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Strata2013HiveTutorial

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Hadoop Data Warehousing with *Hive*

Monday, February 25, 13

Think Big Analytics provides Big Data consulting and training. This tutorial is based on our Hive courseware.
The bit.ly link points to the zip file with the slides, exercises, etc.: http://bit.ly/Strata2013HiveTutorial. So, uh, zip warning!

Dean Wampler

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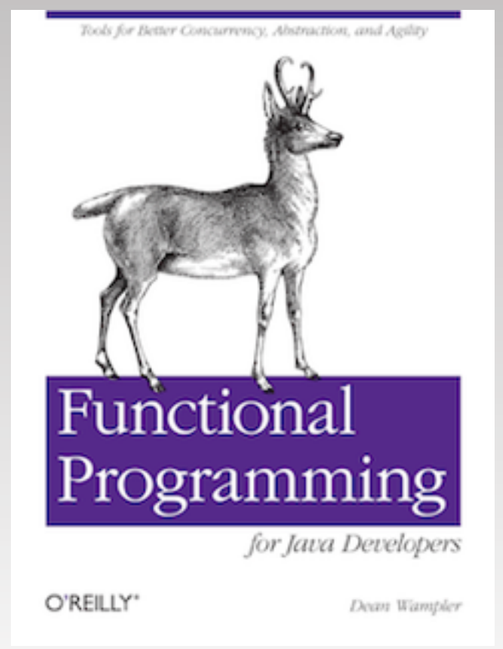

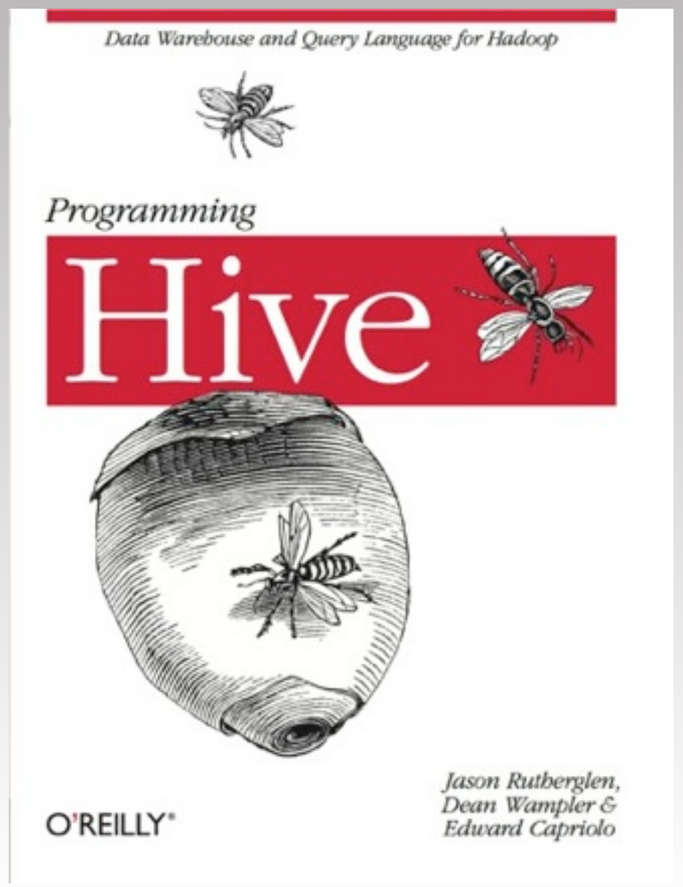

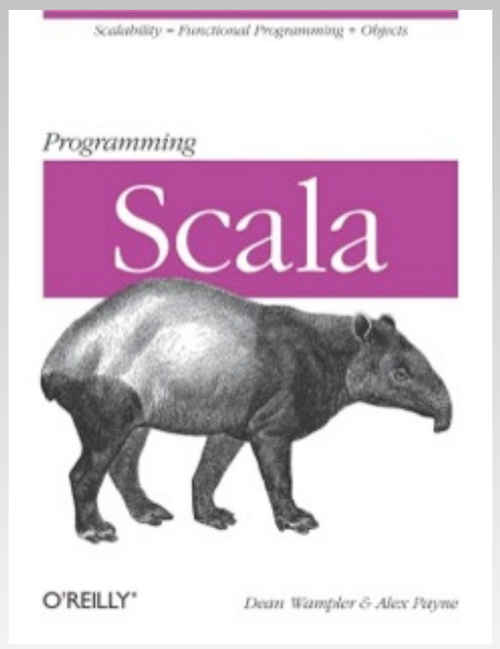

I'm the co-author of Programming Hive and books on the Scala Programming language and Functional Programming for Java Developers.

Why *Hive*?

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To warm up, let's review new features in the last few releases. Some of you may be working on v0.7.x or v0.8.x. Let's discuss what's new in v0.8.1 through v0.10.0.

You've missed
your old friends...

SQL Databases

If you've been in the Hadoop world a while, you might be missing the richness and maturity of SQL databases…

Hadoop is
not a *database*,

but you can use *SQL*
to ask it *questions*!

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instead, we wanted to introduce a more general-purpose platform, Hadoop, and how you can use a very traditional tool, SQL, to ask questions of your data.

Hadoop:
Designed for *Big Data*.

A brief overview of Hadoop, so we're all on the "same page".

Big Data: too big for *traditional* tools.

So, *scale horizontally*,
for *storage* and CPU *cycles*.

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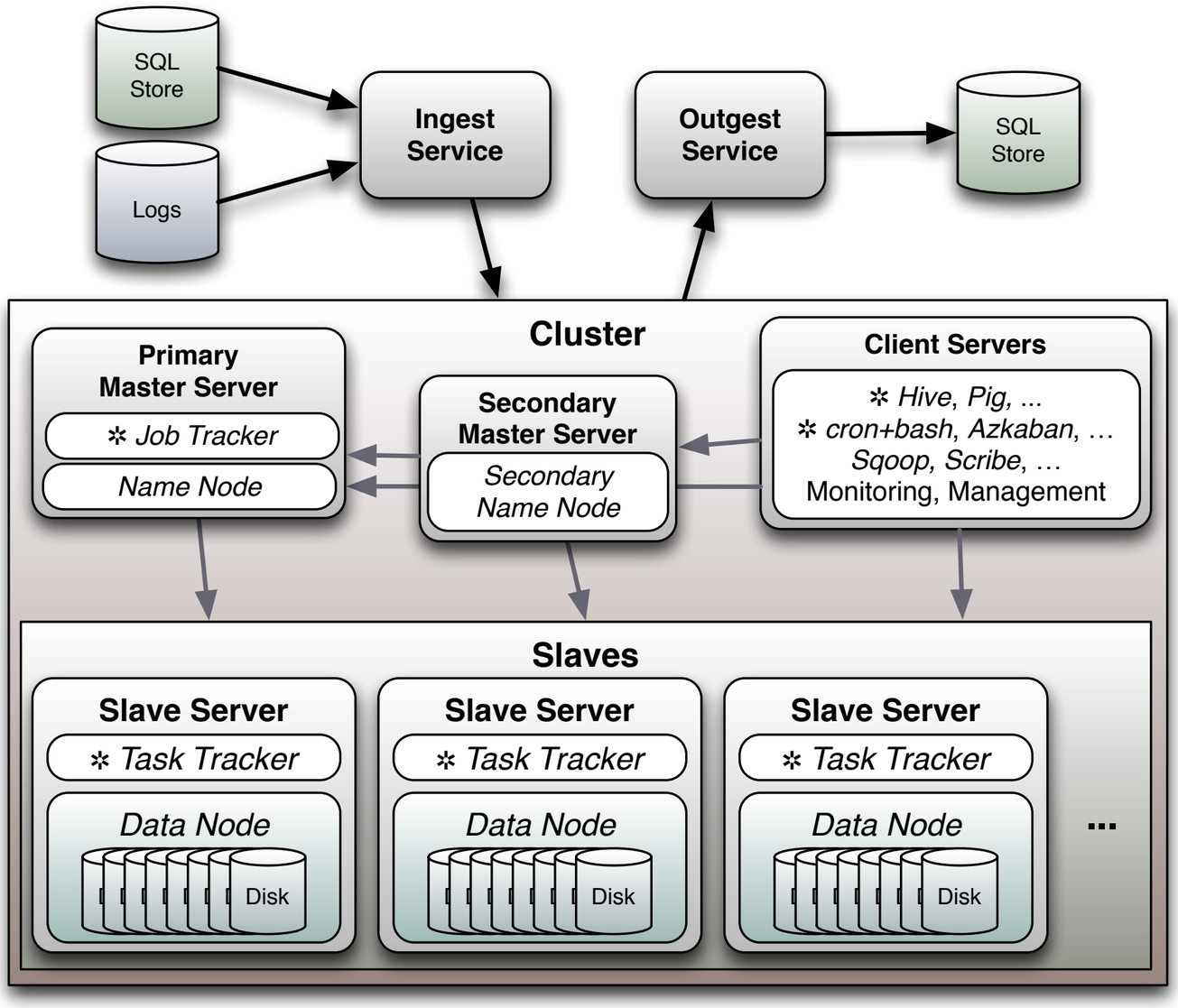
"Big Data" informally refers to the problem of working with data sets that are too large to manage with traditional SQL stores, either because they can't scale sufficiently or the cost/TB is prohibitive. So, the solution is technology better designed for horizontal scalability and processing.

