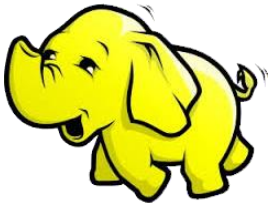
Programming in Hadoop with Pig and Hive

Hadoop Review

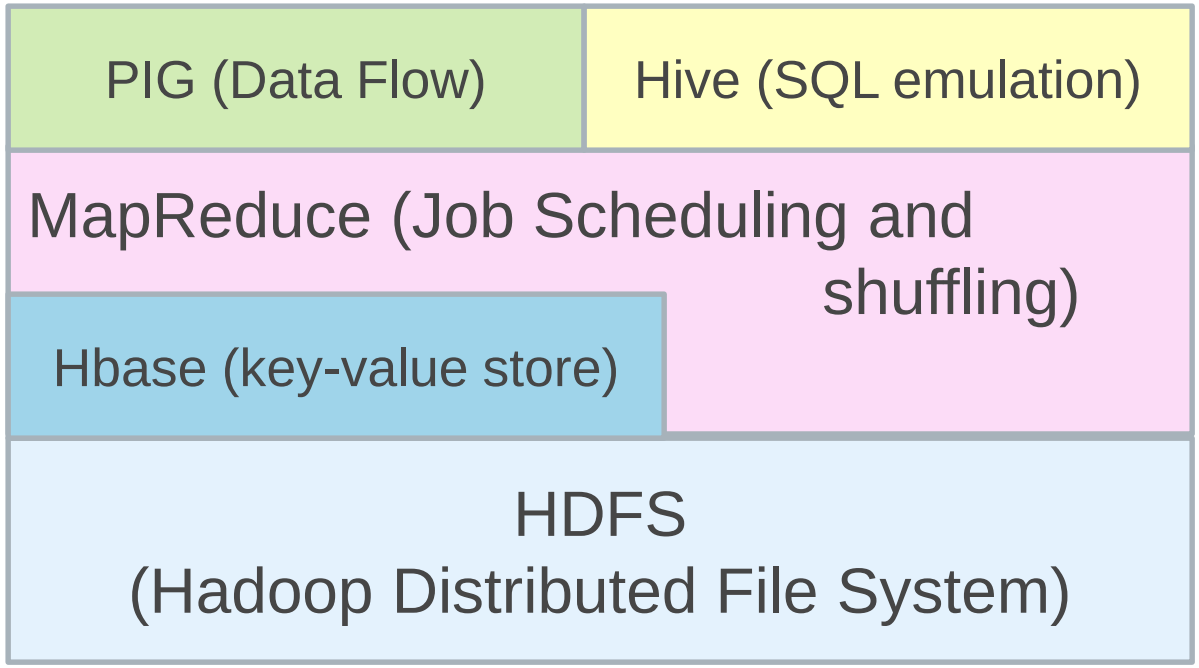
- Hadoop is a open-source reimplementation of
  - A distributed file system
  - A map-reduce processing framework
  - A big-table data model
- Inspired by Google's own description of the technologies underpinning their search engine
- It is a layer-cake of APIs, written mostly in Java, that one can use to write large, distributed, and scalable applications to search and process large datasets

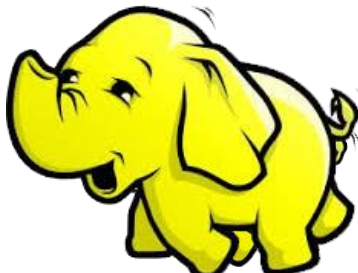


Hadoop Layer Cake

While Hadoop has many advantages, it is not intuitive to translate every data exploration/manipulation/searching task into a serie of map-reduce operations.

Higher-level languages were needed.

