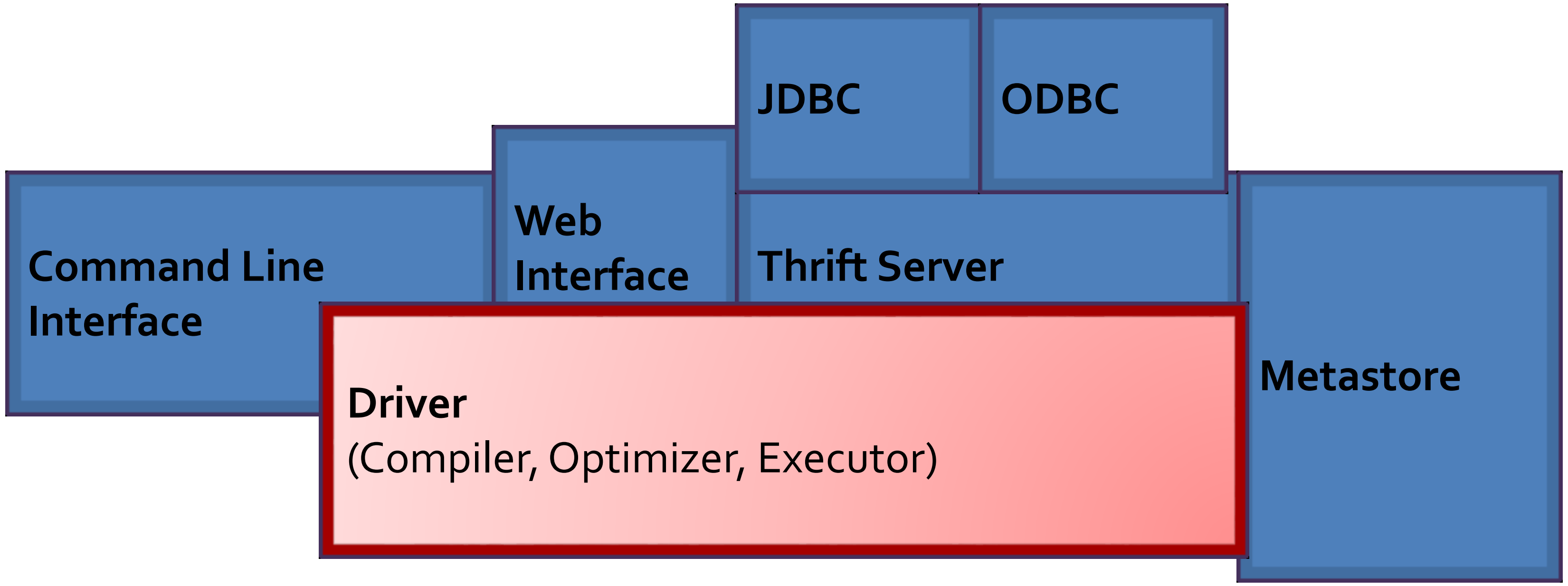
System Architecture and Components



- Query Compiler

  The component that compiles HiveQL into a directed acyclic graph of map/reduce tasks.

