



Modeling and Managing Data with Impala and Hive

Chapter 6



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Modeling and Managing Data in Impala and Hive

In this chapter you will learn

- **How Impala and Hive use the Metastore**
- **How to use Impala SQL and HiveQL DDL to create tables**
- **How to create and manage tables using Hue or HCatalog**
- **How to load data into tables using Impala, Hive, or Sqoop**

Chapter Topics

Modeling and Managing Data With Impala and Hive

Importing and Modeling Structured Data

- **Data Storage Overview**
- Creating Databases and Tables
- Loading Data into Tables
- HCatalog
- Impala Metadata Caching
- Conclusion
- Homework: Create and Populate Tables in Impala or Hive

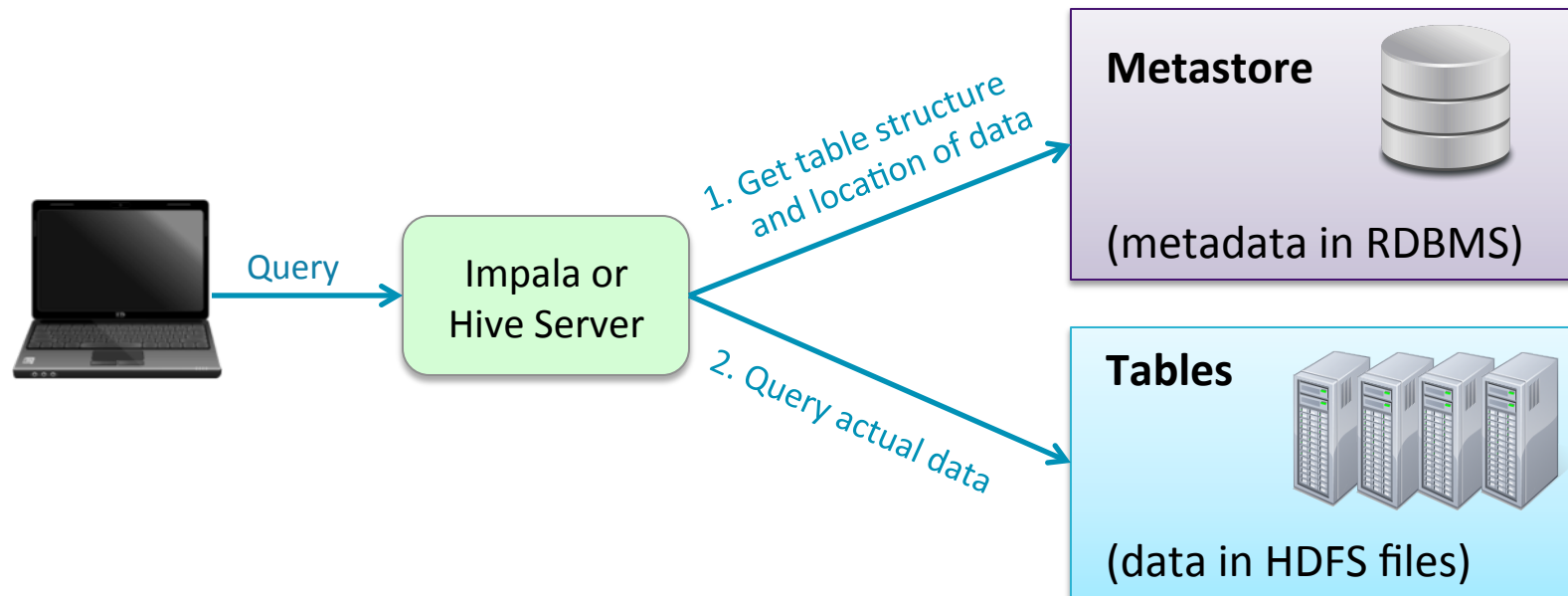
How Hive and Impala Load and Store Data (1)

- **Queries operate on tables, just like in an RDBMS**
 - A table is simply an HDFS directory containing one or more files
 - Default path: `/user/hive/warehouse/<table_name>`
 - Supports many formats for data storage and retrieval
- **What is the structure and location of tables?**
 - These are specified when tables are created
 - This metadata is stored in the *Metastore*
 - Contained in an RDBMS such as MySQL
- **Hive and Impala work with the same data**
 - Tables in HDFS, metadata in the Metastore

HIDDEN SLIDE Hive Metastore instructor notes

How Hive and Impala Load and Store Data (2)

- **Hive and Impala use the Metastore to determine data format and location**
 - The query itself operates on data stored in HDFS



Data and Metadata

- **Data** refers to the information you store and process
 - Billing records, sensor readings, and server logs are examples of data
- **Metadata** describes important aspects of that data
 - Field name and order are examples of metadata