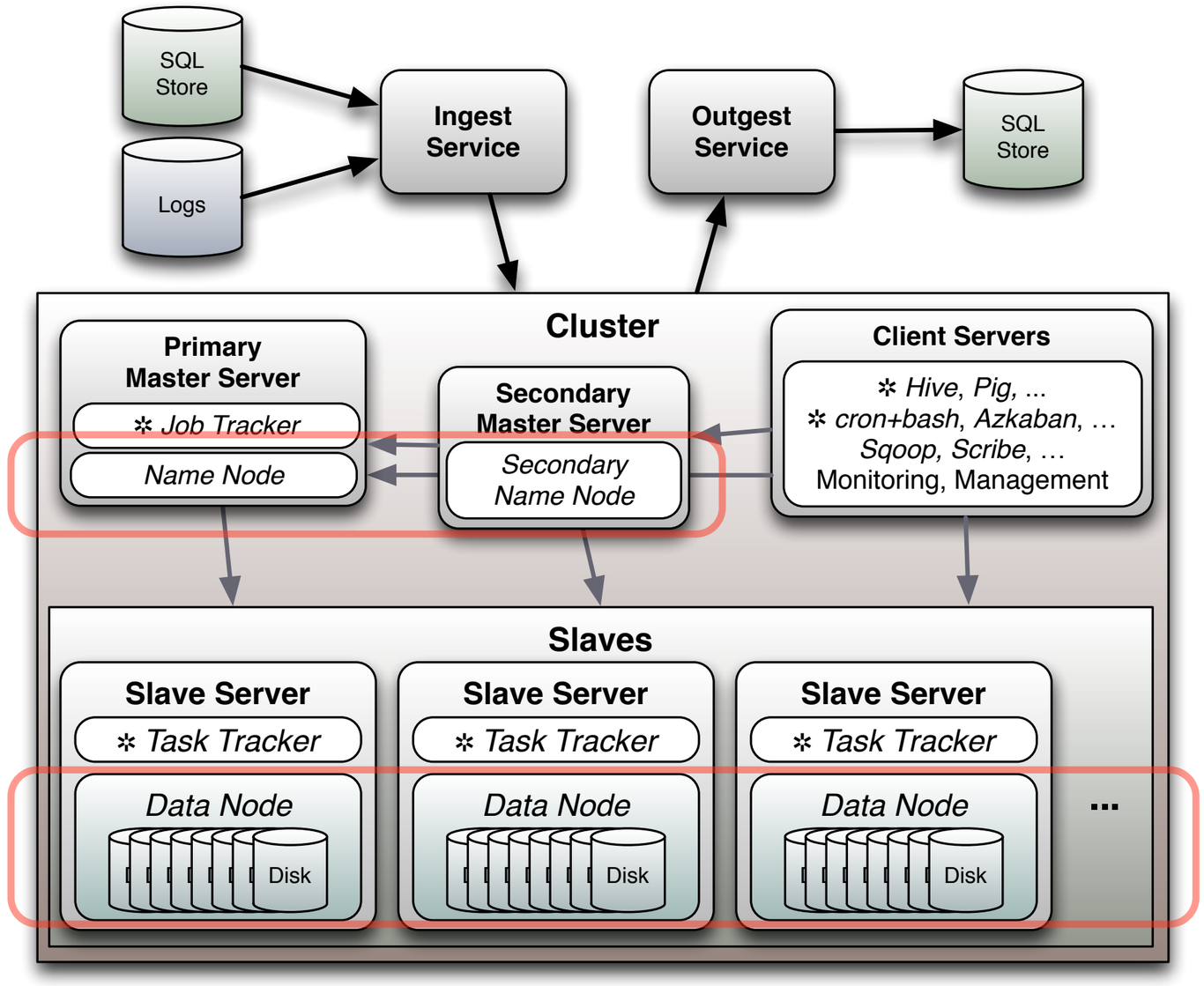
Hadoop Cluster



Here is a typical cluster configuration. (It would be slightly different for an Amazon Elastic MapReduce cluster, like the ones we are using for the exercises.)
I marked the processes involved in running MapReduce (data crunching) jobs with a “gear” (okay, it’s an asterisk…). I also used italics for actual process names (although there may be subprocesses not shown).

Hadoop Distributed FS

- Services
  - *Name Node*
  - *Secondary NN*
  - *Data Nodes*
- 64MB blocks
- 3x replication



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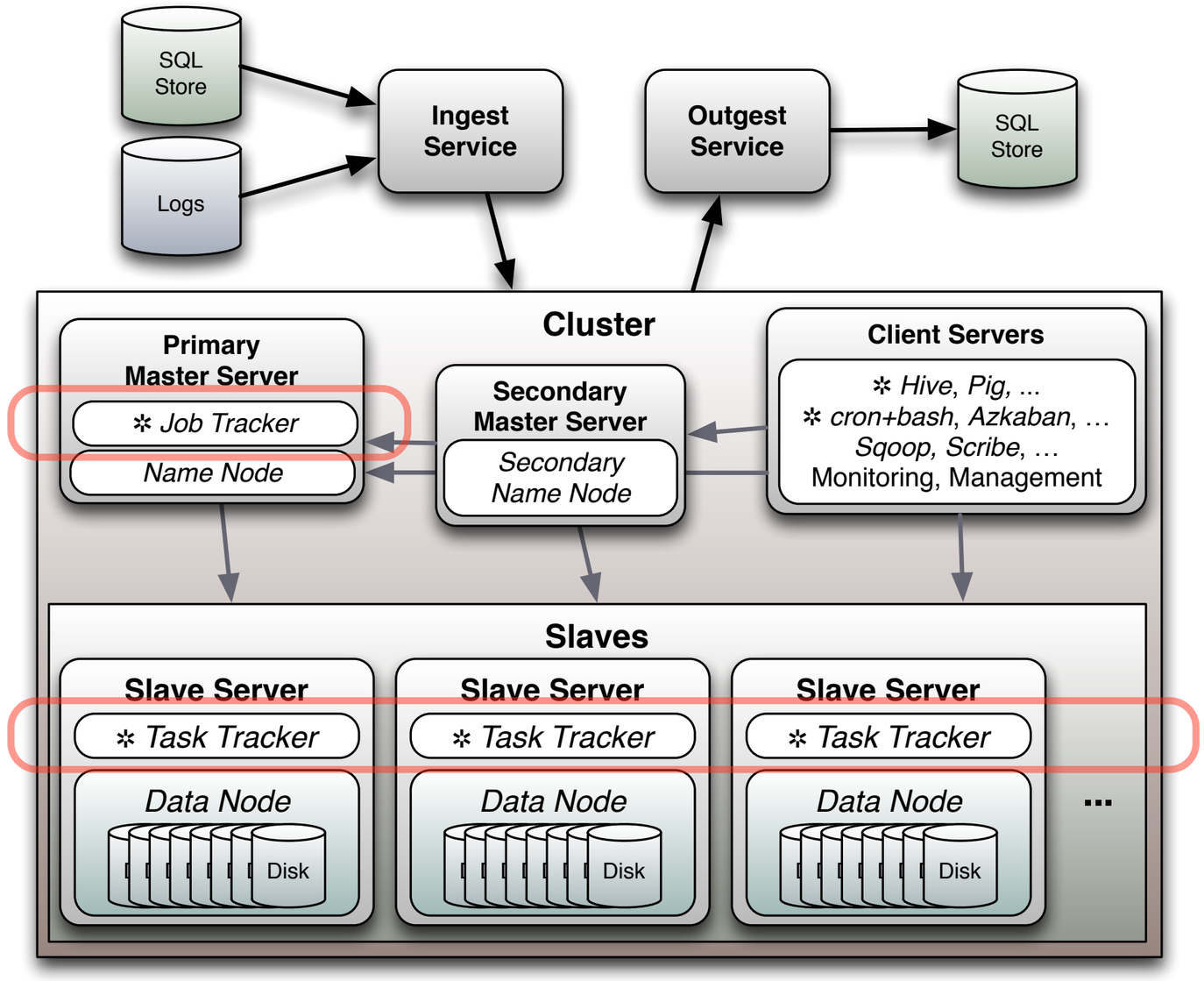
At the bottom is the Hadoop Distributed File System. It sits on top of the native file system and uses 64MB blocks (default) to store large streams of data, so scanning the drives is very fast. Not so good, though, for small files! Also, since you'lll regularly lose drives when you have 1000s of them in a large cluster, each block is replicated 3 times (default), with each block on a separate server.
The Name Node maintains the metadata for the whole filesystem.
The Secondary Name Node is a misnomer and it is being replaced in a forthcoming release of Hadoop. It is really a housekeeping service that offloads work from the name node, namely the persisting of in-memory metadata information. We'll investigate further later shortly.
Each Data Node knows how it stores its blocks (e.g., native file names…).

Jobs and Tasks

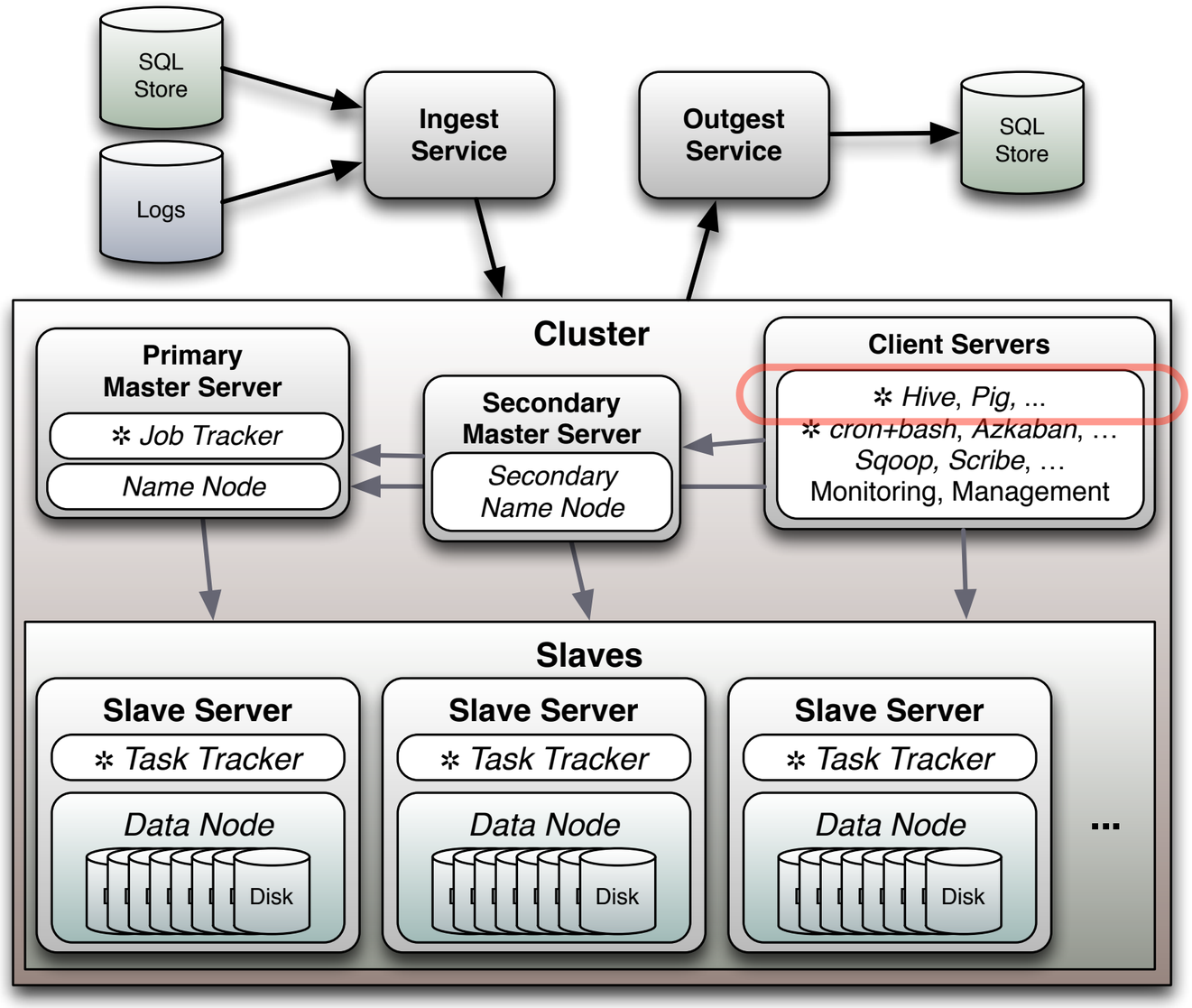
- Services
  - *Job Tracker*
  - *Task Trackers*



"Jobs" are controlled by the Job Tracker "master" process. It sends "tasks" to individual Task Trackers on the "slave" nodes. It tries to send a task to the server that already has the data for that task, to minimize streaming lots of data over the network.
The Job Tracker does the bookkeeping to ensure that every task completes successfully. It will restart failed tasks (for whatever reason) and it can even restart tasks that appear hung, but not yet failed.

