Hive

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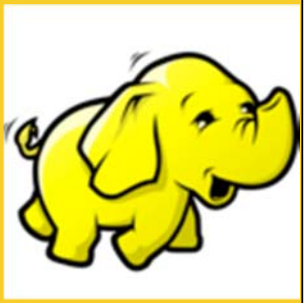

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- Courses developed and taught by Marty Hall
  - JSF 2, PrimeFaces, servlets/JSP, Ajax, jQuery, Android development, Java 6 or 7 programming, custom mix of topics
  - Ajax courses can concentrate on 1 library (jQuery, Prototype/Scriptaculous, Ext-JS, Dojo, etc.) or survey several
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Agenda

- Hive Overview and Concepts
- Installation
- Table Creation and Deletion
- Loading Data into Hive
- Partitioning
- Bucketing
- Joins

Hive

- Data Warehousing Solution built on top of Hadoop
- Provides SQL-like query language named HiveQL
  – Minimal learning curve for people with SQL expertise
  – Data analysts are target audience
- Early Hive development work started at Facebook in 2007
- Today Hive is an Apache project under Hadoop
  – http://hive.apache.org

Hive Provides

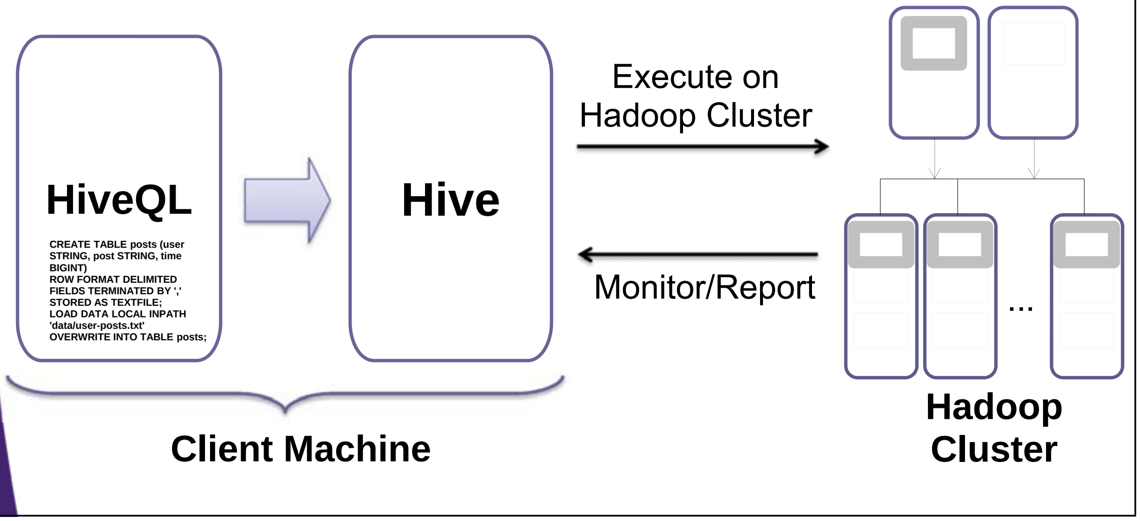
- Ability to bring structure to various data formats
- Simple interface for ad hoc querying, analyzing and summarizing large amounts of data
- Access to files on various data stores such as HDFS and HBase

Hive

- Hive does NOT provide low latency or real-time queries
- Even querying small amounts of data may take minutes
- Designed for scalability and ease-of-use rather than low latency responses

Hive

- **Translates HiveQL statements into a set of MapReduce Jobs which are then executed on a Hadoop Cluster**

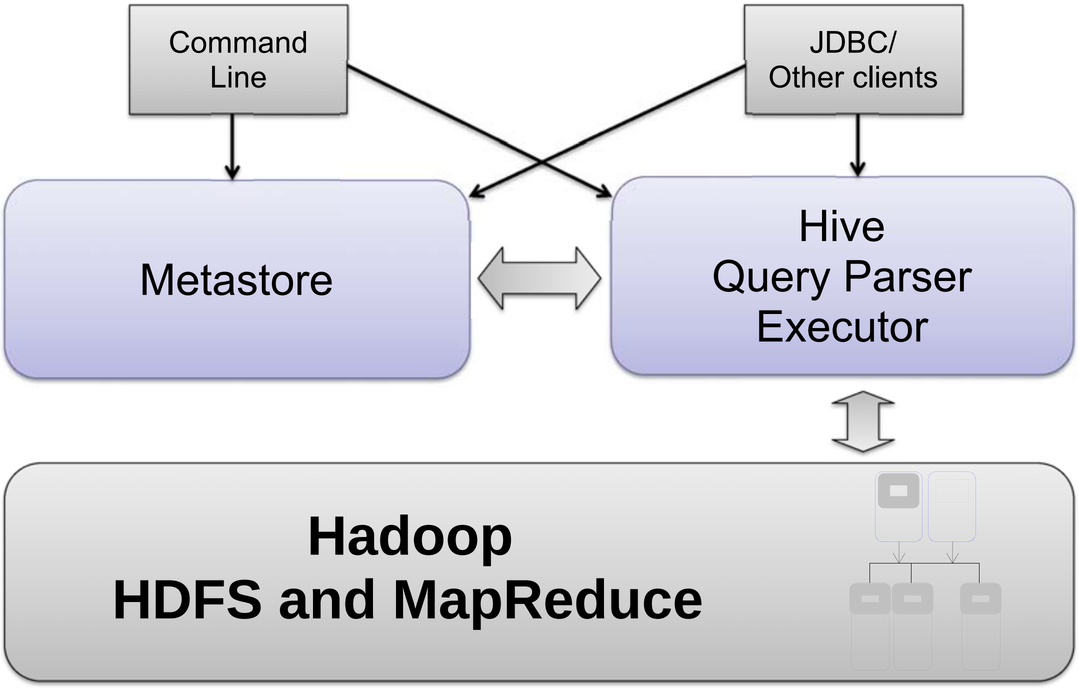


```
CREATE TABLE posts (user
STRING, post STRING, time
BIGINT)
ROW FORMAT DELIMITED
FIELDS TERMINATED BY ','
STORED AS TEXTFILE;
LOAD DATA LOCAL INPATH
'data/user-posts.txt'
OVERWRITE INTO TABLE posts;
```