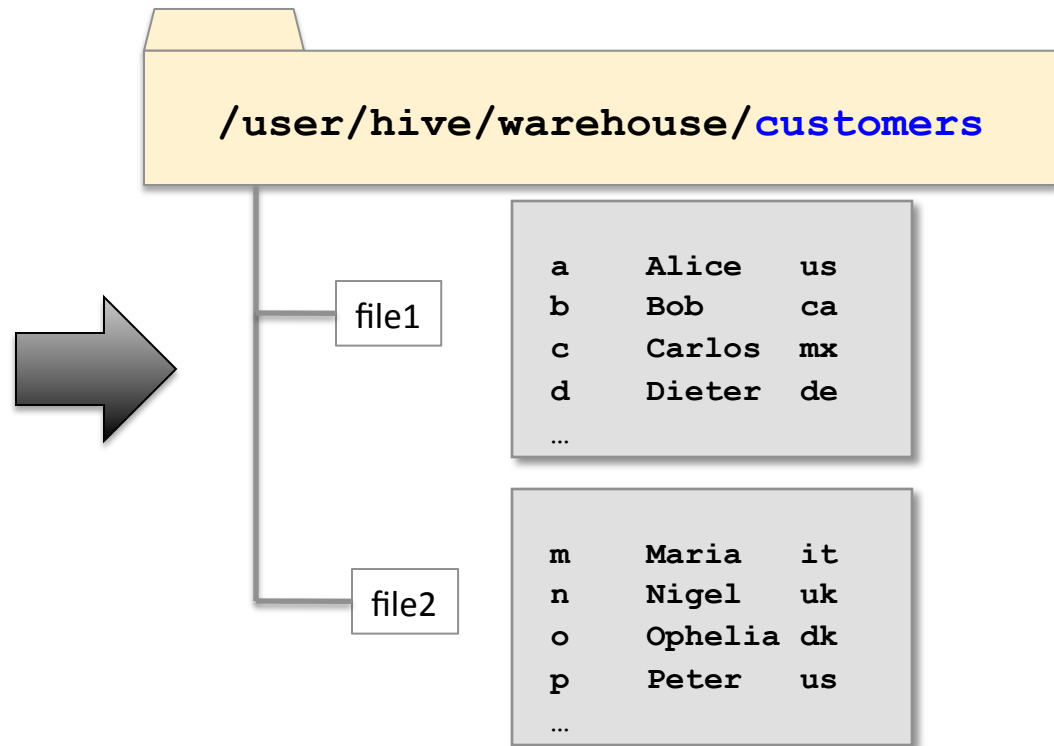
cust_id	name	country
001	Alice	us
002	Bob	ca
003	Carlos	mx
...
392	Maria	it
393	Nigel	uk
394	Ophelia	dk
...

The Data Warehouse Directory

- By default, data is stored in the HDFS directory `/user/hive/warehouse`
- Each table is a subdirectory containing any number of files

customers table

cust_id	name	country
001	Alice	us
002	Bob	ca
003	Carlos	mx
...
392	Maria	it
393	Nigel	uk
394	Ophelia	dk
...



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Defining Databases and Tables

- **Databases and tables are created and managed using the DDL (Data Definition Language) of HiveQL or Impala SQL**
 - Very similar to standard SQL DDL
 - Some minor differences between Hive and Impala DDL will be noted

Creating a Database

- **Hive and Impala databases are simply namespaces**

- Helps to organize your tables

- **To create a new database**

```
CREATE DATABASE loudacre;
```

1. Adds the database definition to the metastore

2. Creates a storage directory in HDFS

e.g./user/hive/warehouse/loudacre.db

- **To conditionally create a new database**

- Avoids error in case database already exists (useful for scripting)

```
CREATE DATABASE IF NOT EXISTS loudacre;
```

Removing a Database

- Removing a database is similar to creating it
 - Just replace **CREATE** with **DROP**

```
DROP DATABASE loudacre;
```

```
DROP DATABASE IF EXISTS loudacre;
```

- These commands will fail if the database contains tables
 - In Hive: Add the **CASCADE** keyword to force removal
 - Caution: this command might remove data in HDFS!



```
DROP DATABASE loudacre CASCADE;
```

Data Types

- **Each column is assigned a specific data type**
 - These are specified when the table is created
 - `NULL` values are returned for non-conforming data in HDFS
- **Here are some common data types**

Name	Description	Example Value
STRING	Character data (of any length)	Alice
BOOLEAN	TRUE or FALSE	TRUE
TIMESTAMP	Instant in time	2014-03-14 17:01:29
INT	Range: same as Java <code>int</code>	84127213
BIGINT	Range: same as Java <code>long</code>	7613292936514215317
FLOAT	Range: same as Java <code>float</code>	3.14159
DOUBLE	Range: same as Java <code>double</code>	3.1415926535897932385



Hive (not Impala) also supports a few complex types such as maps and arrays

Creating a Table (1)

- Basic syntax for creating a table:

```
CREATE TABLE tablename (colname DATATYPE, ...)  
  ROW FORMAT DELIMITED  
  FIELDS TERMINATED BY char  
  STORED AS {TEXTFILE|SEQUENCEFILE|...}
```

- Creates a subdirectory in the database's warehouse directory in HDFS
 - Default database:
`/user/hive/warehouse/tablename`
 - Named database:
`/user/hive/warehouse/dbname.db/tablename`

Creating a Table (2)

```
CREATE TABLE tablename (colname DATATYPE, ...)
```

```
ROW FORMAT DELIMITED
```

```
FIELD
```

```
STORED
```

Specify a name for the table, and list the column names and datatypes (see later)

Creating a Table (3)

```
CREATE TABLE tablename (colname DATATYPE, ...)  
ROW FORMAT DELIMITED  
FIELDS TERMINATED BY char  
STORED AS FORMAT
```

This line states that fields in each file in the table's directory are delimited by some character. The default delimiter is Control-A, but you may specify an alternate delimiter...

