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Data File Partitioning

Chapter 8

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Data File Partitioning

In this chapter you will learn

- **How to improve query performance with data file partitioning**
- **How to create and populate partitioned tables in Impala and Hive**

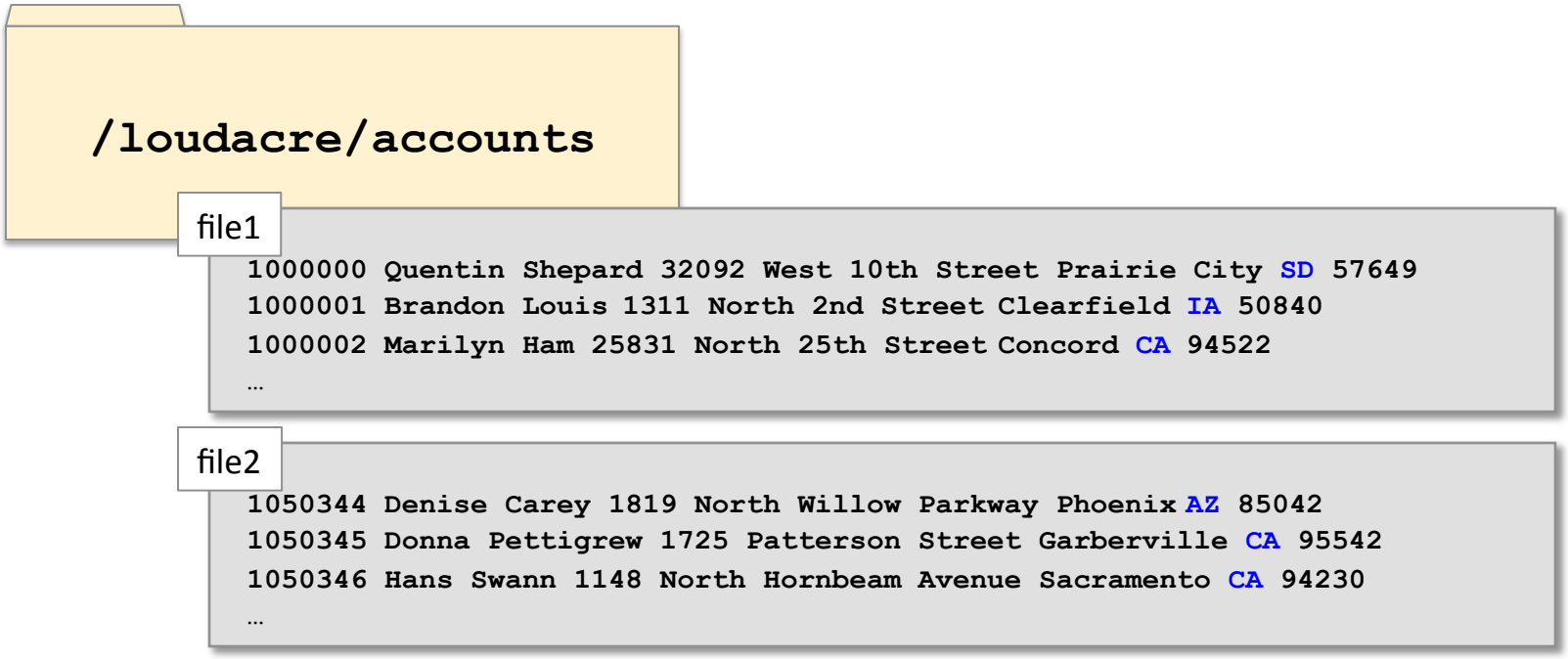
Chapter Topics

Data File Partitioning | **Importing and Modeling Structured Data**

- **Partitioning Overview**
- Partitioning in Impala and Hive
- Conclusion
- Homework: Partition Data in Impala or Hive