Hive Metastore

- **To support features like schema(s) and data partitioning Hive keeps its metadata in a Relational Database**
  - Packaged with Derby, a lightweight embedded SQL DB
    - Default Derby based is good for evaluation an testing
    - Schema is not shared between users as each user has their own instance of embedded Derby
    - Stored in metastore_db directory which resides in the directory that hive was started from
  - Can easily switch another SQL installation such as MySQL

Hive Architecture

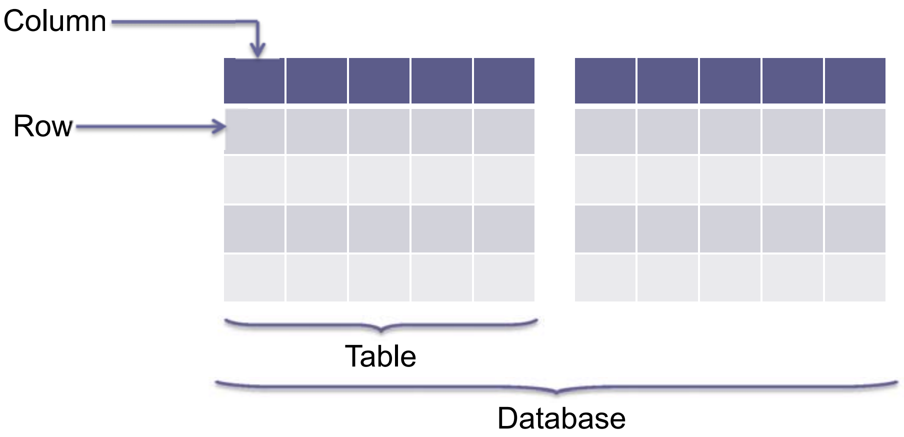


Hive Interface Options

- **Command Line Interface (CLI)**
  - Will use exclusively in these slides
- **Hive Web Interface**
  - https://cwiki.apache.org/confluence/display/Hive/HiveWebInterface
- **Java Database Connectivity (JDBC)**
  - https://cwiki.apache.org/confluence/display/Hive/HiveClient

Hive Concepts

- **Re-used from Relational Databases**
  - **Database**: Set of Tables, used for name conflicts resolution
  - **Table**: Set of Rows that have the same schema (same columns)
  - **Row**: A single record; a set of columns
  - **Column**: provides value and type for a single value



Installation Prerequisites

- **Java 6**
  - Just Like Hadoop
- **Hadoop 0.20.x+**
  - No surprise here

Hive Installation

- **Set $HADOOP_HOME environment variable**
  - Was done as a part of HDFS installation
- **Set $HIVE_HOME and add hive to the PATH**

```
export HIVE_HOME=$CDH_HOME/hive-0.8.1-cdh4.0.0
export PATH=$PATH:$HIVE_HOME/bin
```

- **Hive will store its tables on HDFS and those locations needs to be bootstrapped**

```
$ hdfs dfs -mkdir       /tmp
$ hdfs dfs -mkdir       /user/hive/warehouse
$ hdfs dfs -chmod g+w   /tmp
$ hdfs dfs -chmod g+w   /user/hive/warehouse
```

Hive Installation

- **Similar to other Hadoop's projects Hive's configuration is in $HIVE_HOME/conf/hive-site.xml**

```
<?xml version="1.0"?>
<?xml-stylesheet type="text/xsl" href="configuration.xsl"?>
<configuration>

  <property>
    <name>mapred.job.tracker</name>
    <value>localhost:10040</value>
  </property>

</configuration>
```

Specify the location of ResourceManager so Hive knows where to execute MapReduce Jobs; by default Hive utilizes LocalJobRunner