Creating a Table (4)

```
CREATE TABLE tablename (colname DATATYPE, ...)
  ROW FORMAT DELIMITED
  FIELDS TERMINATED BY char
  STORED AS {TEXTFILE|SEQUENCEFILE|...}
```

...for example, tab-delimited data would require that you specify **FIELDS TERMINATED BY '\t'**

Creating a Table (5)

```
CREATE TABLE tablename (colname DATATYPE, ...)
  ROW FORMAT DELIMITED
  FIELDS TERMINATED BY char
  STORED AS {TEXTFILE|SEQUENCEFILE|...}
```

Finally, you may declare the file format. **STORED AS TEXTFILE** is the default and does not need to be specified.
Other formats will be discussed later in the course.

Example Table Definition

- The following example creates a new table named **jobs**
 - Data stored as text with four comma-separated fields per line

```
CREATE TABLE jobs (  
    id INT,  
    title STRING,  
    salary INT,  
    posted TIMESTAMP  
)  
ROW FORMAT DELIMITED  
FIELDS TERMINATED BY ',';
```

- Example of corresponding record for the table above

```
1,Data Analyst,100000,2013-06-21 15:52:03
```

Creating Tables Based On Existing Schema

- Use **LIKE** to create a new table based on an existing table definition

```
CREATE TABLE jobs_archived LIKE jobs;
```

- Column definitions and names are derived from the existing table
 - New table will contain no data

Creating Tables Based On Existing Data

- **Create a table based on a `SELECT` statement**
 - Often know as 'Create Table As Select' (CTAS)

```
CREATE TABLE ny_customers AS
  SELECT cust_id, fname, lname
  FROM customers
  WHERE state = 'NY';
```

- **Column definitions are derived from the existing table**
- **Column names are inherited from the existing names**
 - Use aliases in the `SELECT` statement to specify new names
- **New table will contain the selected data**

Controlling Table Data Location

- By default, table data is stored in the warehouse directory
- This is not always ideal
 - Data might be shared by several users
- Use **LOCATION** to specify the directory where table data resides

```
CREATE TABLE jobs (  
    id INT,  
    title STRING,  
    salary INT,  
    posted TIMESTAMP  
)  
ROW FORMAT DELIMITED  
FIELDS TERMINATED BY ','  
LOCATION '/loudacre/jobs';
```

Externally Managed Tables

- **CAUTION: Dropping a table removes its data in HDFS**
 - Tables are “managed” or “internal” by default
- **Using `EXTERNAL` when creating the table avoids this behavior**
 - Dropping an *external* table removes only its *metadata*

```
CREATE EXTERNAL TABLE adclicks
( campaign_id STRING,
  click_time TIMESTAMP,
  keyword STRING,
  site STRING,
  placement STRING,
  was_clicked BOOLEAN,
  cost SMALLINT)
LOCATION '/loudacre/ad_data';
```


Exploring Tables (1)

- The **SHOW TABLES** command lists all tables in the current database

```
SHOW TABLES;  
+-----+  
|  tab_name  |  
+-----+  
| accounts  |  
| employees |  
| job       |  
| vendors   |  
+-----+
```

- The **DESCRIBE** command lists the fields in the specified table

```
DESCRIBE jobs;  
+-----+-----+-----+  
| name  | type   | comment |  
+-----+-----+-----+  
| id    | int    |          |  
| title | string |          |  
| salary | int    |          |  
| posted | timestamp |          |  
+-----+-----+-----+
```

Exploring Tables (2)

- **DESCRIBE FORMATTED** also shows table properties

```
DESCRIBE FORMATTED jobs;
```

name	type	comment
# col_name	data_type	comment
id	int	NULL
title	string	NULL
salary	int	NULL
posted	timestamp	NULL
	NULL	NULL
# Detailed Table Information	NULL	NULL
Database:	default	NULL
Owner:	training	NULL
CreateTime:	Wed Jun 17 09:41:23 PDT 2015	NULL
LastAccessTime:	UNKNOWN	NULL
Protect Mode:	None	NULL
Retention:	0	NULL
Location:	hdfs://localhost:8020/loudacre/jobs	NULL
Table Type:	MANAGED_TABLE	NULL

...

Exploring Tables (3)