System Architecture and Components

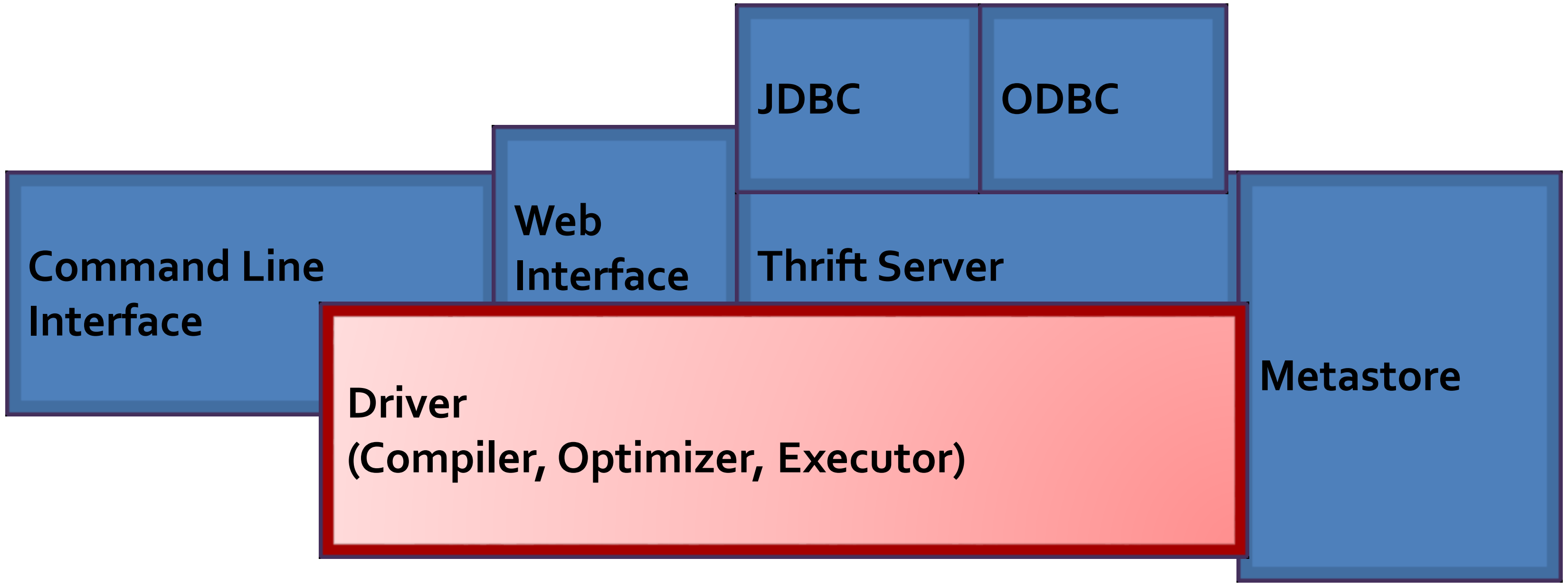


•Optimizer

consists of a chain of transformations such that the operator DAG resulting from one transformation is passed as input to the next transformation