Run Hive

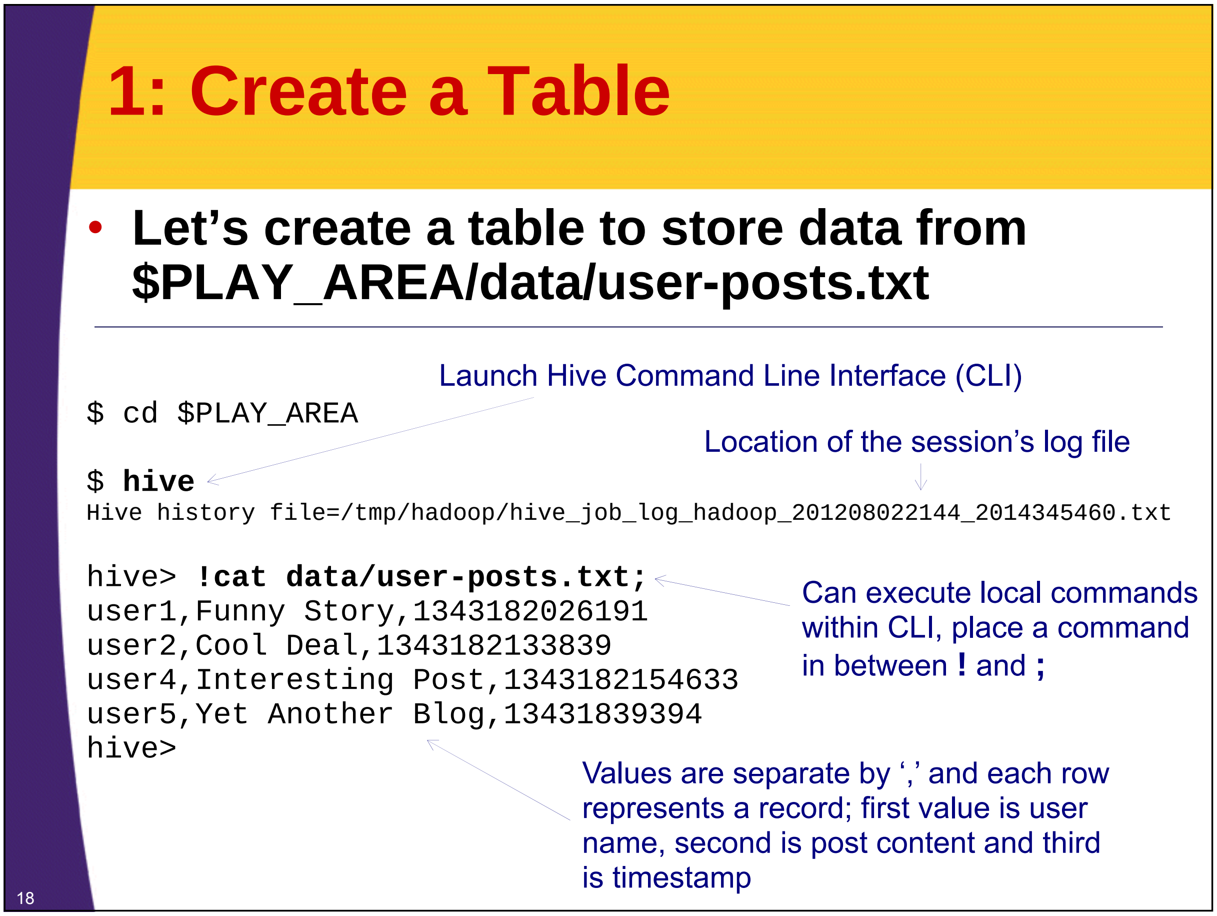
- **HDFS and YARN need to be up and running**

```
$ hive
Hive history file=/tmp/hadoop/hive_job_log_hadoop_201207312052_1402761030.txt
hive>
```

Hive’s Interactive Command Line Interface (CLI)

Simple Example

1. **Create a Table**
2. **Load Data into a Table**
3. **Query Data**
4. **Drop the Table**