- **SHOW CREATE TABLE** displays the SQL command to create the table

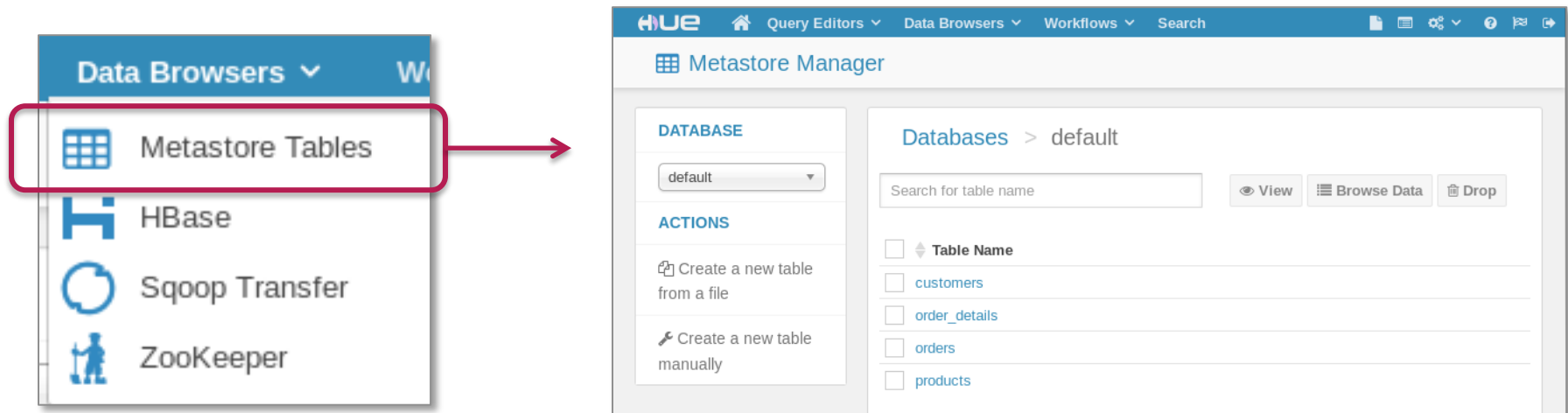
```
SHOW CREATE TABLE jobs;
```

```
+-----+
| CREATE TABLE default.jobs
|     id INT,
|     title STRING,
|     salary INT,
|     posted TIMESTAMP
| )
| ROW FORMAT DELIMITED FIELDS TERMINATED BY ','
|
+-----+
...
```

Using the Hue Metastore Manager

■ The Hue Metastore Manager

- An alternative to using SQL commands to manage metadata
- Allows you to create, load, preview, and delete databases and tables
 - Not all features are supported yet



Chapter Topics

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Data Validation

- **Impala and Hive are 'schema on read'**
 - Unlike an RDBMS, they do not validate data on insert
 - Files are simply moved into place
 - Loading data into tables is therefore very fast
 - Errors in file format will be discovered when queries are performed
- **Missing or invalid data will be represented as NULL**

Loading Data From HDFS Files

- **To load data, simply add files to the table's directory in HDFS**
 - Can be done directly using the `hdfs dfs` commands
 - This example loads data from HDFS into the `sales` table

```
$ hdfs dfs -mv \  
  /tmp/sales.txt /user/hive/warehouse/sales/
```

- **Alternatively, use the `LOAD DATA INPATH` command**
 - Done from within Hive or Impala
 - This *moves* data within HDFS, just like the command above
 - Source can be either a file or directory

```
LOAD DATA INPATH '/tmp/sales.txt'  
  INTO TABLE sales;
```

Overwriting Data From Files

- **Add the OVERWRITE keyword to delete all records before import**
 - Removes all files within the table's directory
 - Then moves the new files into that directory

```
LOAD DATA INPATH '/tmp/sales.txt'  
  OVERWRITE INTO TABLE sales;
```


Appending Selected Records to a Table

- Another way to populate a table is through a query
 - Use **INSERT INTO** to add results to an *existing* Hive table

```
INSERT INTO TABLE accounts_copy  
  SELECT * FROM accounts;
```

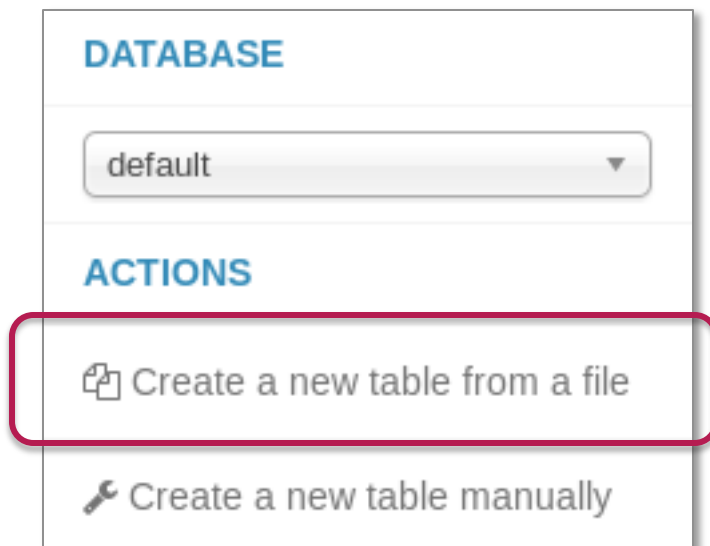
- Specify a **WHERE** clause to control which records are appended

```
INSERT INTO TABLE loyal_customers  
  SELECT * FROM accounts  
  WHERE YEAR(acct_create_dt) = 2008  
        AND acct_close_dt IS NULL;
```

Loading Data Using the Metastore Manager

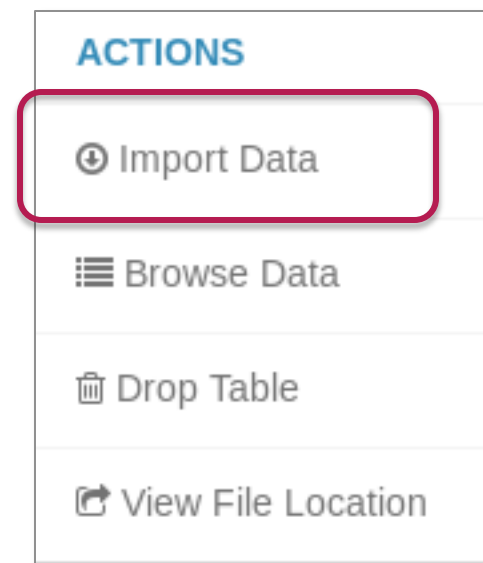
- The Metastore Manager provides two ways to load data into a table

Table creation wizard



The 'Table creation wizard' interface is shown. It has a 'DATABASE' section with a dropdown menu set to 'default'. Below this is an 'ACTIONS' section with two options: 'Create a new table from a file' (highlighted with a red box) and 'Create a new table manually'.