Performs tasks like Column Pruning , Partition Pruning, Repartitioning of Data

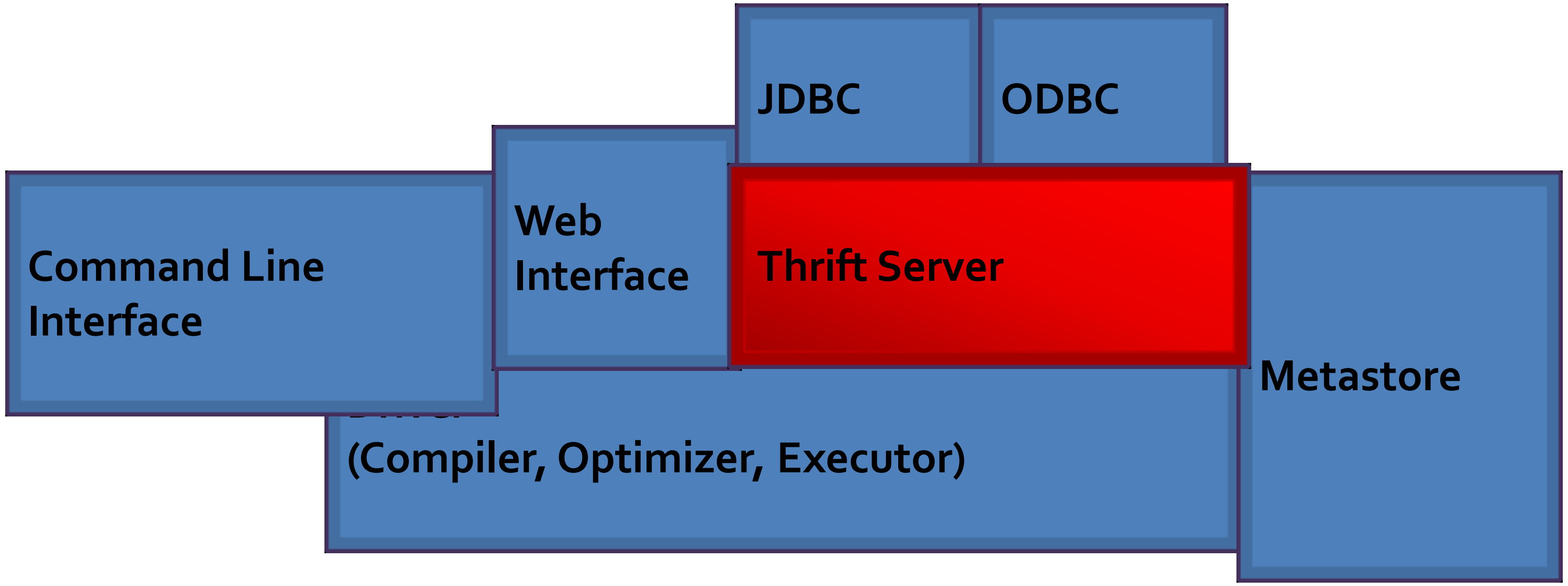
System Architecture and Components



- Execution Engine

  The component that executes the tasks produced by the compiler in proper dependency order. The execution engine interacts with the underlying Hadoop instance.