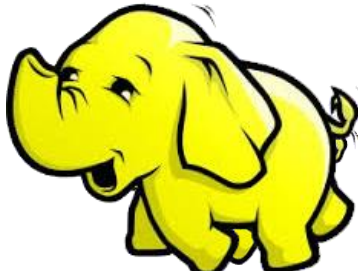




High-level approaches for specifying Hadoop jobs

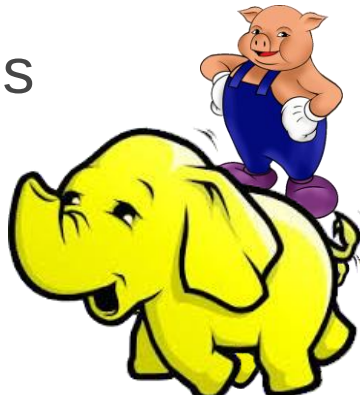
- **PIG** – A scripting language for transforming big data
  - Useful for “cleaning” and “normalizing” data
  - Three parts:
    - Pig Latin – The scripting language
    - Grunt – A interactive shell
    - Piggybank – A repository of Pig extensions
  - Deferred execution model

- **Hive** – A SQL-inspired query-oriented language
  - Imposes structure, in the form of schemas, on Hadoop data
  - Creates “data warehouse” layers