1: Create a Table

- Let's create a table to store data from $PLAY_AREA/data/user-posts.txt

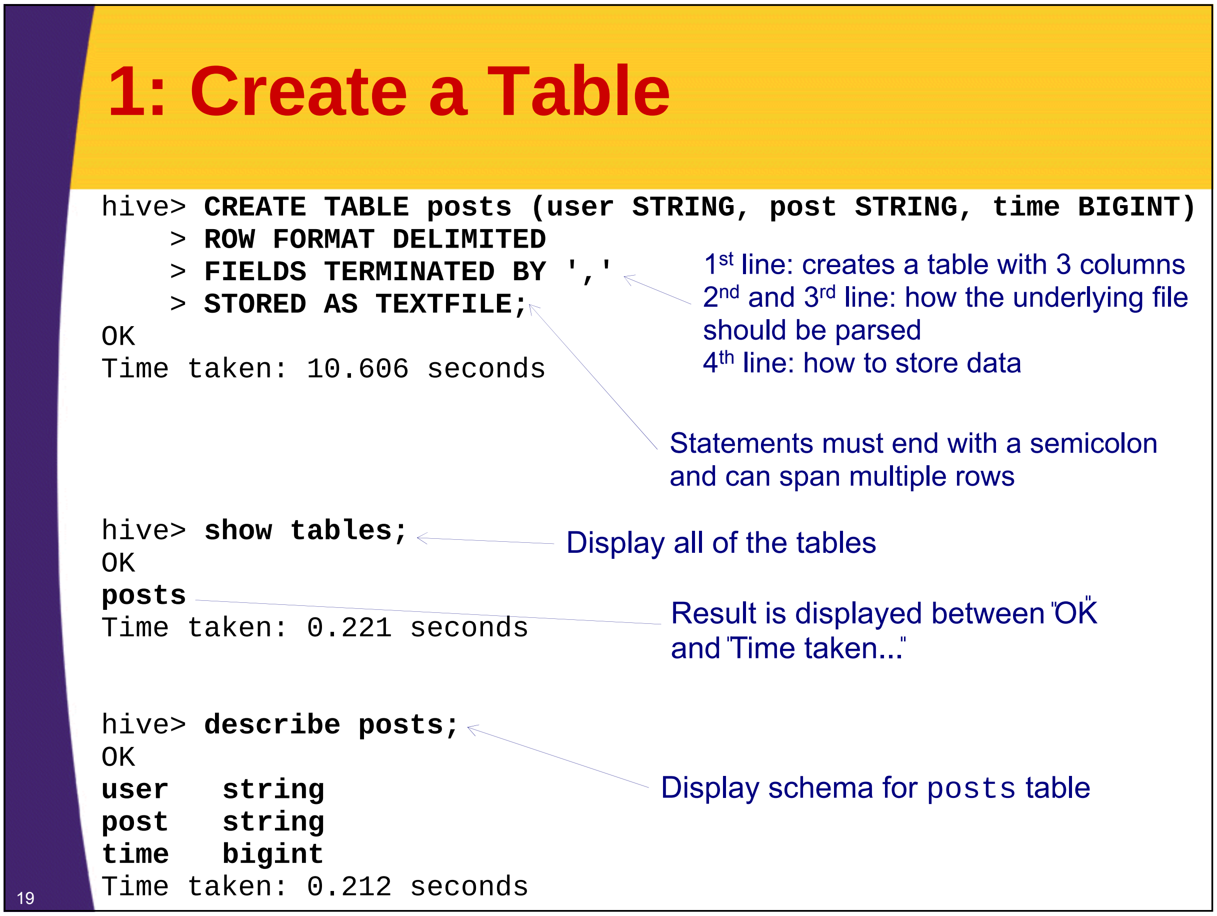
```
$ cd $PLAY_AREA

$ hive
Hive history file=/tmp/hadoop/hive_job_log_hadoop_201208022144_2014345460.txt

hive> !cat data/user-posts.txt;
user1,Funny Story,1343182026191
user2,Cool Deal,1343182133839
user4,Interesting Post,1343182154633
user5,Yet Another Blog,13431839394
hive>
```

Launch Hive Command Line Interface (CLI)

Location of the session's log file

Can execute local commands within CLI, place a command in between **!** and **;**

Values are separate by ',' and each row represents a record; first value is user name, second is post content and third is timestamp



1: Create a Table

```
hive> CREATE TABLE posts (user STRING, post STRING, time BIGINT)
    > ROW FORMAT DELIMITED
    > FIELDS TERMINATED BY ','
    > STORED AS TEXTFILE;
OK
Time taken: 10.606 seconds
```

1st line: creates a table with 3 columns
2nd and 3rd line: how the underlying file should be parsed
4th line: how to store data

Statements must end with a semicolon and can span multiple rows

```
hive> show tables;
OK
posts
Time taken: 0.221 seconds
```

Display all of the tables

Result is displayed between "OK" and "Time taken..."

```
hive> describe posts;
OK
user    string
post    string
time    bigint
Time taken: 0.212 seconds
```

Display schema for `posts` table

2: Load Data Into a Table

```
hive> LOAD DATA LOCAL INPATH 'data/user-posts.txt'
    > OVERWRITE INTO TABLE posts;
Copying data from file:/home/hadoop/Training/play_area/data/user-posts.txt
Copying file: file:/home/hadoop/Training/play_area/data/user-posts.txt
Loading data to table default.posts
Deleted /user/hive/warehouse/posts
OK
Time taken: 5.818 seconds
hive>
```

Existing records the table *posts* are deleted; data in *user-posts.txt* is loaded into Hive's *posts* table

```
$ hdfs dfs -cat /user/hive/warehouse/posts/user-posts.txt
user1,Funny Story,1343182026191
user2,Cool Deal,1343182133839
user4,Interesting Post,1343182154633
user5,Yet Another Blog,13431839394
```

Under the covers Hive stores it's tables in `/user/hive/warehouse` (unless configured differently)