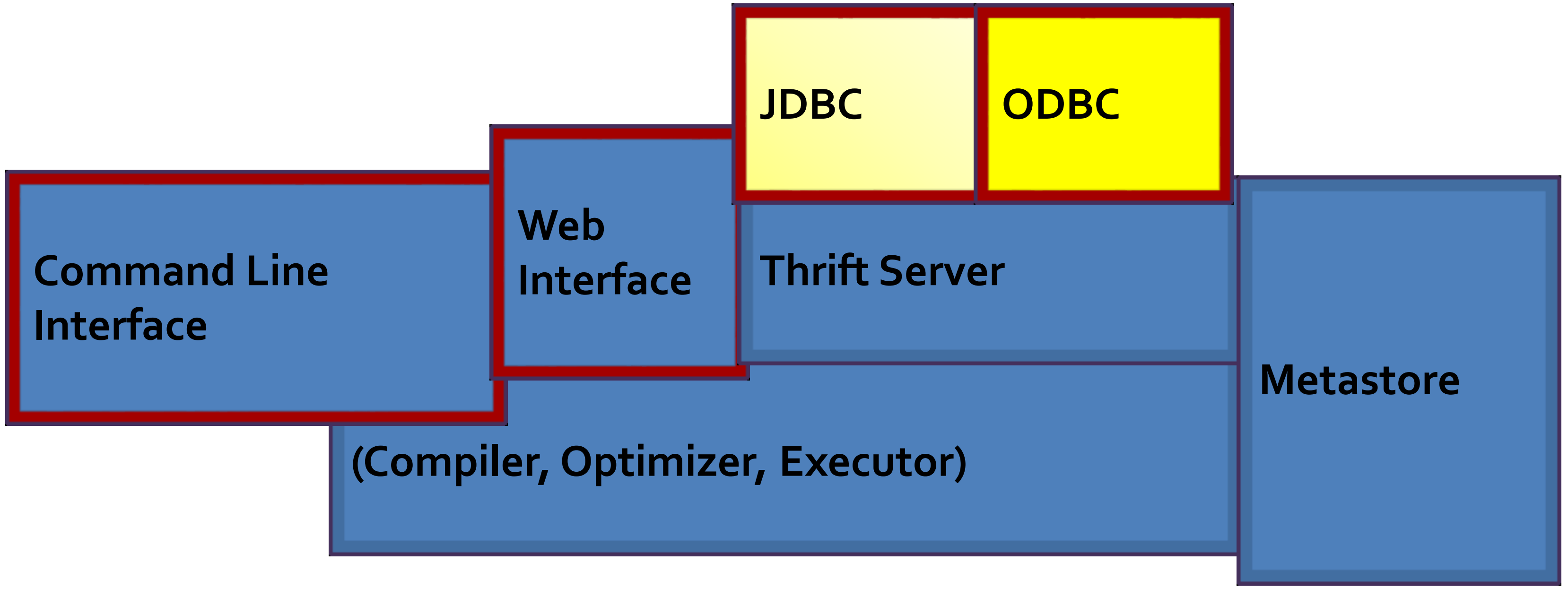
System Architecture and Components



- HiveServer

  The component that provides a trift interface and a JDBC/ODBC server and provides a way of integrating Hive with other applications.

System Architecture and Components



- Client Components

  Client component like Command Line Interface(CLI), the web UI and JDBC/ODBC driver.

Hive Metastore

- Stores Hive metadata
- Default metastore database uses Apache Derby
- Various configurations:
  - Embedded (in-process metastore, in-process database)
    - Mainly for unit tests
  - Local (in-process metastore, out-of-process database)
    - Each Hive client connects to the metastore directly
  - Remote (out-of-process metastore, out-of-process database)
    - Each Hive client connects to a metastore server, which connects to the metadata database itself

Hive Warehouse

- Hive tables are stored in the Hive “warehouse”
  - Default HDFS location: /user/hive/warehouse
- Tables are stored as sub-directories in the warehouse directory
- Partitions are subdirectories of tables
- External tables are supported in Hive
- The actual data is stored in flat files

Hive Schemas

- Hive is schema-on-read
  - Schema is only enforced when the data is read (at query time)
  - Allows greater flexibility: same data can be read using multiple schemas
- Contrast with an RDBMS, which is schema-on-write
  - Schema is enforced when the data is loaded
  - Speeds up queries at the expense of load times

Sample Select Clauses

- Select from a single table

```
    SELECT *
        FROM sales
        WHERE amount > 10 AND
                    region = "US";
```

- Select from a partitioned table

```
    SELECT page_views.*
  FROM page_views
  WHERE page_views.date >= '2008-03-01' AND
      page_views.date <= '2008-03-31'
```

Create Table Syntax

```
CREATE TABLE table_name
    (col1 data_type,
     col2 data_type,
     col3 data_type,
     col4 datatype )
   ROW FORMAT DELIMITED
   FIELDS TERMINATED BY ','
   STORED AS format_type;
```

Simple Table

```
CREATE TABLE page_view
    (viewTime INT,
     userid BIGINT,
     page_url STRING,
     referrer_url STRING,
     ip STRING COMMENT 'IP Address of the User' )
   ROW FORMAT DELIMITED
   FIELDS TERMINATED BY '\t'
   STORED AS TEXTFILE;
```

More Complex Table

```
CREATE TABLE employees  (
    (name STRING,
    salary FLOAT,
    subordinates ARRAY<STRING>,
    deductions MAP<STRING, FLOAT>,
    address STRUCT<street:STRING,
                 city:STRING,
                 state:STRING,
                 zip:INT>)
  ROW FORMAT DELIMITED
  FIELDS TERMINATED BY '\t'
  STORED AS TEXTFILE;
```

External Table

```
CREATE EXTERNAL TABLE page_view_stg
    (viewTime INT,
     userid BIGINT,
     page_url STRING,
     referrer_url STRING,
     ip STRING COMMENT 'IP Address of the User')
   ROW FORMAT DELIMITED
   FIELDS TERMINATED BY '\t'
   STORED AS TEXTFILE
   LOCATION '/user/staging/page_view';
```