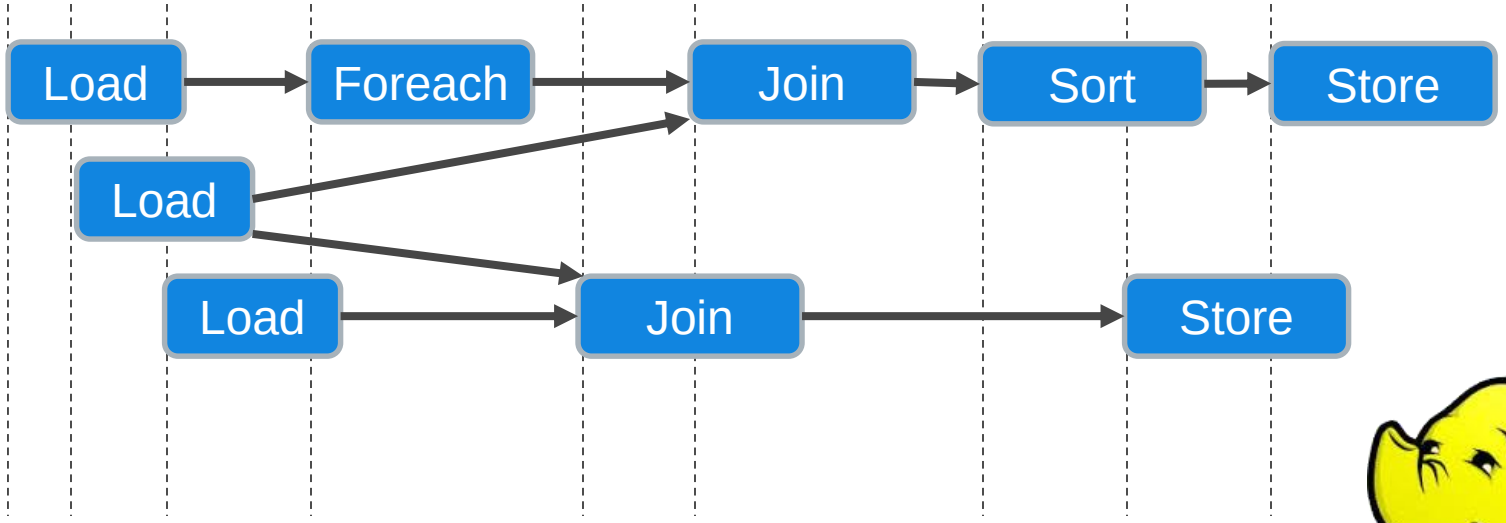
Pig Latin's data model

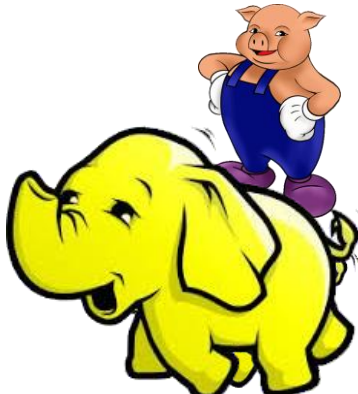
- PIG – A dataflow scripting language
  - Automatically translated to a series of Map-Reduce jobs that are run on Hadoop
  - It requires no meta-data or schema
  - It is extensible, via user-defined functions (UDFs) written in Java or other languages (C, Python, etc.)
  - Provides run-time and debugging environments
  - A language specifically designed for data manipulations and analysis
    - Supports join, sort, filter, etc.
    - Automatically partitions large operations into smaller jobs and chains them together



Pig Latin scripts describe dataflows

- Every Pig Latin script describes one or more flows of data through a series of operations that can be processed in parallel (i.e. the next one can start before the ones providing inputs to it finish).
- Dataflows are Directed Acyclic Graphs (DAGS)
- Ordering and Scheduling is deferred until a node generates data

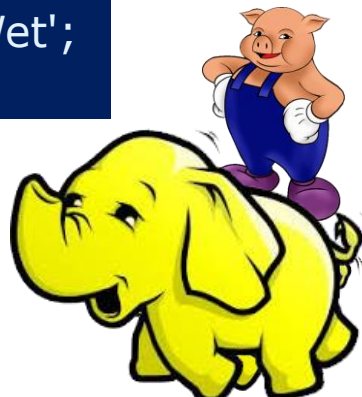




Pig Latin Processing

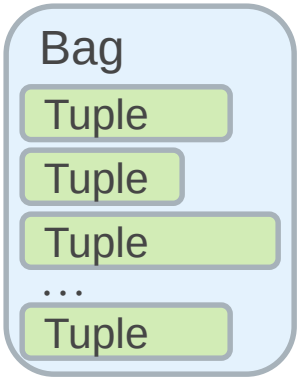
- Pig Latin script are processed line by line
  - Syntax and References are checked
  - Valid statements are added to a logical plan
  - Execution is deferred until either a DUMP or STORE statement is reached
  - Reused intermediate results are mapped to a common node

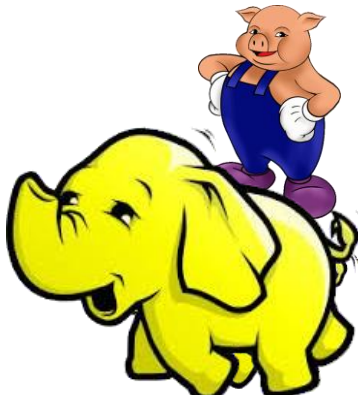
```
grunt> Mokepo = LOAD "monkepo.csv";
grunt> WetOnes = FILTER Monkepo BY $1='Wet' OR $2='Wet';
grunt> DUMP WetOnes;
```



Pig Relations

- Pig variables are bags of tuples
  - Fields – data items
  - Tuples – a vector of fields
  - Bags – a collection of unordered tuples
    - Unlike *Relations* in relational databases the tuples in a Pig bag, need not have the same number of fields, or the same types
- Pig also supports Maps
  - Maps – a dictionary of name-value pairs





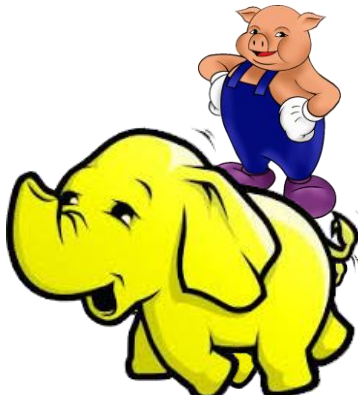
Pig Latin Examples

- Pig scripts are easy to read

```
Mokepo = LOAD "monkepo.csv" USING PigStorage(',') AS
   (name:chararray, majorclass:chararray, minorclass:chararray,
    latitude:double, longitude:double, date:datetime);
WetOnes = FILTER Monkepo BY (majorclass='Wet' OR minorclass='Wet')
    AND date >= '2016-11-23' AND date <= '2016-11-30';
Groups = GROUP WetOnes BY name;
STORE Groups INTO "WetTypes/";
```