Creating Apps

- Java API
- *Hive*
- *Pig*
- *Cascading*, ...
- *Mahout*
- *others...*



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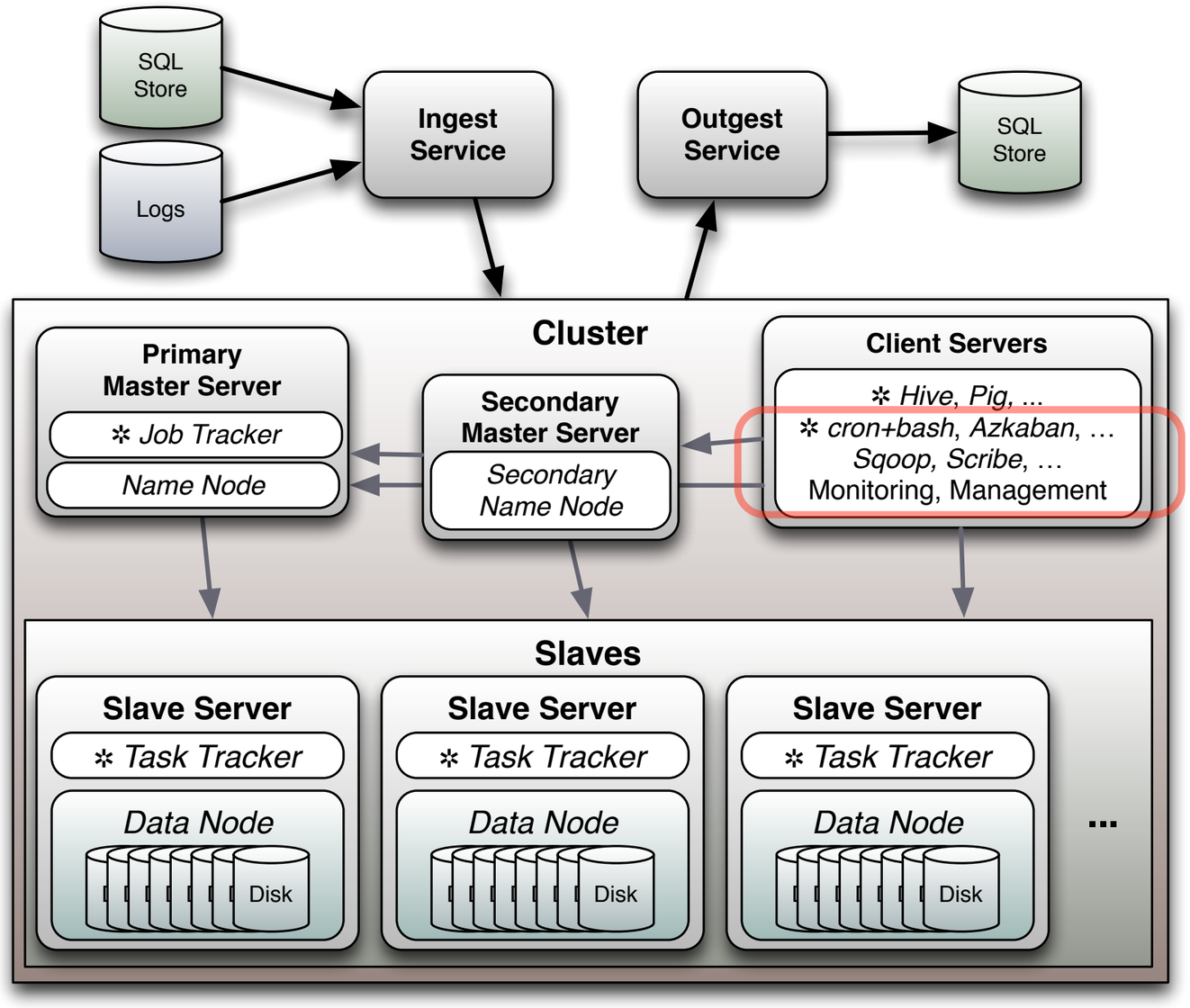
As we'll see, the MapReduce API is the assembly language of this ecosystem. It's great when you need the fine-grained control, but otherwise, it can be very difficult to map data flows and complex queries into MR. Also, non-developers can't write Java code and the Streaming API isn't much better for them. So, higher-level tools exist that present a better DSL for users and drive MR to execute the work. Here are some of the options.
Hive is a SQL-like language invented at Facebook. It's ideal for data warehouse applications.
Pig is a data flow language that is great for complex transformations, but is harder to learn for people with a SQL background.
Both Hive and Pig can be extended with "User Defined Functions" (UDFs) and in other ways, as we'll see.
We'll spend most of tomorrow on Hive and most of the next day on Pig.
Cascading is a Java API providing higher-level abstractions. There are very good Clojure and Scala wrappers that further improve productivity.
Mahout is a Machine Learning library that runs on Hadoop (although it also has standalone components).
The 3rd-party tools include developer-oriented tools and commercial query tools.

Enterprise Integration, etc.

- ETL
  - *Scoop*, *Scribe*, *Flume*, …
- Monitoring, ...



Other tools include extract, transform, and load tools (ETL) for moving log and DB data into Hadoop and exporting back to DBs, as needed. There are job scheduling and monitoring tools, too...

Hadoop Design Goals:

Maximize Disk I/O!!

Oh, and run on commodity, server-class hardware.

Many of the strengths and limitations of Hadoop are oriented around maximizing disk I/O for up to petabytes of data.

Hadoop Design Goals:

Batch Processing:

JVM spin-up for big tasks, lots of disk sector scans.

Hadoop Design Goals:

Batch Processing:

Not so great for

"real-time" event processing.

Use Cases (Today):

Storing large data sets.
Long-running jobs *crunch*
that data in *parallel*.

Use Cases (Tomorrow):

Better event processing,
incremental updates.

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The batch orientation is a great start, but long term, Hadoop will need to be better at incremental algorithms and suitability for “real time”, event processing. People want answers now, not overnight.
HBase + Hadoop is currently the best Hadoop-oriented pseudo-real-time option.

What is *MapReduce*?

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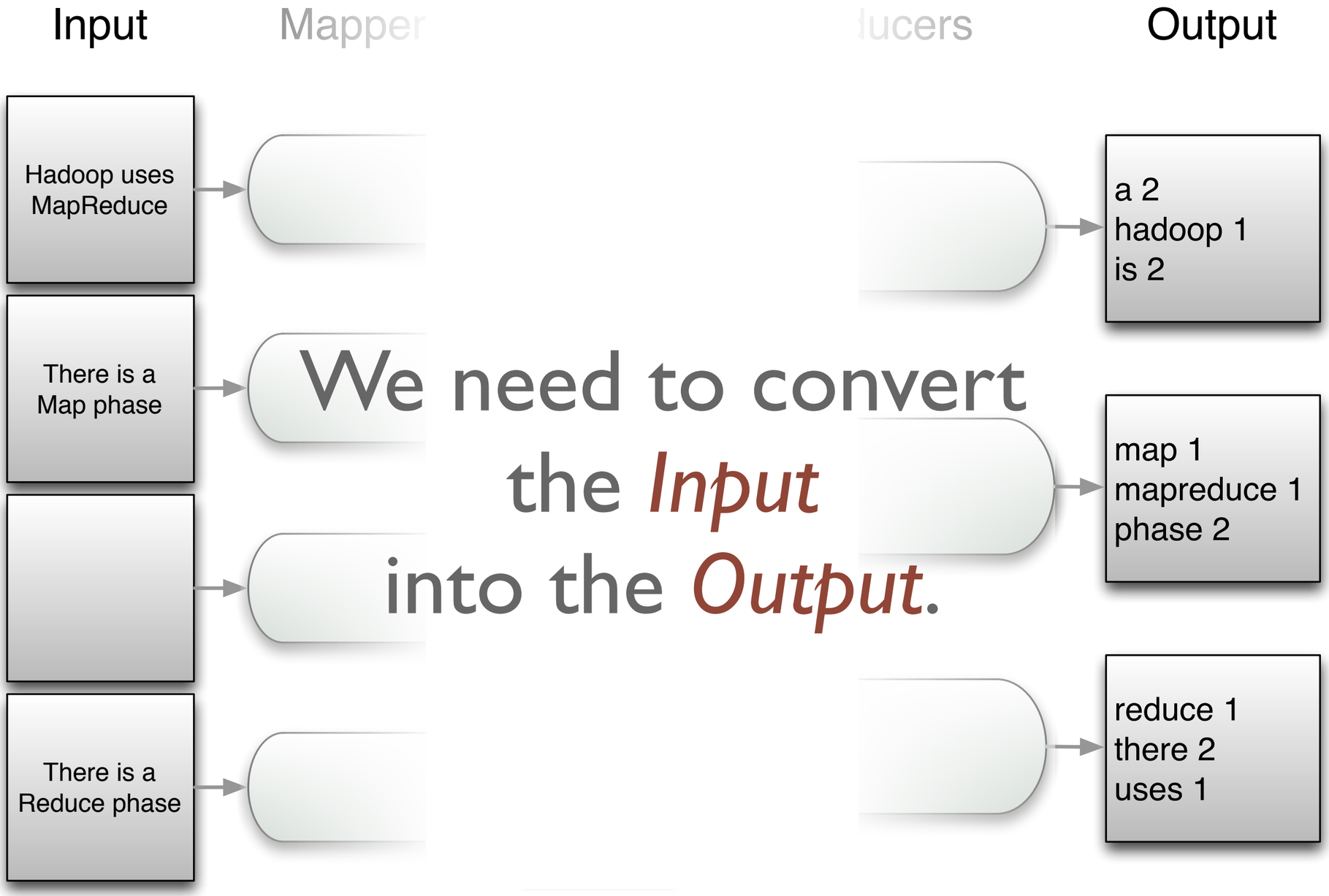
What's all this talk about "MapReduce", then?

MapReduce in Hadoop

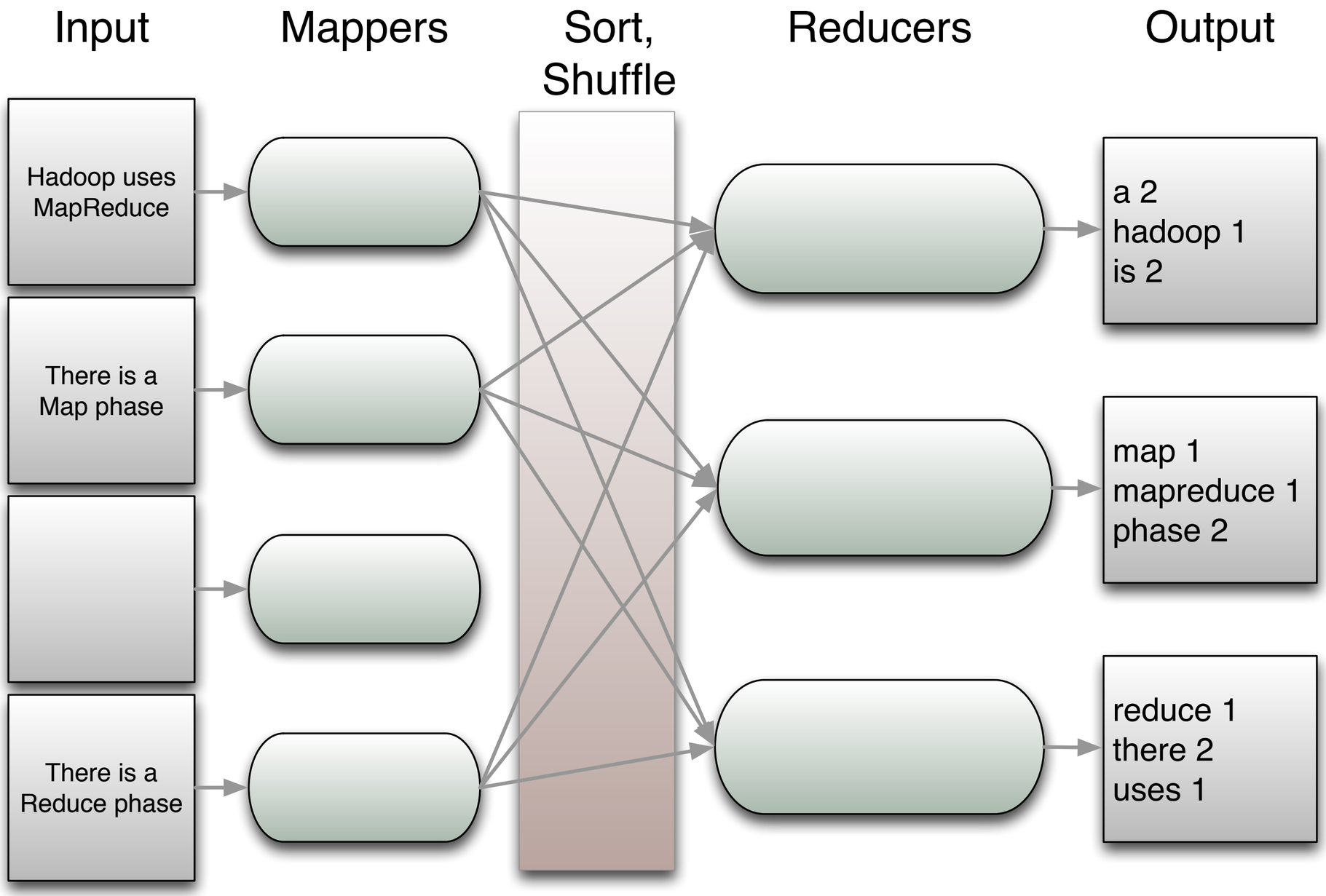
Let's look at a
MapReduce algorithm: *WordCount*.