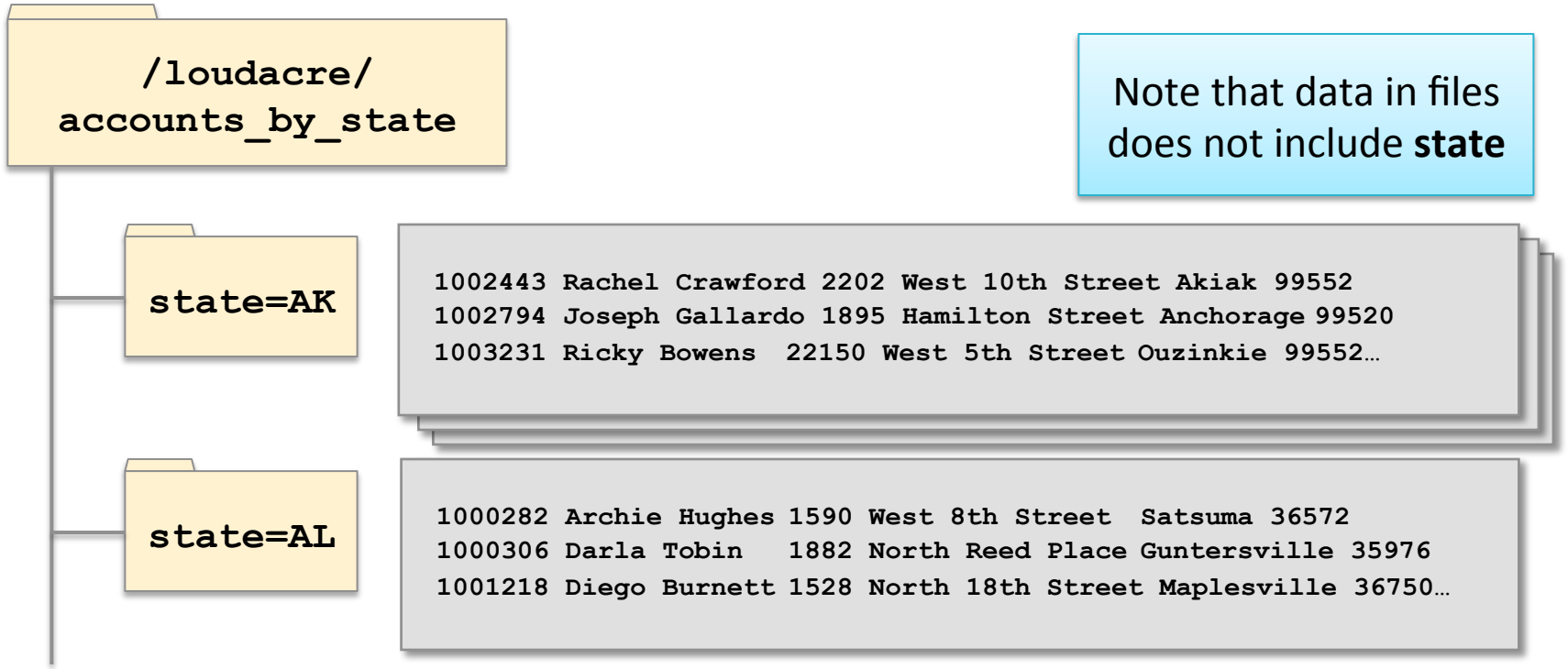
Data Storage Partitioning (1)

- **By default, all files in a data set are stored in a single HDFS directory**
  - *All* files in the directory are read during analysis or processing
  - "Full table scan"



Data Storage Partitioning (2)

- ***Partitioning* subdivides the data**
  - Analysis can be done on only the relevant subset of data
  - Potentially much faster!
- **Hadoop partitions using subdirectories**



Hadoop Partitioning

- **Partitioning is involved at two phases**
  - Storage – putting the data into correct partition (subdirectory)
  - Retrieval – getting the data out of the correct partition based on the query or analysis being done
- **Hadoop with built-in support for partitioning**
  - Hive and Impala (covered in next section)
  - Sqoop – When using the **`--hive-import`** option you can specify flags **`--hive-partition-key`** and **`--hive-partition-value`**
- **Other tools can be used to store partitioned data**
  - Spark and MapReduce
  - Flume (at ingestion)

Chapter Topics

- Partitioning Overview
- **Partitioning in Impala and Hive**
- Conclusion
- Homework: Partition Data in Impala or Hive

Example: Impala/Hive Partitioning Accounts By State (1)