- FOREACH to specify processing steps for all tuples in a bagexample

```
e1 = LOAD "input/Employees" USING PigStorage(',') AS
   (name:chararray, age:int, zip:int, salary:double);
f = FOREACH e1 GENERATE age, salary;
DESCRIBE f;
DUMP f;
```



More Pig Latin Examples

- ORDER

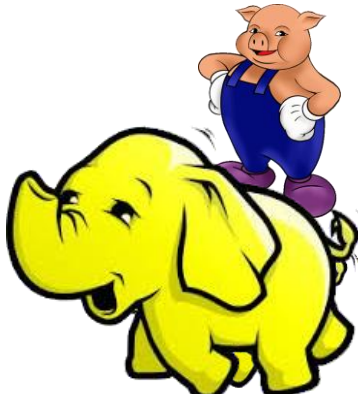
```
emp = LOAD "input/Employees" USING PigStorage(',') AS
    (name:chararray, age:int, zip:int, salary:double);
sorted = ORDER emp BY salary;
```

- LIMIT

```
emp = LOAD "input/Employees" USING PigStorage(',') AS
    (name:chararray, age:int, zip:int, salary:double);
agegroup = GROUP emp BY age;
shortlist = LIMIT agegroup 100;
```

- JOIN

```
emp = LOAD "input/Employees" USING PigStorage(',') AS
    (name:chararray, age:int, zip:int, salary:double);
pbk = LOAD "input/Phonebook" USING PigStorage(',') AS
    (name:chararray, phone:chararray);
contact = JOIN emp BY name, pbk BY name;
DESCRIBE contact;
DUMP contact;
```



Hive Query Language

- Hive is an alternative/complement to Pig
  - Hive is a SQL-like Query language
  - It imposes "Structure" on "Unstructured" data
  - Needs a predefined schema definition
  - It is also extensible, via user-defined functions (UDFs) written in Java or other languages (C, Python, etc.)
- Hive does NOT make Hadoop a relational database
  - No transactions, no isolation, no consistency promises
  - Searches and processes Hadoop data stores
  - Not suitable for real-time queries and row-level updates
  - Generally much higher latency than a DBMS, but higher performance
  - Best for batch jobs over large "immutable" data

Hive Query Language

- Hive is best used to perform analyses and summaries over large data sets
- Hive requires a meta-store to keep information about virtual tables
- It evaluates query plans, selects the most promising one, and then evaluates it using a series of map-reduce functions
- Hive is best used to *answer a single instance of a specific question* whereas Pig is best used to accomplish *frequent reorganization, combining, and reformatting* tasks

Hive Query Language

- Hive is similar to SQL-92
- Based on familiar database concepts, tables, rows, columns, and schemas
- Makes "Big Data" appear as tables on the fly
- Like Pig, Hive has a command-line shell

```
$ hive
hive>
```

- Or it can execute scripts

```
$ hive -f myquery.hive
```

- There are also WIMP interfaces

Defining Hive Tables

- A Hive table consists of
  - Data linked to a file or multiple files in an HDFS
  - Schema stored as mapping of the data to a set of columns with types
- Schema and Data are separated
  - Allows multiple schemas on the same data

```
$ hive
hive> CREATE TABLE Monkepo (
      name string,
      majorclass string,
      minorclass string,
      latitude real,
      longitude real,
      date datetime)
      ROW FORMAT DELIMITED
      FIELDS TERMINATED BY ','
      STORED AS TEXTFILE;
```

More Operations on Hive Tables

Table Operation	Command Syntax
See current tables	hive> SHOW TABLES;
Check schema	hive> DESCRIBE Monkepo;
Change table name	hive> ALTER TABLE Monkepo RENAME TO Pokemon;
Add a column	hive> ALTER TABLE Monkepo ADD COLUMNS (RealName, STRING);
Drop a partition	hive> ALTER TABLE Monkepo DROP PARTITION (Name='PigDye');