(The *Hello World* in big data…)

Let's walk through this algorithm at a conceptual level...



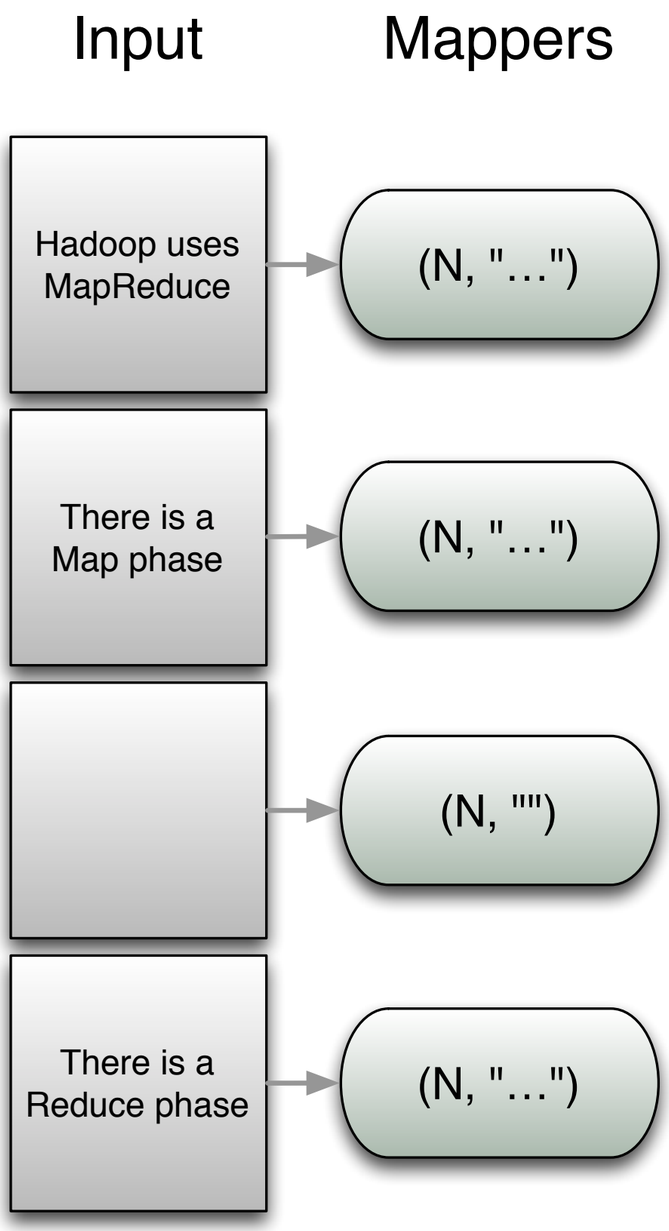
Four input documents, one left empty, the others with small phrases (for clarity…). The word count output is on the right (we'll see why there are three output "documents"). We need to get from the input on the left-hand side to the output on the right-hand side.



Here is a schematic view of the steps in Hadoop MapReduce. Each Input file is read by a single Mapper process (default: can be many-to-many, as we'll see later).

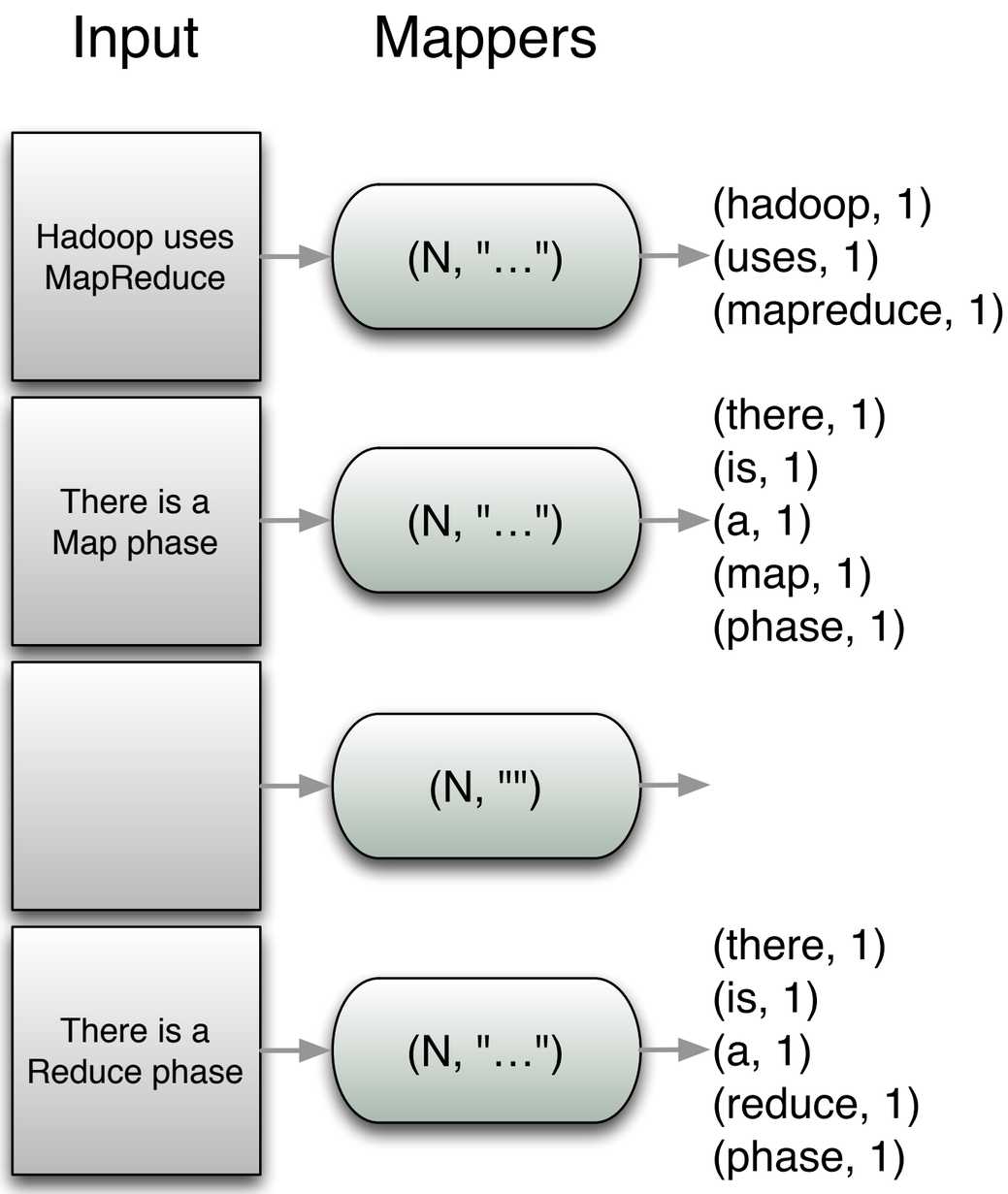
The Mappers emit key-value pairs that will be sorted, then partitioned and "shuffled" to the reducers, where each Reducer will get all instances of a given key (for 1 or more values).

Each Reducer generates the final key-value pairs and writes them to one or more files (based on the size of the output).

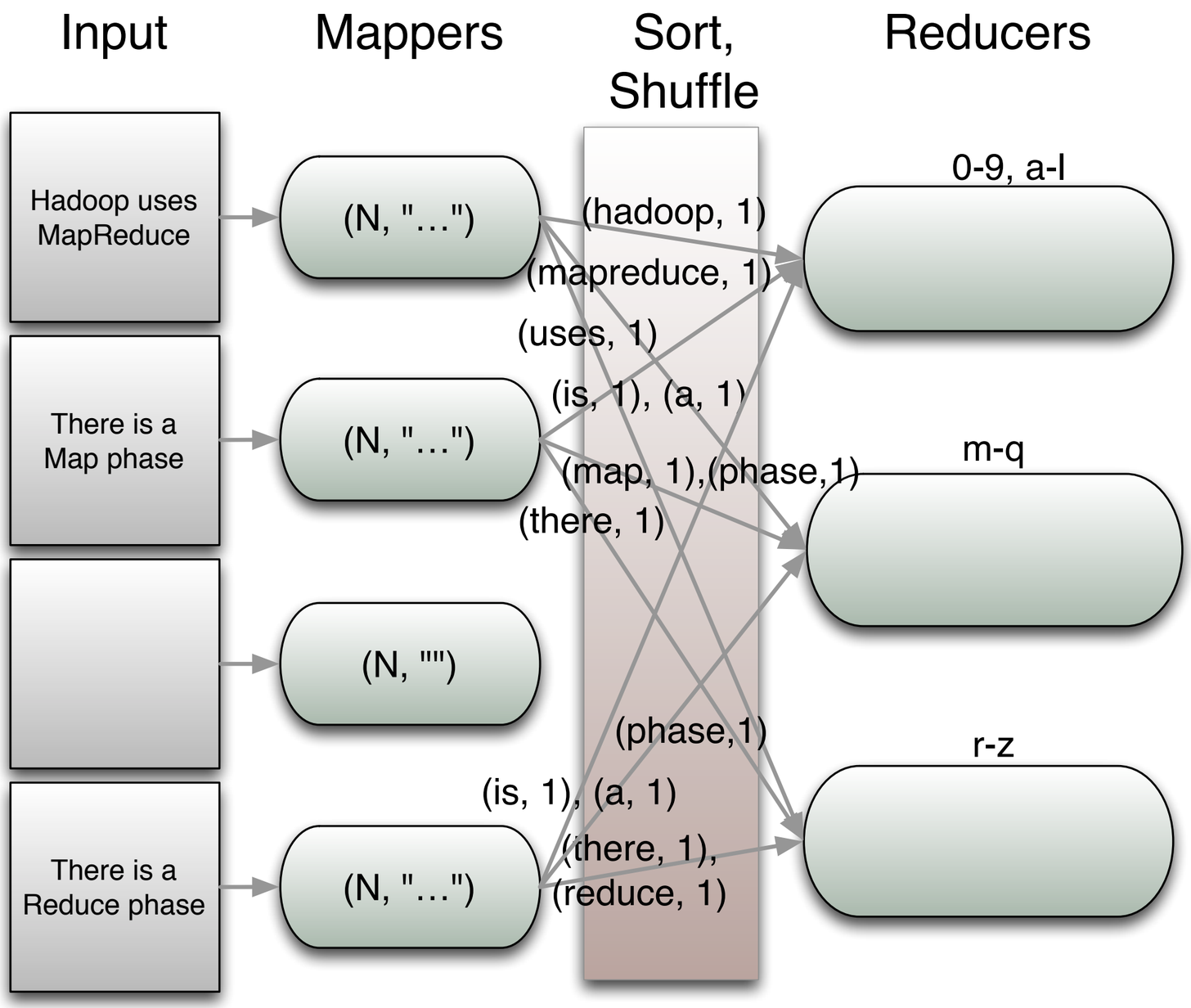


Each document gets a mapper. I'm showing the document contents in the boxes for this example. Actually, large documents might get split to several mappers (as we'll see). It is also possible to concatenate many small documents into a single, larger document for input to a mapper.