Import data wizard



The 'Import data wizard' interface is shown. It has an 'ACTIONS' section with four options: 'Import Data' (highlighted with a red box), 'Browse Data', 'Drop Table', and 'View File Location'.

Loading Data From a Relational Database

- Sqoop has built-in support for importing data into Hive and Impala
- Add the **--hive-import** option to your Sqoop command
 - Creates the table in the Hive metastore
 - Imports data from the RDBMS to the table's directory in HDFS

```
$ sqoop import \  
  --connect jdbc:mysql://localhost/loudacre \  
  --username training \  
  --password training \  
  --fields-terminated-by '\t' \  
  --table employees \  
  --hive-import
```

- Note that **--hive-import** creates a table accessible in both Hive and Impala

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The Metastore and HCatalog

- **HCatalog is a Hive sub-project that provides access to the Metastore**
 - Accessible via command line and REST API
 - Allows you to define tables using HiveQL DDL syntax
 - Access those tables from Hive, Impala, MapReduce, Pig, and other tools
 - Included with CDH 4.2 and later

Creating Tables in HCatalog

- **HCatalog uses Hive's DDL (data definition language) syntax**
 - You can specify a single command using the `-e` option

```
$ hcat -e "CREATE TABLE vendors \  
    (id INT, company STRING, email STRING) \  
    ROW FORMAT DELIMITED FIELDS TERMINATED BY ',' \  
    LOCATION '/dualcore/vendors'"
```

- **Tip: save longer commands to a text file and use the `-f` option**
 - If the file has more than one command, separate each with a semicolon

```
$ hcat -f createtable.txt
```

Displaying Metadata in HCatalog

- The **SHOW TABLES** command also shows tables created directly in Hive

```
$ hcat -e 'SHOW TABLES'
employees
vendors
```

- The **DESCRIBE** command lists the fields in a specified table
 - Use **DESCRIBE FORMATTED** instead to see detailed information

```
$ hcat -e 'DESCRIBE vendors'
id          int
company     string
email       string
```

Removing a Table in HCatalog

- The **DROP TABLE** command has the same behavior as it does in Hive and Impala
 - Caution: this will remove the data as well as the metadata (unless table is **EXTERNAL**)!

```
$ hcat -e 'DROP TABLE vendors'
```


Chapter Topics

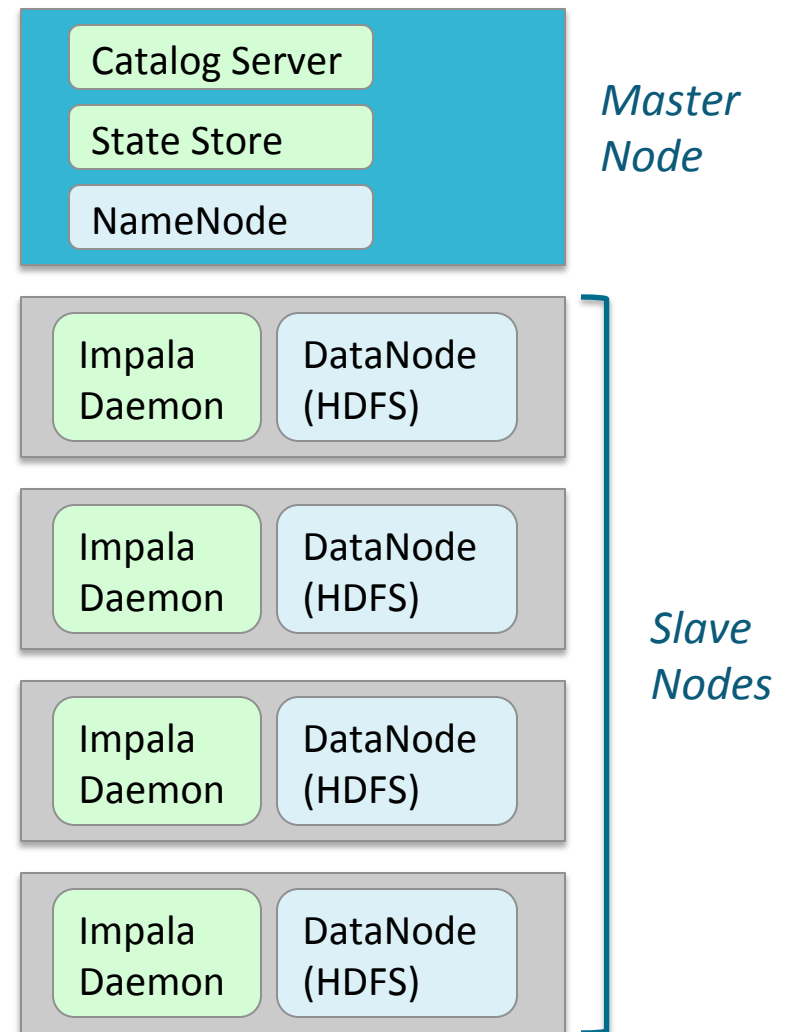
Modeling and Managing Data With Impala and Hive