Loading Hive Tables

- Use LOAD DATA to import data into a HIVE table

```
$ hive
hive> LOAD DATA LOCAL INPATH 'monkepo.csv'
        INTO TABLE Monkepo;
```

- No files are modified by Hive, the schema simply imposes structure on the file as it is read
- You can use the keyword OVERWRITE to modify previous loaded files
- Loading a file creates a "data warehouse"
- Schema is verified as data is queried
- Missing columns are mapped to NULL

Loading Hive Tables

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```
hive> LOAD DATA INPATH '/project/monkepo.csv'
hive>         OVERWRITE INTO TABLE Monkepo;
hive> INSERT INTO WetOnes
hive>         SELECT * FROM Monkepo
hive>         WHERE majorclass='wet'
hive>               OR minorclass='wet';
```

- Missing columns are mapped to NULL

Loading Hive Tables

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- You can use the keyword OVERWRITE to modify previous loaded files
- Missing columns are mapped to NULL
- INSERT is used to populate one Hive table from another

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hive>         SELECT * FROM Monkepo
hive>         WHERE majorclass='wet'
hive>               OR minorclass='wet';
```

Hive Queries

- SELECT

```
$ hive
hive> SELECT * FROM WetOnes;
```

- Supports the following:
  - WHERE clause
  - UNION ALL
  - DISTINCT
  - GROUP BY and HAVING
  - LIMIT
  - JOIN,
  - LEFT OUTER JOIN, RIGHT OUTER JOIN, OUTER JOIN
    - Returned rows are random, and may vary between calls
- Can use regular expressions in column specification

```
$ hive
hive> SELECT M.name, 'M.*class', 'M.l*ude'
hive>        FROM Monkepo M;
```

Hive Query Examples

```
hive> SELECT * FROM customers;
hive> SELECT COUNT(*) FROM customers;
hive>
hive> SELECT first, last, address, zip FROM customers
hive> WHERE orderID > 0
hive> GROUP BY zip;
hive>
hive> SELECT customers.*, orders.*
hive> FROM customers JOIN orders
hive>     ON (customers.customerID – orders.customerID);
hive>
hive> SELECT customers.*, orders.*
hive> FROM customers LEFT OUTER JOIN orders
hive>     ON (customers.customerID – orders.customerID);
```

- If you understand SQL, you should be able to follow
- Note: These are queries, not transactions
- The data's state could change between and within a query

Hive Subqueries

- Hive allows subqueries only within FROM clauses

```
hive> SELECT sid, mid, total FROM
hive>       (SELECT sid, mid, refCnt + altCnt AS total
hive>        FROM genotype)  gtypeTotals
hive> WHERE total > 20;
```

- Subqueries are generally materialized (computed and saved as hive tables)
- You MUST to include a name for the subquery result table
- The columns of a subquery's SELECT list are available to the outer query

Sorting in Hive

- Hive supports ORDER BY, but its result differs from SQL's
  - Only one Reduce step is applied and partial results are broadcast and combined
  - No need for any intermediate files
  - This allows optimization to a single MapReduce step

- Hive also supports SORT BY with multiple fields
  - Produces a "total ordering" of all results
  - Might require multiple MapReduce operations
  - Might materialize several intermediate tables

Summary

- There are two primary "high-level" programming languages for Hadoop-- Pig and Hive

- *Pig* is a "scripting language" that excels in specifying a processing pipeline that is automatically parallelized into Map-Reduce operations
  - Deferred execution allows for optimizations in scheduling Map-Reduce operations
  - Good for general data manipulation and cleaning
- *Hive* is a "query languge" that borrows heavily from SQL, which excels for searching and summarizing data
  - Requires the specification of an "external" schema
  - Often materializes many more intermediate results than a DBMS would