Each mapper will be called repeatedly with key-value pairs, where each key is the position offset into the file for a given line and the value is the line of text. We will ignore the key, tokenize the line of text, convert all words to lower case and count them...



The mappers emit key-value pairs, where each key is one of the words, and the value is the count. In the most naive (but also most memory efficient) implementation, each mapper simply emits (word, 1) each time “word” is seen.
The mappers themselves don’t decide to which reducer each pair should be sent. Rather, the job setup configures what to do and the Hadoop runtime enforces it during the Sort/Shuffle phase, where the key-value pairs in each mapper are sorted by key (that is locally, not globally or “totally”) and then the pairs are routed to the correct reducer, on the current machine or other machines.
Note how we partitioned the reducers (by first letter of the keys). Also, note that the mapper for the empty doc. emits no pairs, as you would expect.



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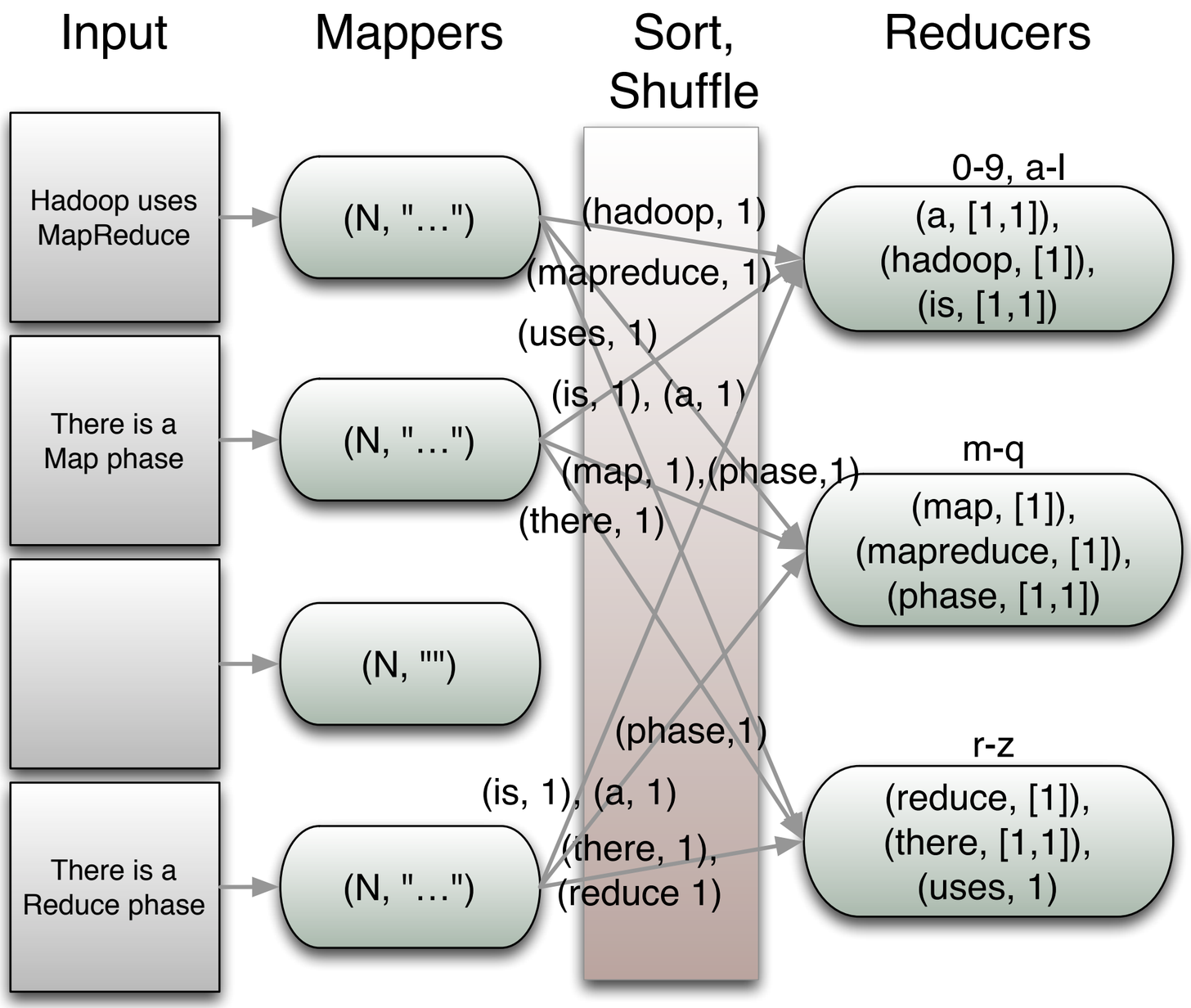

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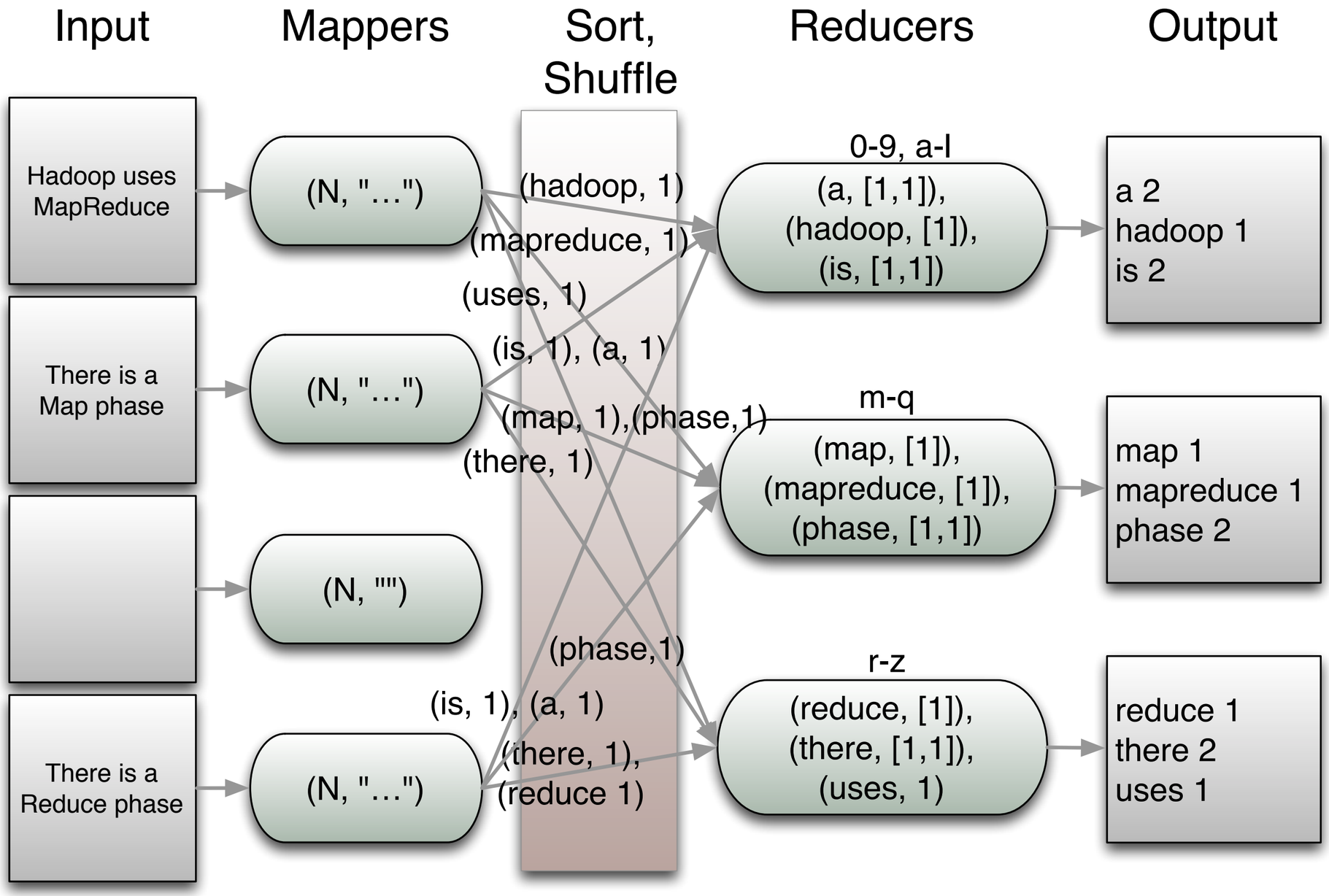
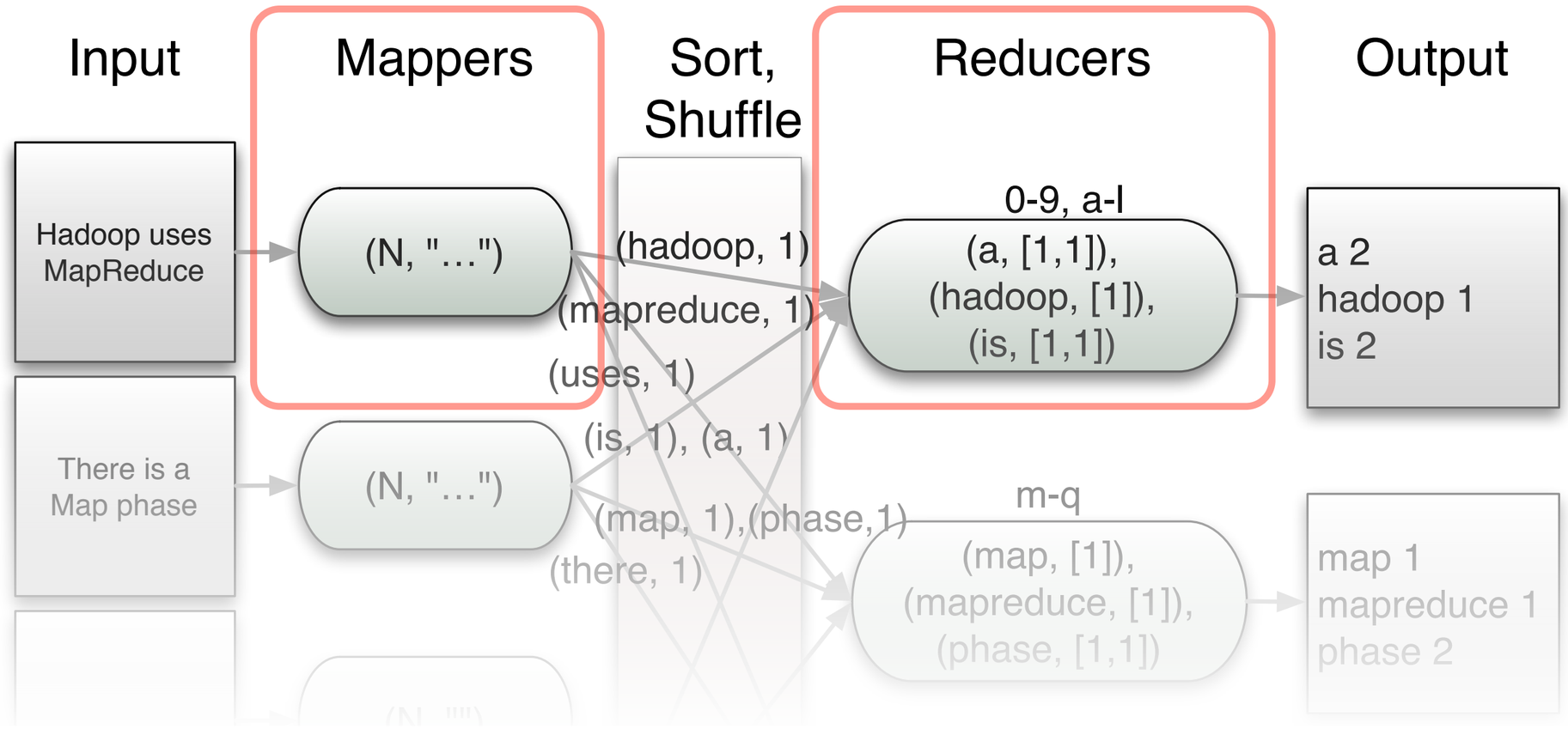


The final view of the WordCount process flow for our example.
We'll see in more detail shortly how the key-value pairs are passed to the reducers, which add up the counts for each word (key) and then writes the results to the output files.
The the output files contain one line for each key (the word) and value (the count), assuming we're using text output. The choice of delimiter between key and value is up to you. (We'll discuss options as we go.)