3: Query Data

```
hive> select count (1) from posts;
Total MapReduce jobs = 1
Launching Job 1 out of 1
...
Starting Job = job_1343957512459_0004, Tracking URL =
http://localhost:8088/proxy/application_1343957512459_0004/
Kill Command = hadoop job  -Dmapred.job.tracker=localhost:10040 -kill
job_1343957512459_0004
Hadoop job information for Stage-1: number of mappers: 1; number of reducers: 1
2012-08-02 22:37:24,962 Stage-1 map = 0%,  reduce = 0%
2012-08-02 22:37:30,497 Stage-1 map = 100%,  reduce = 0%, Cumulative CPU 0.87 sec
2012-08-02 22:37:31,577 Stage-1 map = 100%,  reduce = 0%, Cumulative CPU 0.87 sec
2012-08-02 22:37:32,664 Stage-1 map = 100%,  reduce = 100%, Cumulative CPU 2.64 sec
MapReduce Total cumulative CPU time: 2 seconds 640 msec
Ended Job = job_1343957512459_0004
MapReduce Jobs Launched:
Job 0: Map: 1  Reduce: 1   Accumulative CPU: 2.64 sec   HDFS Read: 0 HDFS Write: 0
SUCESS
Total MapReduce CPU Time Spent: 2 seconds 640 msec
OK
4
Time taken: 14.204 seconds
```

Count number of records in posts table

Transformed HiveQL into 1 MapReduce Job

Result is 4 records

3: Query Data

```
hive> select * from posts where user="user2";
...
...
OK
user2  Cool Deal     1343182133839
Time taken: 12.184 seconds
```

Select records for "user2"

Select records whose timestamp is less or equals to the provided value

```
hive> select * from posts where time<=1343182133839 limit 2;
...
...
OK
user1  Funny Story   1343182026191
user2  Cool Deal     1343182133839
Time taken: 12.003 seconds
hive>
```

Usually there are too many results to display, then one could utilize `limit` command to bound the display

4: Drop the Table

```
hive> DROP TABLE posts;
OK
Time taken: 2.182 seconds

hive> exit;

$ hdfs dfs -ls /user/hive/warehouse/
$
```

Remove the table; use with caution

If hive was managing underlying file then it will be removed

Loading Data

- **Several options to start using data in HIVE**
  - Load data from HDFS location

```
hive> LOAD DATA INPATH '/training/hive/user-posts.txt'
    > OVERWRITE INTO TABLE posts;
```

    - File is copied from the provided location to /user/hive/warehouse/ (or configured location)
  - Load data from a local file system

```
hive> LOAD DATA LOCAL INPATH 'data/user-posts.txt'
        > OVERWRITE INTO TABLE posts;
```

    - File is copied from the provided location to /user/hive/warehouse/ (or configured location)
  - Utilize an existing location on HDFS
    - Just point to an existing location when creating a table

Re-Use Existing HDFS Location

```
hive> CREATE EXTERNAL TABLE posts
    > (user STRING, post STRING, time BIGINT)
    > ROW FORMAT DELIMITED
    > FIELDS TERMINATED BY ','
    > STORED AS TEXTFILE
    > LOCATION '/training/hive/';
OK
Time taken: 0.077 seconds
hive>
```

Hive will load all the files under /training/hive directory in posts table

Schema Violations

- **What would happen if we try to insert data that does not comply with the pre-defined schema?**

```
hive> !cat data/user-posts-inconsistentFormat.txt;
user1,Funny Story,1343182026191
user2,Cool Deal,2012-01-05
user4,Interesting Post,1343182154633
user5,Yet Another Blog,13431839394

hive> describe posts;
OK
user  string
post  string
time  bigint
Time taken: 0.289 seconds
```

Third Column ‘post’ is of type bigint; will not be able to convert ‘2012-01-05’ value

Schema Violations

```
hive> LOAD DATA LOCAL INPATH
        > 'data/user-posts-inconsistentFormat.txt'
    > OVERWRITE INTO TABLE posts;
OK
Time taken: 0.612 seconds

hive> select * from posts;
OK
user1  Funny Story   1343182026191
user2  Cool Deal     NULL
user4  Interesting Post    1343182154633
user5  Yet Another Blog    13431839394
Time taken: 0.136 seconds
hive>
```