- **Example: `accounts` is a non-partitioned table**

```
CREATE EXTERNAL TABLE accounts(
    cust_id INT,
    fname STRING,
    lname STRING,
    address STRING,
    city STRING,
    state STRING,
    zipcode STRING)
  ROW FORMAT DELIMITED
  FIELDS TERMINATED BY ','
  LOCATION '/loudacre/accounts';
```

Example: Impala/Hive Partitioning Accounts By State (2)

- **What if most of Loudacre's analysis on the customer table was done by state? For example:**

```
SELECT fname, lname
  FROM accounts
  WHERE state='NY';
```

- **By default, all queries have to scan *all* files in the directory**
- **Use partitioning to store data in separate files by state**
  - State-based queries scan only the relevant files

Example: Impala/Hive Partitioning Accounts By State (3)

- **Create a partitioned table using PARTITIONED BY**

```
CREATE EXTERNAL TABLE accounts_by_state(
    cust_id INT,
    fname STRING,
    lname STRING,
    address STRING,
    city STRING,
    state STRING,
    zipcode STRING)
  PARTITIONED BY (state STRING)
  ROW FORMAT DELIMITED
  FIELDS TERMINATED BY ','
  LOCATION '/loudacre/accounts_by_state';
```

Partition Columns

- **The partition column is displayed if you `DESCRIBE` the table**

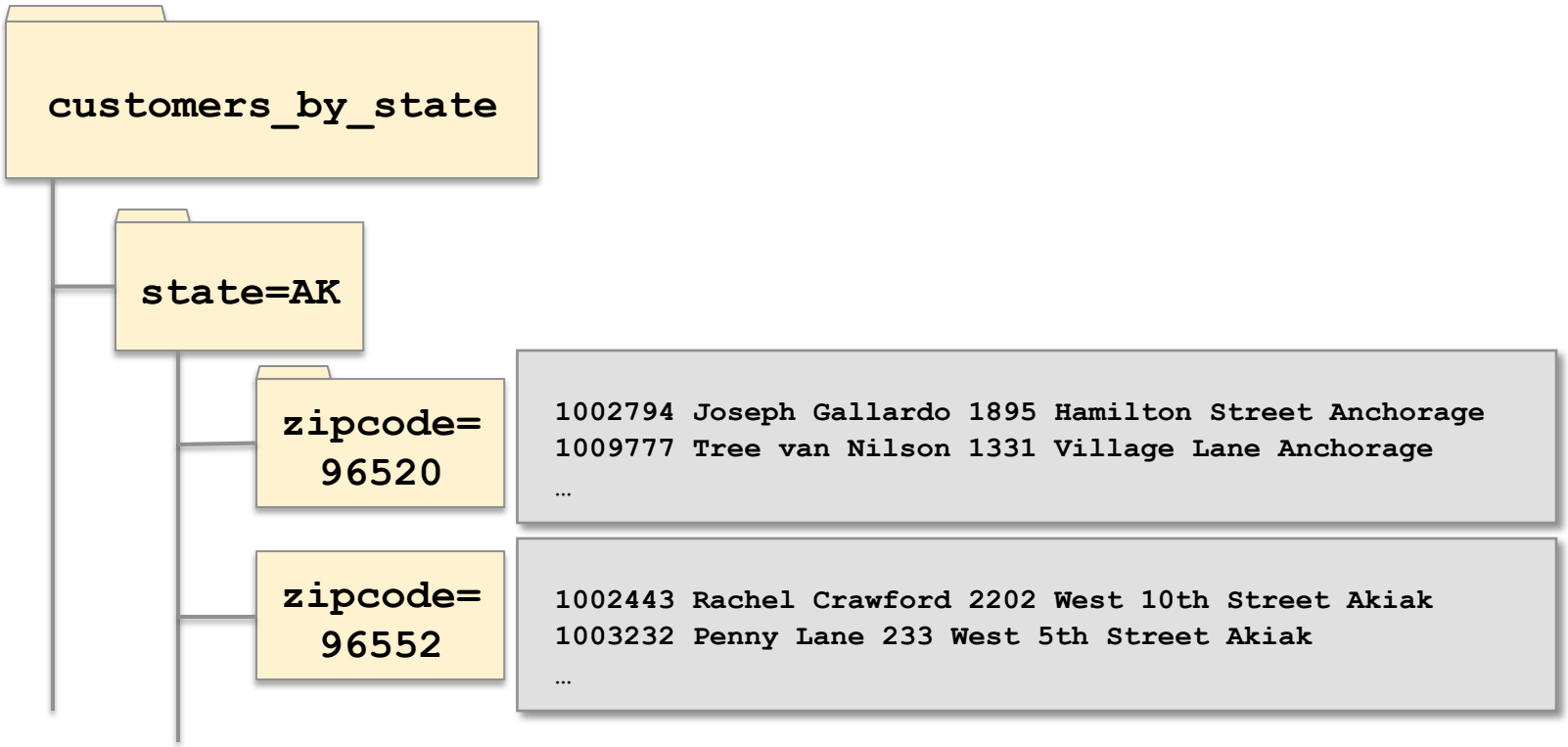
```
DESCRIBE accounts_by_state;
+---------+--------+---------+
| name    | type   | comment |
+---------+--------+---------+
| cust_id | int    |         |
| fname   | string |         |
| lname   | string |         |
| address | string |         |
| city    | string |         |
| zipcode | string |         |
| state   | string |         |
+---------+--------+---------+
```