Map:

- Transform *one* input to *0-N* outputs.

Reduce:

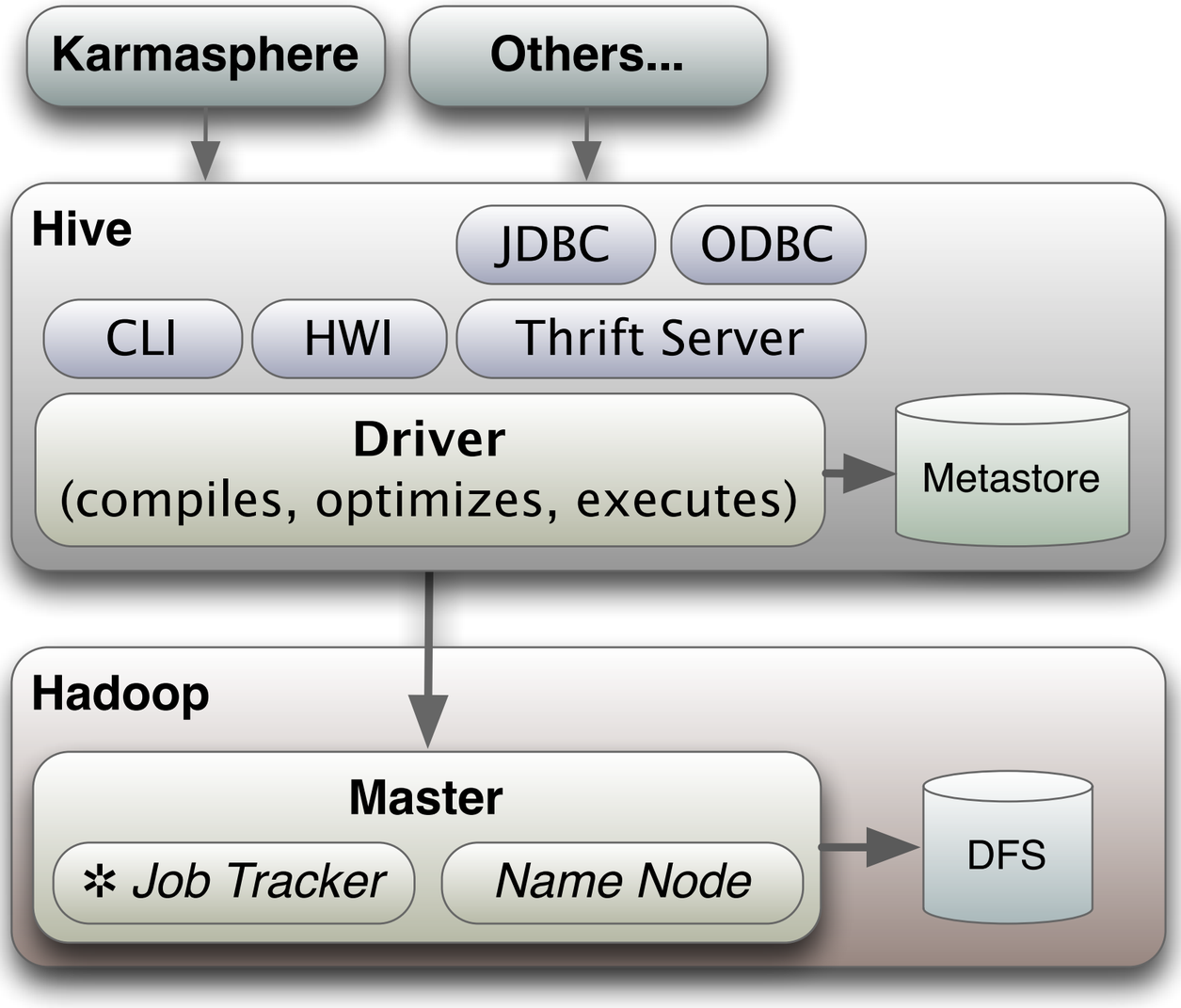
- Collect *multiple* inputs into *one* output.

To recap, a “map” transforms one input to one output, but this is generalized in MapReduce to be one to 0-N. The output key-value pairs are distributed to reducers. The “reduce” collects together multiple inputs with the same key into

Hive
(to the Rescue)

Now, let's talk Hive, which saves us from the tedium of writing MapReduce jobs by hand...

Hive + Hadoop



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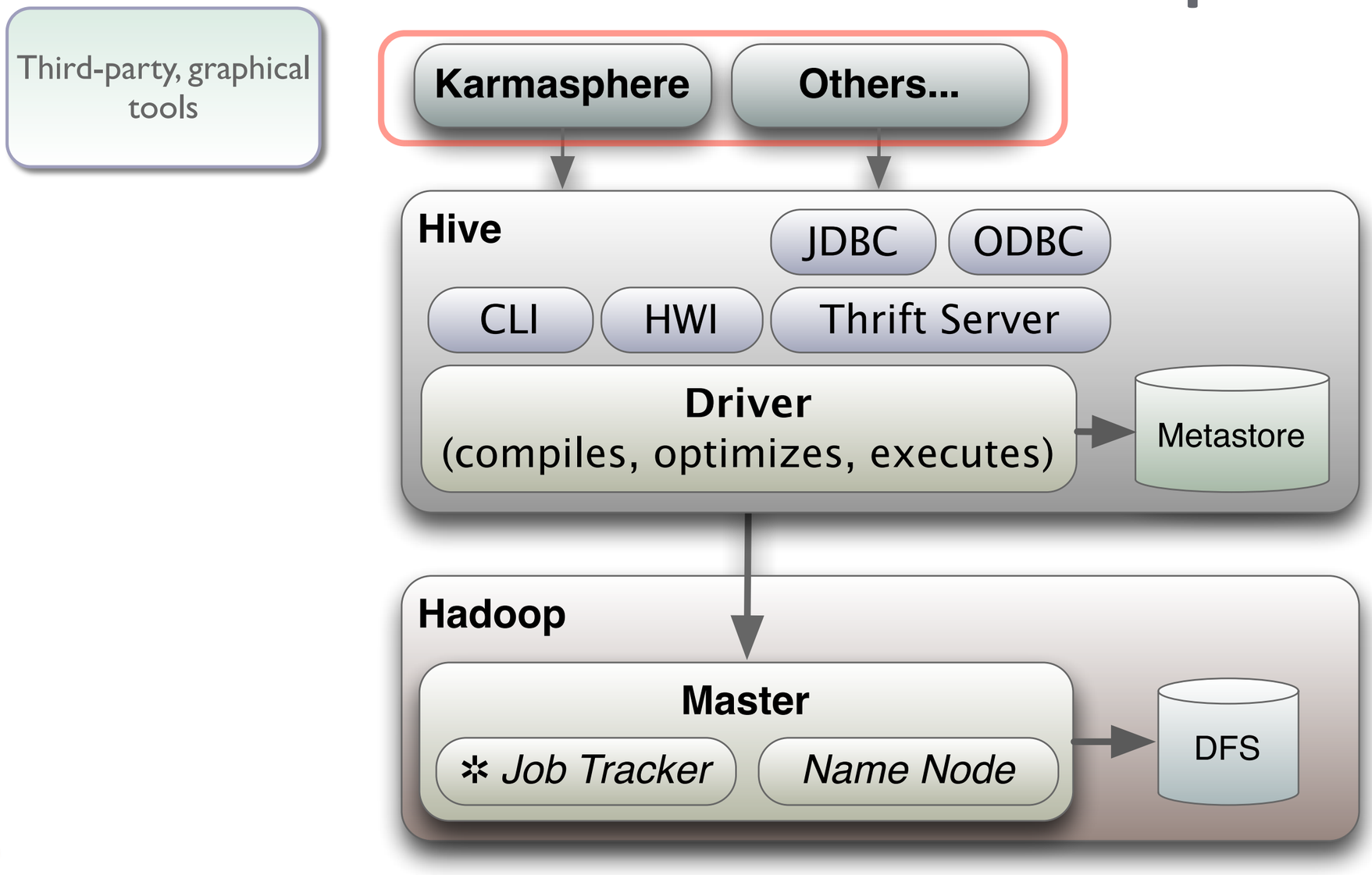
Most Hive queries generate MapReduce jobs. (Some operations don't invoke MapReduce, e.g., those that just write updates to the metastore and "select * from table;" queries.) We've omitted some arrows within the Hive bubble for clarity. They go "down", except for the horizontal connection between the driver and the metastore.

Hive + Hadoop



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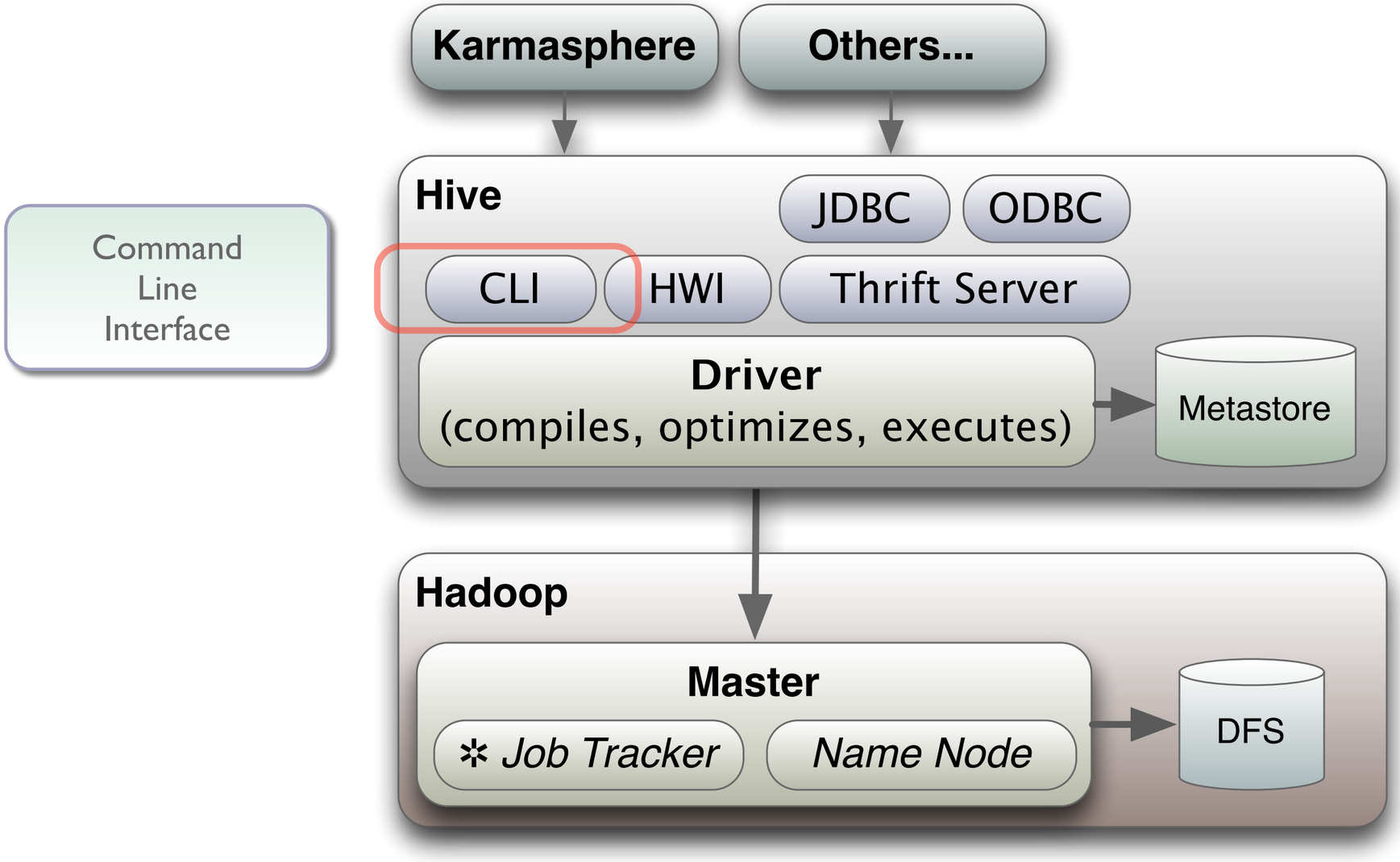
CLI = Command Line Interface.
HWI = Hive Web Interface.
We'll discuss the operation of the driver shortly.