null is set for any value that violates pre-defined schema

Partitions

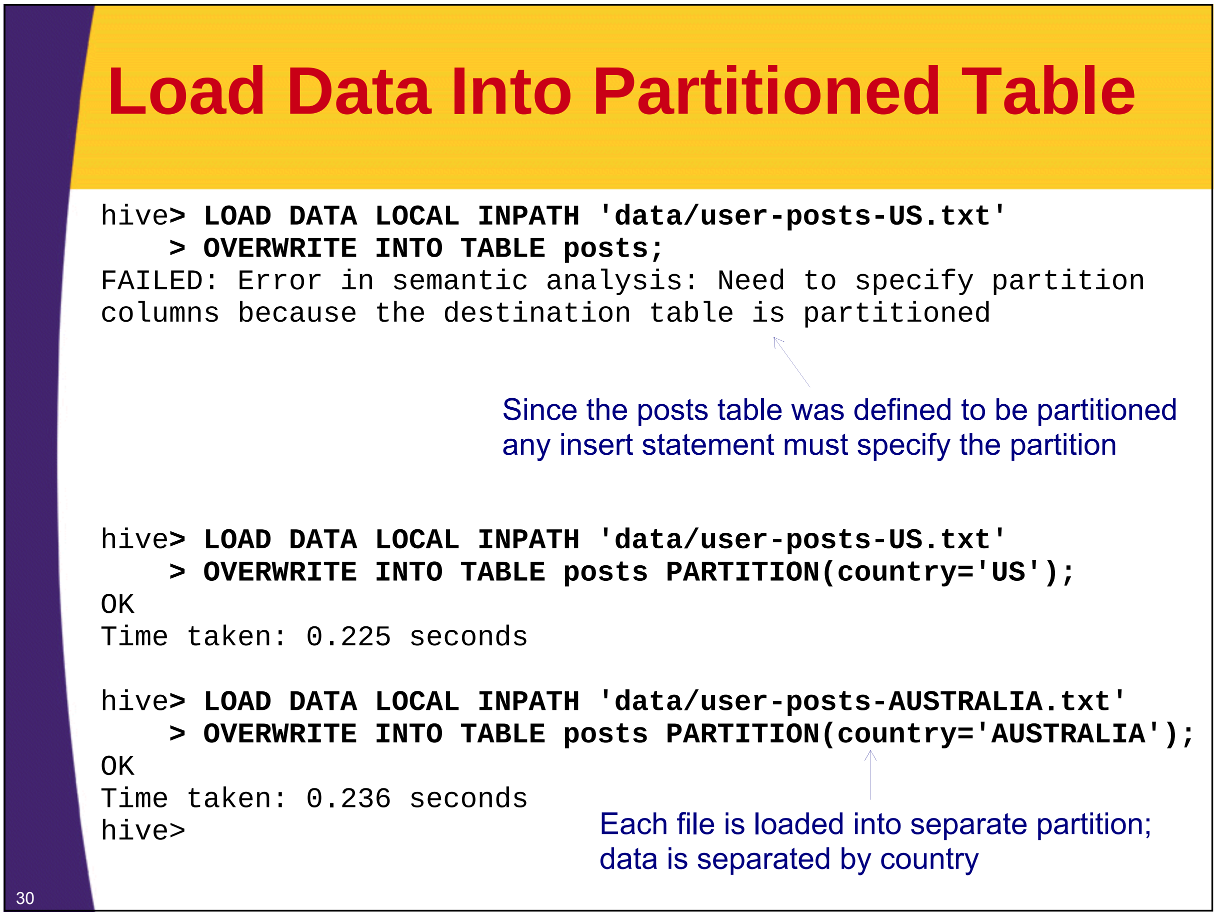
- **To increase performance Hive has the capability to partition data**
  - The values of partitioned column divide a table into segments
  - Entire partitions can be ignored at query time
  - Similar to relational databases’ indexes but not as granular
- **Partitions have to be properly crated by users**
  - When inserting data must specify a partition
- **At query time, whenever appropriate, Hive will automatically filter out partitions**

Creating Partitioned Table

```
hive> CREATE TABLE posts (user STRING, post STRING, time BIGINT)
    > PARTITIONED BY(country STRING)
    > ROW FORMAT DELIMITED
    > FIELDS TERMINATED BY ','
    > STORED AS TEXTFILE;
OK
Time taken: 0.116 seconds

hive> describe posts;
OK
user    string
post    string
time    bigint
countrystring
Time taken: 0.111 seconds

hive> show partitions posts;
OK
Time taken: 0.102 seconds
hive>
```

Partition table based on the value of a country.