A partition column is a "virtual column"; data is not stored in the file

Nested Partitions

- **You can also created nested partitions**

```
… PARTITIONED BY (state STRING, zipcode STRING)
```



Loading Data Into a Partitioned Table

- **Dynamic partitioning**
  - Impala/Hive add new partitions automatically as needed at load time
  - Data is stored into the correct partition (subdirectory) based on column value
- **Static partitioning**
  - You define new partitions using `ADD PARTITION`
  - When loading data, you specify which partition to store data in

Dynamic Partitioning

- **We can create new partitions dynamically from existing data**

```
INSERT OVERWRITE TABLE accounts_by_state
  PARTITION(state)
  SELECT cust_id, fname, lname, address,
    city, zipcode, state FROM accounts;
```

- **Partitions are automatically created based on the value of the *last* column**
  - If the partition does not already exist, it will be created
  - If the partition does exist, it will be overwritten

Static Partitioning Example: Partition Calls by Day (1)

- **Loudacre's customer service phone system generates logs detailing calls received**
  - Analysts use this data to summarize previous days' calls
  - For example:

```
SELECT event_type, COUNT(event_type)
  FROM call_log
  WHERE call_date = '2014-10-01'
  GROUP BY event_type;
```

Static Partitioning Example: Partition Calls by Day (2)

- **Logs are generated daily, e.g.**

call-20141001.log

```
19:45:19,312-555-7834,CALL_RECEIVED
19:45:23,312-555-7834,OPTION_SELECTED,Shipping
19:46:23,312-555-7834,ON_HOLD
19:47:51,312-555-7834,AGENT_ANSWER,Agent ID N7501
19:48:37,312-555-7834,COMPLAINT,Item not received
19:48:41,312-555-7834,CALL_END,Duration: 3:22
…
```

call-20141002.log

```
03:45:01,505-555-2345,CALL_RECEIVED
03:45:09,505-555-2345,OPTION_SELECTED,Billing
03:56:21,505-555-2345,AGENT_ANSWER,Agent ID A1503
03:57:01,505-555-2345,QUESTION
…
```

Static Partitioning Example: Partition Calls by Day (3)

- **In the previous example, existing data was partitioned dynamically based on a column value**
- **This time we use static partitioning**
  - Because the data files do not include the partitioning data

Static Partitioning Example: Partition Calls by Day (4)

- **The partitioned table is defined the same way**

```
CREATE TABLE call_logs (
    call_time STRING,
    phone STRING,
    event_type STRING,
    details STRING)
 PARTITIONED BY (call_date STRING)
  ROW FORMAT DELIMITED
  FIELDS TERMINATED BY ',';
```

Loading Data Into Static Partitions (1)

- **With static partitioning, you create new partitions as needed**
- **e.g. For each new day of call log data, add a partition:**

```
ALTER TABLE call_logs
  ADD PARTITION (call_date='2014-10-02');
```

- **This command**
  1. Adds the partition to the table's metadata
  2. Creates subdirectory
     `/user/hive/warehouse/call_logs/call_date=2014-10-02`