Hive + Hadoop



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CLI = Command Line Interface.
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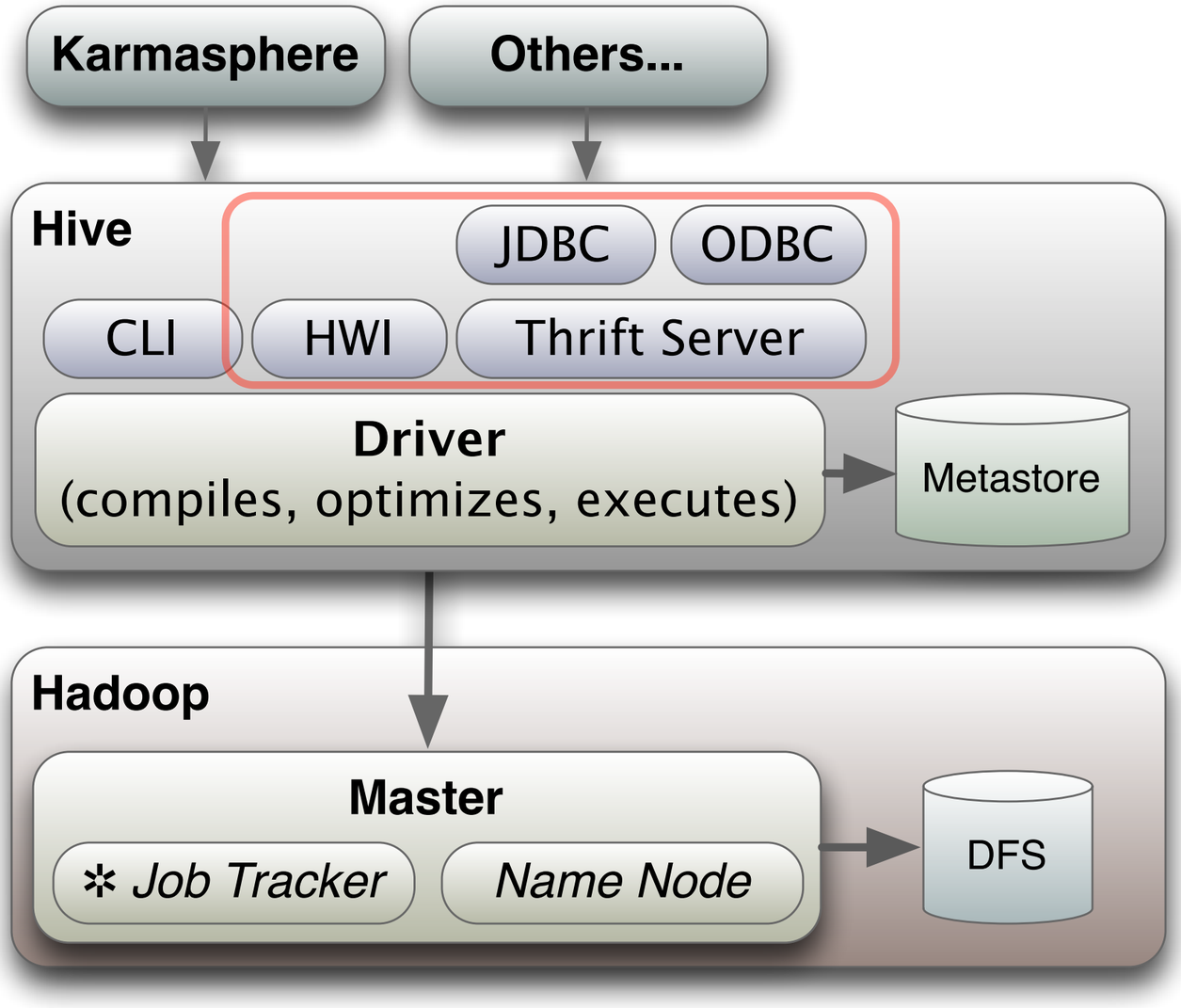
Hive + Hadoop

"Hive Web Interface", JDBC, ODBC, and Thrift



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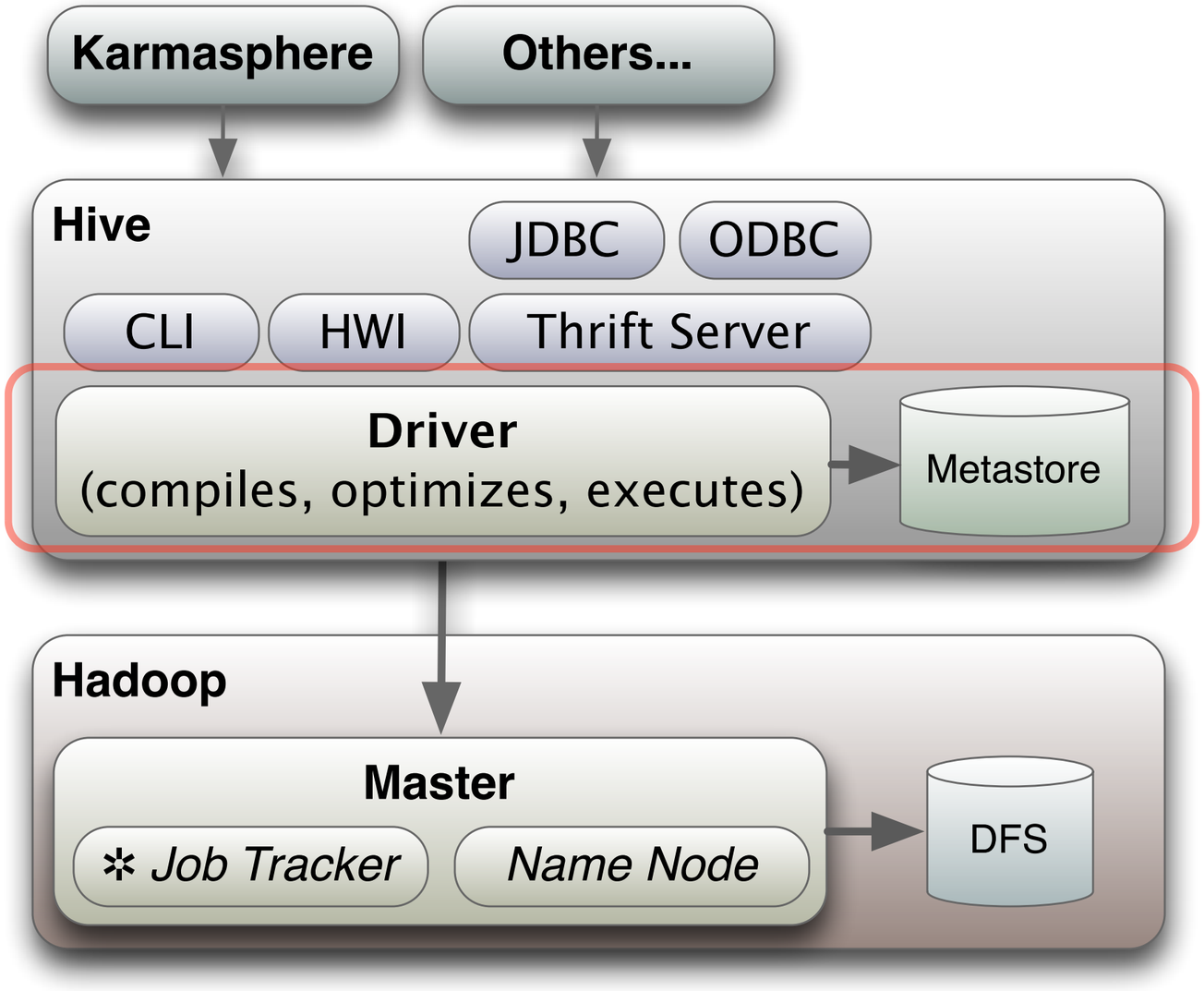
The HWI is very primitive and not very useful. You can also drive Hive from Java programs using JDBC and other languages using ODBC. These interfaces sit on top of a Thrift server, where Thrift is an RPC system invented by Facebook.

Hive + Hadoop



Compile queries, optimize them, then run them.

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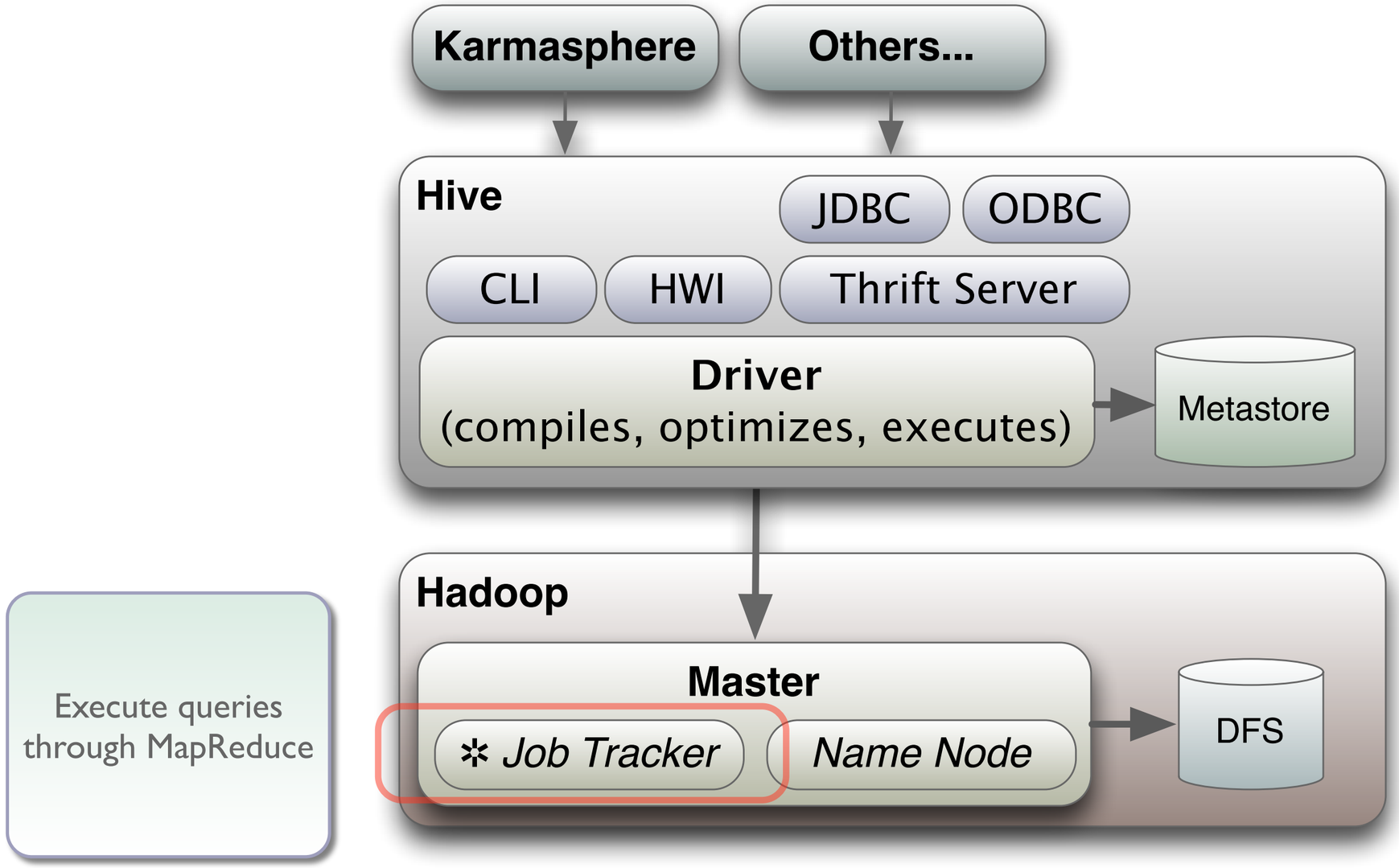
The Driver compiles the queries, optimizes them, and executes them, by *usually* invoking MapReduce jobs, but not always, as we'll see.