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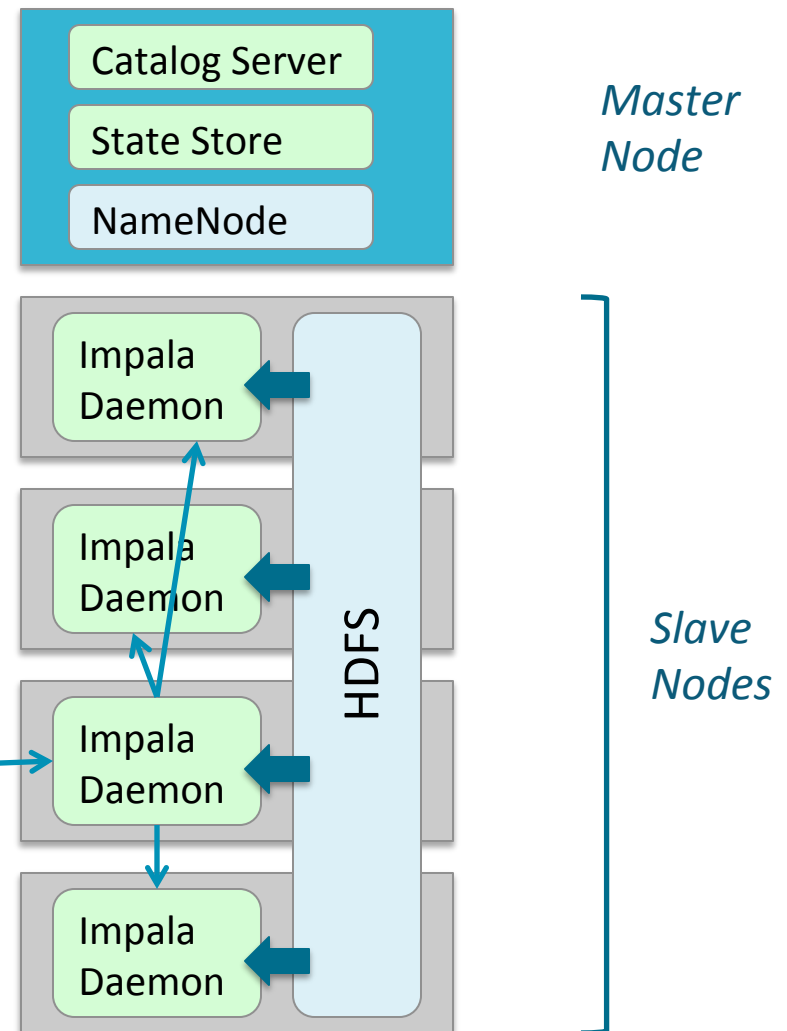
Impala in the Cluster

- **Each slave node in the cluster runs an Impala daemon**
 - Co-located with the HDFS slave daemon (DataNode)
- **Two other daemons running on master nodes support query execution**
 - The **State Store** daemon
 - Provides lookup service for Impala daemons
 - Periodically checks status of Impala daemons
 - The **Catalog** daemon
 - Relays metadata changes to all the Impala daemons in a cluster