There is no difference in schema between "partition" columns and "data" columns



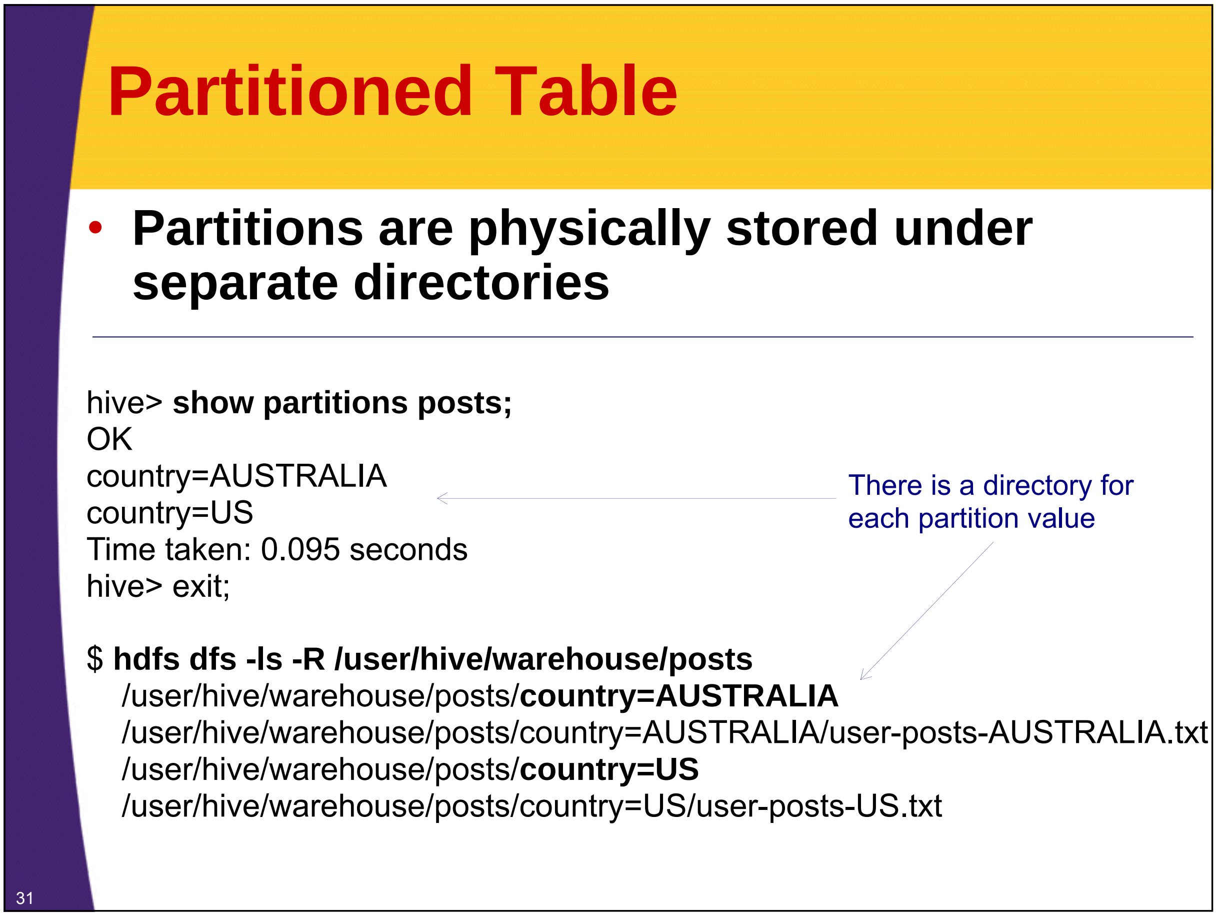
Load Data Into Partitioned Table

```
hive> LOAD DATA LOCAL INPATH 'data/user-posts-US.txt'
    > OVERWRITE INTO TABLE posts;
FAILED: Error in semantic analysis: Need to specify partition
columns because the destination table is partitioned
```

Since the posts table was defined to be partitioned any insert statement must specify the partition

```
hive> LOAD DATA LOCAL INPATH 'data/user-posts-US.txt'
    > OVERWRITE INTO TABLE posts PARTITION(country='US');
OK
Time taken: 0.225 seconds

hive> LOAD DATA LOCAL INPATH 'data/user-posts-AUSTRALIA.txt'
    > OVERWRITE INTO TABLE posts PARTITION(country='AUSTRALIA');
OK
Time taken: 0.236 seconds
hive>
```

Each file is loaded into separate partition; data is separated by country



Partitioned Table

- **Partitions are physically stored under separate directories**

```
hive> show partitions posts;
OK
country=AUSTRALIA
country=US
Time taken: 0.095 seconds
hive> exit;

$ hdfs dfs -ls -R /user/hive/warehouse/posts
   /user/hive/warehouse/posts/country=AUSTRALIA
   /user/hive/warehouse/posts/country=AUSTRALIA/user-posts-AUSTRALIA.txt
   /user/hive/warehouse/posts/country=US
   /user/hive/warehouse/posts/country=US/user-posts-US.txt
```

There is a directory for each partition value

Querying Partitioned Table

- There is no difference in syntax
- When partitioned column is specified in the where clause entire directories/partitions could be ignored

Only "COUNTRY=US" partition will be queried,
"COUNTRY=AUSTRALIA" partition will be ignored

```
hive> select * from posts where country='US' limit 10;
OK
user1 Funny Story 1343182026191     US
user2 Cool Deal   1343182133839     US
user2 Great Interesting Note  13431821339485    US
user4 Interesting Post  1343182154633     US
user1 Humor is good     1343182039586     US
user2 Hi I am user #2   1343182133839     US
Time taken: 0.197 seconds
```

Bucketing

- Mechanism to query and examine random samples of data
- Break data into a set of buckets based on a hash function of a "bucket column"
  - Capability to execute queries on a sub-set of random data
- Doesn’t automatically enforce bucketing
  - User is required to specify the number of buckets by setting # of reducer

```
hive> mapred.reduce.tasks = 256;
OR
hive> hive.enforce.bucketing = true;
```

Either manually set the # of reducers to be the number of buckets or you can use ‘hive.enforce.bucketing’ which will set it on your behalf

Create and Use Table with Buckets

```
hive> CREATE TABLE post_count (user STRING, count INT)
    > CLUSTERED BY (user) INTO 5 BUCKETS;
OK
Time taken: 0.076 seconds

hive> set hive.enforce.bucketing = true;
hive> insert overwrite table post_count
    > select user, count(post) from posts group by user;
Total MapReduce jobs = 2
Launching Job 1 out of 2
...
Launching Job 2 out of 2
...
OK
Time taken: 42.304 seconds
hive> exit;
$ hdfs dfs -ls -R /user/hive/warehouse/post_count/
   /user/hive/warehouse/post_count/000000_0
   /user/hive/warehouse/post_count/000001_0
   /user/hive/warehouse/post_count/000002_0
   /user/hive/warehouse/post_count/000003_0
   /user/hive/warehouse/post_count/000004_0
```