More About Tables

- CREATE TABLE
  - LOAD: file moved into Hive's data warehouse directory
  - DROP: both metadata and data deleted
- CREATE EXTERNAL TABLE
  - LOAD: no files moved
  - DROP: only metadata deleted
  - Use this when sharing with other Hadoop applications, or when you want to use multiple schemas on the same data

Partitioning

- Can make some queries faster
- Divide data based on partition column
- Use PARTITION BY clause when creating table
- Use PARTITION clause when loading data
- SHOW PARTITIONS will show a table's partitions

Bucketing

- Can speed up queries that involve sampling the data
  - Sampling works without bucketing, but Hive has to scan the entire dataset
- Use CLUSTERED BY when creating table
  - For sorted buckets, add SORTED BY
- To query a sample of your data, use TABLESAMPLE

Browsing Tables And Partitions

Command	Comments
`SHOW TABLES;`	Show all the tables in the database
`SHOW TABLES 'page.*';`	Show tables matching the specification (uses regex syntax)
`SHOW PARTITIONS page_view;`	Show the partitions of the page_view table
`DESCRIBE page_view;`	List columns of the table
`DESCRIBE EXTENDED page_view;`	More information on columns (useful only for debugging)
`DESCRIBE page_view PARTITION (ds='2008-10-31');`	List information about a partition

Loading Data

- Use LOAD DATA to load data from a file or directory
  - Will read from HDFS unless LOCAL keyword is specified
  - Will append data unless OVERWRITE specified
  - PARTITION required if destination table is partitioned

```
LOAD DATA LOCAL INPATH '/tmp/pv_2008-06-8_us.txt'
  OVERWRITE INTO TABLE page_view
  PARTITION (date='2008-06-08', country='US')
```

Inserting Data

- Use INSERT to load data from a Hive query
  - Will append data unless OVERWRITE specified
    - PARTITION required if destination table is partitioned

```
FROM page_view_stg pvs
 INSERT OVERWRITE TABLE page_view
 PARTITION (dt='2008-06-08', country='US')
  SELECT pvs.viewTime, pvs.userid, pvs.page_url,
        pvs.referrer_url
 WHERE pvs.country = 'US';
```

Inserting Data

- Normally only one partition can be inserted into with a single INSERT
- A multi-insert lets you insert into multiple partitions

```
FROM page_view_stg pvs
INSERT OVERWRITE TABLE page_view
PARTITION  ( dt='2008-06-08', country='US‵ )
SELECT pvs.viewTime, pvs.userid, pvs.page_url, pvs.referrer_url WHERE pvs.country = 'US'
INSERT OVERWRITE TABLE page_view
PARTITION ( dt='2008-06-08', country='CA' )
SELECT pvs.viewTime, pvs.userid, pvs.page_url, pvs.referrer_url WHERE pvs.country = 'CA'
INSERT OVERWRITE TABLE page_view
PARTITION ( dt='2008-06-08', country='UK' )
SELECT pvs.viewTime, pvs.userid, pvs.page_url, pvs.referrer_url WHERE pvs.country = 'UK';
```

Inserting Data During Table Creation

- Use AS SELECT in the CREATE TABLE statement to populate a table as it is created

```
CREATE TABLE page_view AS
  SELECT pvs.viewTime, pvs.userid, pvs.page_url,
         pvs.referrer_url
  FROM page_view_stg pvs
  WHERE pvs.country = 'US';
```

Loading And Inserting Data: Summary

Use this	For this purpose
`LOAD`	Load data from a file or directory
`INSERT`	Load data from a query • One partition at a time • Use multiple INSERTs to insert into multiple partitions in the one query
`CREATE TABLE AS (CTAS)`	Insert data while creating a table
Add/modify external file	Load new data into external table

Hive Query Language

- Basic SQL
  - From clause sub-query
  - ANSI JOIN (equi-join only)
  - Multi-Table insert
  - Multi group-by
  - Sampling
  - Objects Traversal
- Extensibility
  - Pluggable Map-reduce scripts using TRANSFORM

Hive Query Language

- JOIN

```
SELECT t1.a1 as c1, t2.b1 as c2
FROM t1 JOIN t2 ON (t1.a2 = t2.b2);
```

- INSERTION

```
 INSERT OVERWRITE TABLE t1
SELECT *  FROM t2;
```

Hive Query Language –Contd.