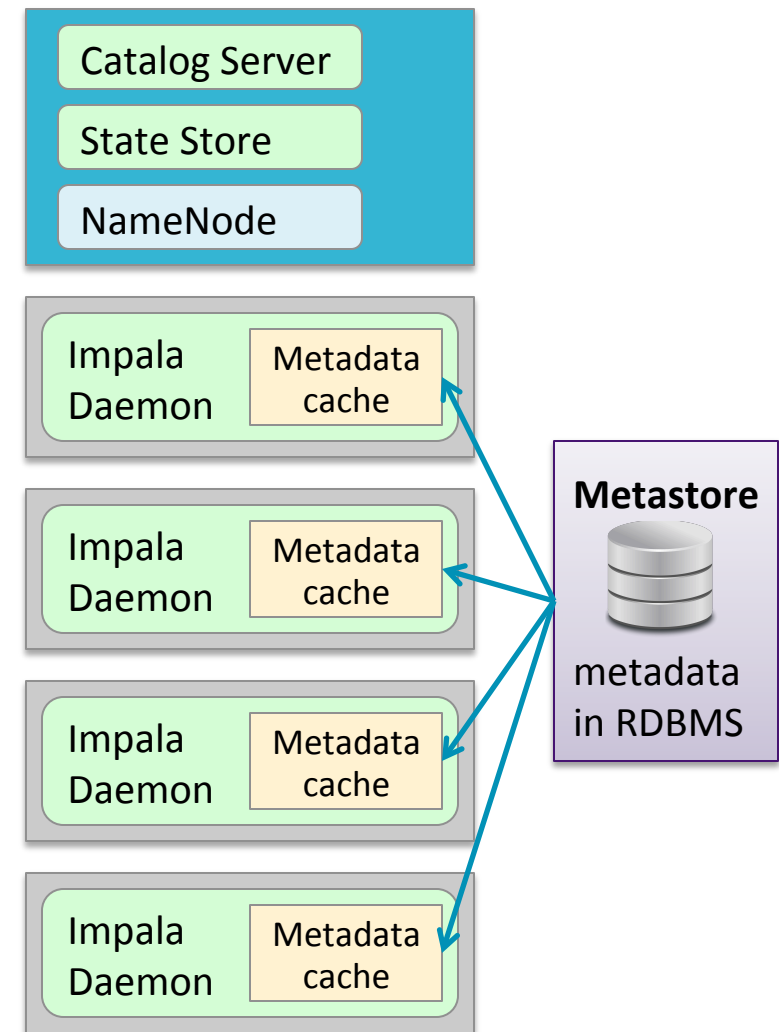
How Impala Executes a Query

- **Impala daemon plans the query**
 - Client (impala-shell or Hue) connects to a local impala daemon
 - This is the *coordinator*
 - Coordinator requests a list of other Impala daemons in the cluster from the State Store
 - Coordinator distributes the query across other Impala daemons
 - Streams results to client



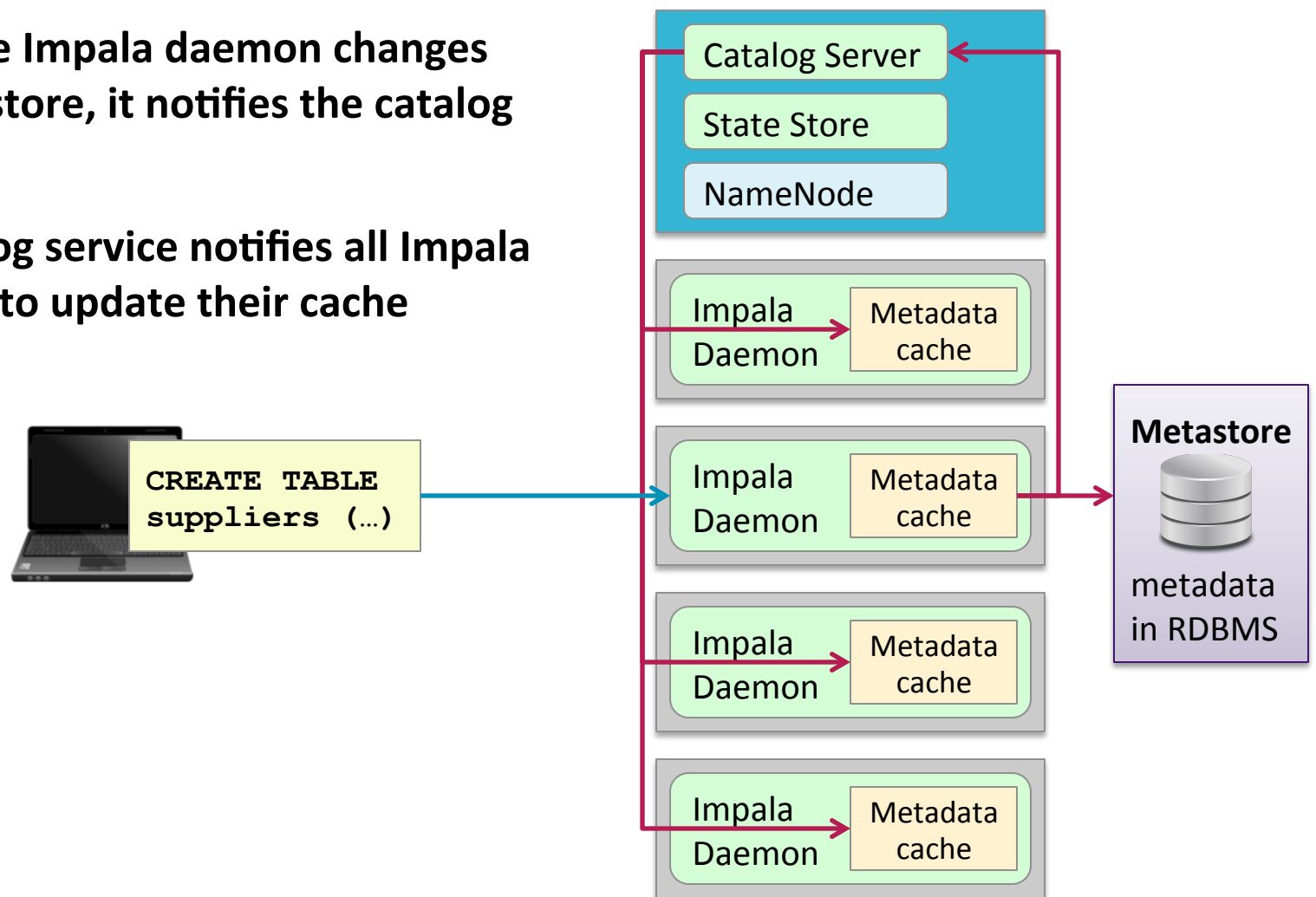
Metadata Caching (1)

- **Impala daemons cache metadata**
 - The tables' schema definitions
 - The locations of tables' HDFS blocks
- **Metadata is cached from the Metastore at startup**