Declare table with 5 buckets for user column

# of reducer will get set 5

Insert data into post_count bucketed table; number of posts are counted up for each user

A file per bucket is created; now only a sub-set of buckets can be sampled

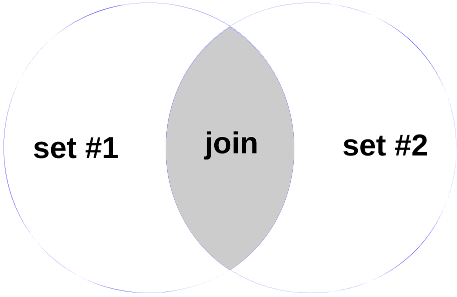
Random Sample of Bucketed Table

```
hive> select * from post_count TABLESAMPLE(BUCKET 1 OUT OF 2);
OK
user5   1
user1   2
Time taken: 11.758 seconds
hive>
```

Sample approximately 1 for every 2 buckets

Joins

- **Joins in Hive are trivial**
- **Supports outer joins**
  - left, right and full joins
- **Can join multiple tables**
- **Default Join is Inner Join**
  - Rows are joined where the keys match
  - Rows that do not have matches are not included in the result



Simple Inner Join

- **Let's say we have 2 tables: posts and likes**

```
hive> select * from posts limit 10;
OK
user1   Funny Story        1343182026191
user2   Cool Deal          1343182133839
user4   Interesting Post   1343182154633
user5   Yet Another Blog   1343183939434
Time taken: 0.108 seconds
hive> select * from likes limit 10;
OK
user1   12      1343182026191
user2   7       1343182139394
user3   0       1343182154633
user4   50      1343182147364
Time taken: 0.103 seconds
hive> CREATE TABLE posts_likes (user STRING, post STRING, likes_count INT);
OK
Time taken: 0.06 seconds
```

We want to join these 2 data-sets and produce a single table that contains user, post and count of likes

Simple Inner Join

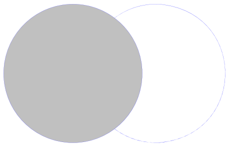
```
hive> INSERT OVERWRITE TABLE posts_likes
    > SELECT p.user, p.post, l.count
    > FROM posts p JOIN likes l ON (p.user = l.user);
OK
Time taken: 17.901 seconds
```

Two tables are joined based on user column; 3 columns are selected and stored in posts_likes table

```
hive> select * from posts_likes limit 10;
OK
user1 Funny Story       12
user2 Cool Deal         7
user4 Interesting Post  50
Time taken: 0.082 seconds
hive>
```

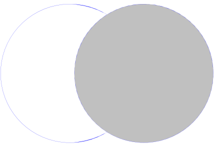
Outer Join

- **Rows which will not join with the ‘other’ table are still included in the result**



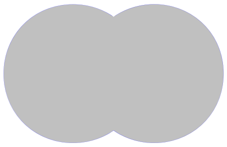
Left Outer

- – Row from the first table are included whether they have a match or not. Columns from the unmatched (second) table are set to null.



Right Outer

- – The opposite of Left Outer Join: Rows from the second table are included no matter what. Columns from the unmatched (first) table are set to null.



Full Outer

- – Rows from both sides are included. For unmatched rows the columns from the ‘other’ table are set to null.

Outer Join Examples

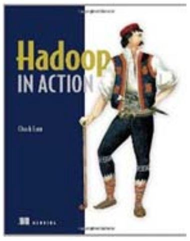
```
SELECT p.*, l.*
FROM posts p LEFT OUTER JOIN likes l ON (p.user = l.user)
limit 10;

SELECT p.*, l.*
FROM posts p RIGHT OUTER JOIN likes l ON (p.user = l.user)
limit 10;

SELECT p.*, l.*
FROM posts p FULL OUTER JOIN likes l ON (p.user = l.user)
limit 10;
```

Resources

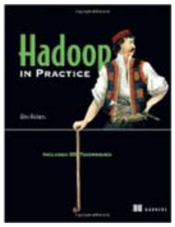
- **http://hive.apache.org/**
- **Hive Wiki**
  - https://cwiki.apache.org/confluence/display/Hive/Home

Hive
Edward Capriolo (Author), Dean Wampler (Author), Jason Rutherglen (Author)
O'Reilly Media; 1 edition (October 3, 2012)

Chapter About Hive
Hadoop in Action
Chuck Lam (Author)
Manning Publications; 1st Edition (December, 2010)



Resources



Chapter about Hive
Hadoop in Practice
Alex Holmes (Author)
Manning Publications; (October 10, 2012)

Wrap-Up

Summary

- **We learned about**
  - Hive Concepts
  - Hive Installation
  - Table Creation and Deletion
  - Loading Data into Hive
  - Partitioning
  - Bucketing
  - Joins

Questions?