- Insertion

INSERT OVERWRITE TABLE sample1 '/tmp/hdfs_out' **SELECT** * **FROM** sample **WHERE** ds='2012-02-24';

INSERT OVERWRITE DIRECTORY '/tmp/hdfs_out' **SELECT** * **FROM** sample **WHERE** ds='2012-02-24';

INSERT OVERWRITE LOCAL DIRECTORY '/tmp/hive-sample-out' **SELECT** * **FROM** sample;

Hive Query Language –Contd.

- Map Reduce

```
FROM (MAP doctext USING 'python wc_mapper.py' AS (word, cnt)
FROM docs
CLUSTER BY word
)
REDUCE word, cnt USING 'python wc_reduce.py';
```

- FROM (FROM session_table

```
SELECT sessionid, tstamp, data
DISTRIBUTE BY sessionid SORT BY tstamp
)
REDUCE sessionid, tstamp, data USING 'session_reducer.sh';
```

Hive Query Language

- Example of multi-table insert query and its optimization

```
FROM (SELECT a.status, b.school, b.gender
        FROM status_updates a JOIN profiles b
            ON (a.userid = b.userid AND a.ds='2009-03-20' )) subq1

INSERT OVERWRITE TABLE gender_summary
                        PARTITION(ds='2009-03-20')
SELECT subq1.gender, COUNT(1)
GROUP BY subq1.gender

INSERT OVERWRITE TABLE school_summary
                        PARTITION(ds='2009-03-20')
SELECT subq1.school, COUNT(1)
GROUP BY subq1.school
```

Relational Operators

- ALL and DISTINCT
  - Specify whether duplicate rows should be returned
  - ALL is the default (all matching rows are returned)
  - DISTINCT removes duplicate rows from the result set
- WHERE
  - Filters by expression
  - Does not support IN, EXISTS or sub-queries in the WHERE clause
- LIMIT
  - Indicates the number of rows to be returned

Relational Operators

- GROUP BY
  - Group data by column values
  - Select statement can only include columns included in the GROUP BY clause
- ORDER BY / SORT BY
  - ORDER BY performs total ordering
    - Slow, poor performance
  - SORT BY performs partial ordering
    - Sorts output from each reducer

Advanced Hive Operations

- JOIN
  - If only one column in each table is used in the join, then only one MapReduce job will run
    - This results in 1 MapReduce job:

```
SELECT * FROM a JOIN b ON a.key = b.key JOIN c ON b.key = c.key
```

    - This results in 2 MapReduce jobs:

```
SELECT * FROM a JOIN b ON a.key = b.key JOIN c ON b.key2 = c.key
```

  - If multiple tables are joined, put the biggest table last and the reducer will stream the last table, buffer the others
  - Use left semi-joins to take the place of IN/EXISTS

```
SELECT a.key, a.val FROM a LEFT SEMI JOIN b on a.key = b.key;
```

HiveQL Limitations

- HQL only supports equi-joins, outer joins, left semi-joins
- Because it is only a shell for mapreduce, complex queries can be hard to optimise
- Missing large parts of full SQL specification:
  - HAVING clause in SELECT
  - Correlated sub-queries
  - Sub-queries outside FROM clauses
  - Updatable or materialized views
  - Stored procedures

Conclusion

- Pros
  - Good explanation of Hive and HiveQL with proper examples
  - Architecture is well explained
  - Usage of Hive is properly given
- Cons
  - Accepts only a subset of SQL queries
  - Performance comparisons with other systems would have been more appreciable

Thank You!!!