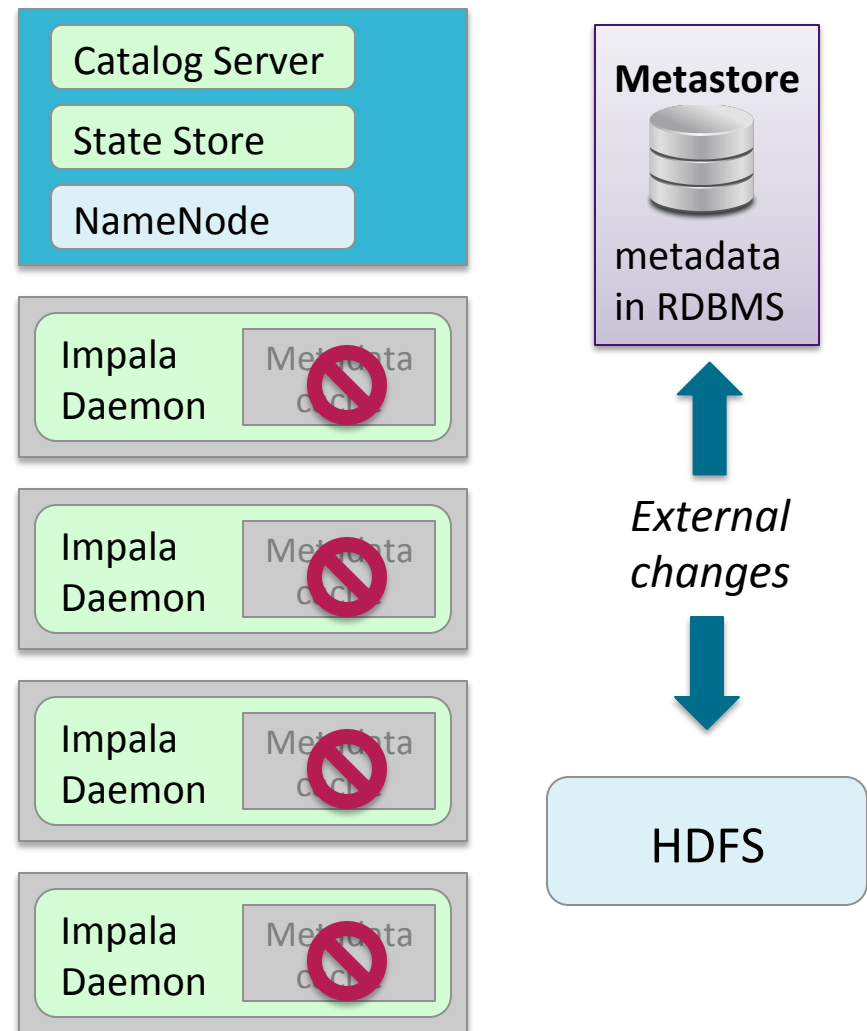
Metadata Caching (2)

- When one Impala daemon changes the metastore, it notifies the catalog service
- The catalog service notifies all Impala daemons to update their cache



External Changes and Metadata Caching

- **Metadata updates made *from outside of Impala* are not known to Impala, e.g.**
 - Changes via Hive, HCatalog or Hue Metadata Manager
 - Data added directly to directory in HDFS
- **Therefore the Impala metadata caches will be invalid**
- **You must manually refresh or invalidate Impala's metadata cache**



Updating the Impala Metadata Cache

External Metadata Change	Required Action	Effect on Local Caches
New table added	INVALIDATE METADATA (with no table name)	Marks the entire cache as stale; metadata cache is reloaded as needed.
Table schema modified <i>or</i> New data added to a table	REFRESH <table>	Reloads the metadata for one table <i>immediately</i> . Reloads HDFS block locations for new data files only.
Data in a table extensively altered, such as by HDFS balancing	INVALIDATE METADATA <table>	Marks the metadata for a single table as stale. When the metadata is needed, all HDFS block locations are retrieved.

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Essential Points

- **Each table maps to a directory in HDFS**
 - Table data is stored as one or more files
 - Default format: plain text with delimited fields
- **The Metastore stores data *about* the data in an RDBMS**
 - E.g. Location, column names and types
- **Tables are created and managed using the Impala SQL or HiveQL Data Definition Language**
- **Impala caches metadata from the Metastore**
 - Invalidate or refresh the cache if tables are modified outside Impala
- **HCatalog provides access to the Metastore from tools outside Hive or Impala (e.g. Pig, MapReduce)**

Bibliography

The following offer more information on topics discussed in this chapter

- **Impala Concepts and Architecture**

- <http://tiny.cloudera.com/adcc12a>

- **Impala SQL Language Reference**

- <http://tiny.cloudera.com/impalasql>

- **Impala-related Articles on Cloudera's Blog**

- <http://tiny.cloudera.com/adcc12e>

- **Apache Hive Web Site**

- <http://hive.apache.org/>

- **HiveQL Language Manual**

- <http://tiny.cloudera.com/adcc10b>

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Homework: Create and Populate Tables in Impala

- **In this homework assignment you will**
 - Create a table in Impala to model and view existing data
 - Use Sqoop to create a new table automatically from data imported from MySQL
- **Please refer to the Homework description**