Loading Data Into Static Partitions (2)

- **Then load the day's data into the correct partition**

```
LOAD DATA INPATH '/mystaging/call-20141002.log'
  INTO TABLE call_logs
  PARTITION(call_date='2014-10-02');
```

  - This command moves the HDFS file **`call-20141002.log`** to the partition subdirectory

- **To overwrite all data in a partition**

```
LOAD DATA INPATH '/mystaging/call-20141002.log'
  INTO TABLE call_logs OVERWRITE
  PARTITION(call_date='2014-10-02');
```

Hive Only: Shortcut for Loading Data Into Partitions

- **Hive will create a new partition if the one specified doesn't exist**


```
LOAD DATA INPATH '/mystaging/call-20141002.log'
  INTO TABLE call_logs
  PARTITION(call_date='2014-10-02');
```

- **This command**
  1. Adds the partition to the table's metadata if it doesn't exist
  2. Creates subdirectory **`/user/hive/warehouse/call_logs/call_date=2014-10-02`** if it doesn't exist
  3. Moves the HDFS file **`call-20141002.log`** to the partition subdirectory

Viewing, Adding, and Removing Partitions

- **To view the current partitions in a table**

```
SHOW PARTITIONS call_logs;
```

- **Use `ALTER TABLE` to add or drop partitions**

```
ALTER TABLE call_logs
   ADD PARTITION (call_date='2013-06-05')
   LOCATION '/loudacre/call_logs/call_date=2013-06-05';
```

```
ALTER TABLE call_logs
   DROP PARTITION (call_date='2013-06-06');
```

Creating Partitions from Existing Partition Directories in HDFS

- **Partition directories in HDFS can be created and populated outside Hive or Impala**
  - For example, by a Spark or MapReduce application
- **In Hive, use the `MSCK REPAIR TABLE` command to create (or recreate) partitions for an existing table**


```
MSCK REPAIR TABLE call_logs;
```

When To Use Partitioning

- **Use partitioning for tables when**
  - Reading the entire data set takes too long
  - Queries almost always filter on the partition columns
  - There are a reasonable number of different values for partition columns
  - The data generation or ETL process segments data by file or directory names
    - Partition column values are not in the data itself

When *Not* To Use Partitioning

- **Avoid partitioning data into numerous small data files**
  - Don't partition on columns with too many unique values
- **Caution: This can happen easily when using dynamic partitioning!**
  - For example, partitioning customers by first name could produce thousands of partitions

Partitioning in Hive (1)

- **In older versions of Hive, dynamic partitioning is not enabled by default**
  - Enable it by setting these two properties

```
SET hive.exec.dynamic.partition=true;
SET hive.exec.dynamic.partition.mode=nonstrict;
```

- **Note: Hive variables set in Beeline are for the current session only**
  - Your system administrator can configure settings permanently

Partitioning in Hive (2)

- **Caution: if the partition column has many unique values, many partitions will be created**
- **Three Hive configuration properties exist to limit this**
  - **`hive.exec.max.dynamic.partitions.pernode`**
    - Maximum number of dynamic partitions that can be created by any given node involved in a query
    - Default 100
  - **`hive.exec.max.dynamic.partitions`**
    - Total number of dynamic partitions that can be created by one HiveQL statement
    - Default 1000
  - **`hive.exec.max.created.files`**
    - Maximum total files (on all nodes) created by a query
    - Default 100000

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- Partitioning Overview
- Partitioning in Impala and Hive
- **Conclusion**
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Essential Points

- **Partitioning splits table storage by column values for improved query performance**
- **Partitions are HDFS directories**
  - Names follow the format ***`column=value`***
- **Partitions can be defined and loaded dynamically or statically**
- **Only partition on columns with a reasonable number of possible values**

Bibliography

The following offer more information on topics discussed in this chapter

- **Impala documentation on partitioning**
  - `http://tiny.cloudera.com/impalapart`
- **Improving Query Performance Using Partitioning in Apache Hive (Cloudera Engineering Blog)**
  - `http://tiny.cloudera.com/partblog`

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Homework: Partition Data in Impala or Hive

- **In this homework assignment you will**
  - Create a table for accounts that is partitioned by area code
- **Please refer to the Homework description**