Hive + Hadoop



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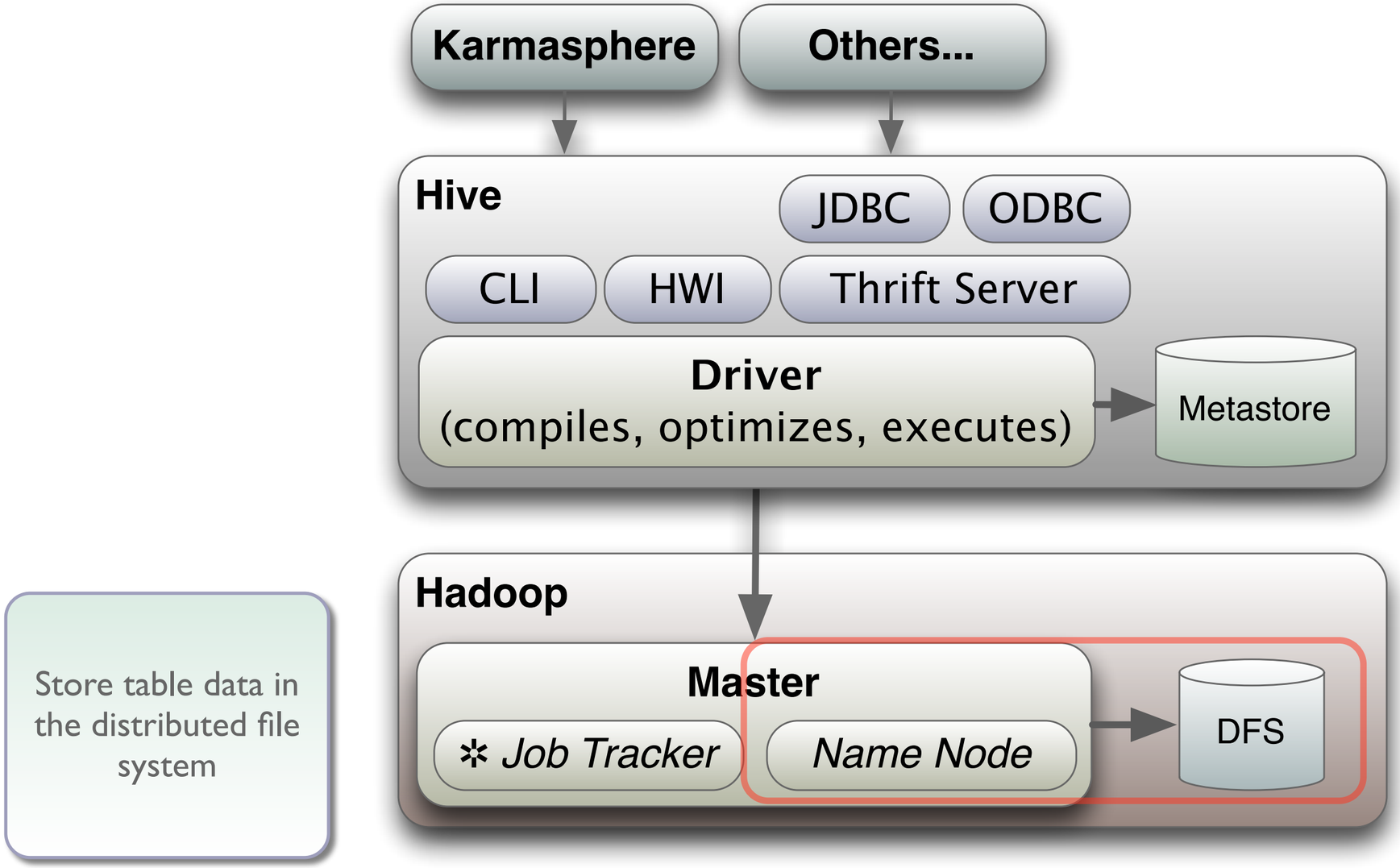
Hive + Hadoop



Store table data in the distributed file system

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Most Hive queries generate MapReduce jobs. (Some operations don't invoke MapReduce, e.g., those that just write updates to the metastore and "select * from table;" queries.) We've omitted some arrows within the Hive bubble for clarity. They go "down", except for the horizontal connection between the driver and the metastore.

- Due to HDFS and MapReduce foundations:
  - — No Row-level updates nor transactions.
  - + Parallelized queries over massive data sets.

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Exercise:

Hive-1-Walkthrough

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The first exercise; an instructor-lead walkthrough of Hive on the EMR clusters. The bit.ly link is the same download link on the title slide, repeated for your convenience.

Hive *Schema*

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The unique features of table schema in Hive.

Specifying Table Schemas

- Example:

```
CREATE TABLE demo1(
  id INT,
  name STRING);
```

- Two columns:
  - One of type INT.
  - One of type STRING (not CHARARRAY).

Simple Data Types

`TINYINT`, `SMALLINT`, `INT`, `BIGINT`	1, 2, 4, and 8 byte integers
`FLOAT`, `DOUBLE`	4 byte (single precision), and 8 byte (double precision) floating point numbers
`BOOLEAN`	Boolean
`STRING`	Arbitrary-length String
`TIMESTAMP`	(v0.8.0) Date string: "yyyy-mm-dd hh:mm:ss.fffffffff" (The "fs" are nanosecs.)
`BINARY`	(v0.8.0) a limited `VARBINARY` type

All the types reflect underlying Java types. TIMESTAMP and BINARY are new to v0.8.0. Use an a string for pre-0.8.0 timestamps (or BIGINT for Unix epoch seconds, etc.). BINARY has limited support for representing VARBINARY objects. Note that this isn't a BLOB type, because those are stored separately, while BINARY data is stored within the record.

Complex Data Types

`ARRAY`	Indexable list of items of the same type. Indices start at 0: `orders[0]`
`MAP`	Keys and corresponding values. `address['city']`
`STRUCT`	Like C-struct or Java object. `name.first, name.last`

All the types reflect underlying Java types. TIMESTAMP and BINARY are new to v0.8.0. Use an integer type or strings for pre-0.8.0. Use BINARY as the last “column” in a schema to as a way of saying “ignore the rest of this record”.

Complex Schema

```
CREATE TABLE employees (
     name STRING,
     salary FLOAT,
     subordinates ARRAY<STRING>,
     deductions MAP<STRING, FLOAT>,
     address STRUCT<street:STRING,
      city:STRING, state:STRING, zip:INT>
  );
```

- Uses Java-style “generics” syntax.
- `ARRAY<STRING>`
- `MAP<STRING, FLOAT>`
- `STRUCT<street:STRING, ...>`

The <...> is a Java convention. We have to say what type of things the complex values hold. Note that we also name the elements of the STRUCT.

Complex Schema

```
CREATE TABLE employees (
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    address STRUCT<street:STRING,
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    );
```

name and salary

Let’s walk through this...

Complex Schema

```
CREATE TABLE employees (
    name STRING,
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    );
```

Arrays of the same type

Let's walk through this...

Complex Schema

```
CREATE TABLE employees (
     name STRING,
     salary FLOAT,
     subordinates ARRAY<STRING>,
     deductions MAP<STRING, FLOAT>,
     address STRUCT<street:STRING,
          city:STRING, state:STRING, zip:INT>
     );
```

Paycheck deductions: (name, %)

Let's walk through this...

Complex Schema

```
CREATE TABLE employees (
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    salary FLOAT,
    subordinates ARRAY<STRING>,
    deductions MAP<STRING, FLOAT>,
    address STRUCT<street:STRING,
      city:STRING, state:STRING, zip:INT>
);
```

Home address

Let's walk through this...

Normal Form??

```
subordinates ARRAY<STRING>,
deductions MAP<STRING, FLOAT>,
address STRUCT<street:STRING,
 city:STRING, state:STRING, zip:INT>
```

- We're trading normal form for faster access to all the data.
- *Essential for multi-TB data sets stored on hard drives!*

Relational DBs don't use complex structures, usually. Instead, they prefer separate tables and using joins to construct a similar relationship between rows. This is usually slower than a straight disk scan (but there can be other efficiency advantages, like optimizing space and using uniform record lengths…) and requires multi-table and multi-row transactions, which Hive doesn't provide.

Storage Format

- So far, we've used a *plain-text file format*.
- Let's explore it's properties.
- We'll see other formats later.

Terminators (Delimiters)

`'\n'`	Between rows (records)
`^A ('\001')`	Between fields (columns)
`^B ('\002')`	Between `ARRAY` and `STRUCT` elements and `MAP` key-value pairs
`^C ('\003')`	Between each `MAP` key and value

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Hive uses the term “terminators” in table definitions, but they are really delimiters or separators between “things”. “^A” means “control-A”. The corresponding ‘\001 is the “octal code” for how you write the control character in CREATE TABLE statements.

Specifying Encodings

```
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 '\001'
  COLLECTION ITEMS TERMINATED BY '\002'
  MAP KEYS TERMINATED BY '\003'
  LINES TERMINATED BY '\n'
  STORED AS TEXTFILE;
```

All the *defaults* shown explicitly!

Our original employees table, now written to show all the default values used for the terminators and the fact that it's stored as a text file.

The Actual File Format

```
John Doe^A100000.0^AMary Smith^BTodd Jones^AFederal
Taxes^C.2^BState Taxes^C.05^BInsurance^C.1^A1 Michigan
Ave.^BChicago^BIL^B60600
...
```

One *record*,
a line of text.

```
CREATE TABLE employees (
    name STRING,
    salary FLOAT,
    subordinates ARRAY<STRING>,
    deductions MAP<STRING, FLOAT>,
    address STRUCT<street:STRING,
     city:STRING, state:STRING, zip:INT>)
```

The *schema*, for
comparison

This is what's actually stored in the file. The first line, a single record, of the file we'll use is shown here, with all the default delimiters.

Exercise:

Hive-2-Tables-Schemas

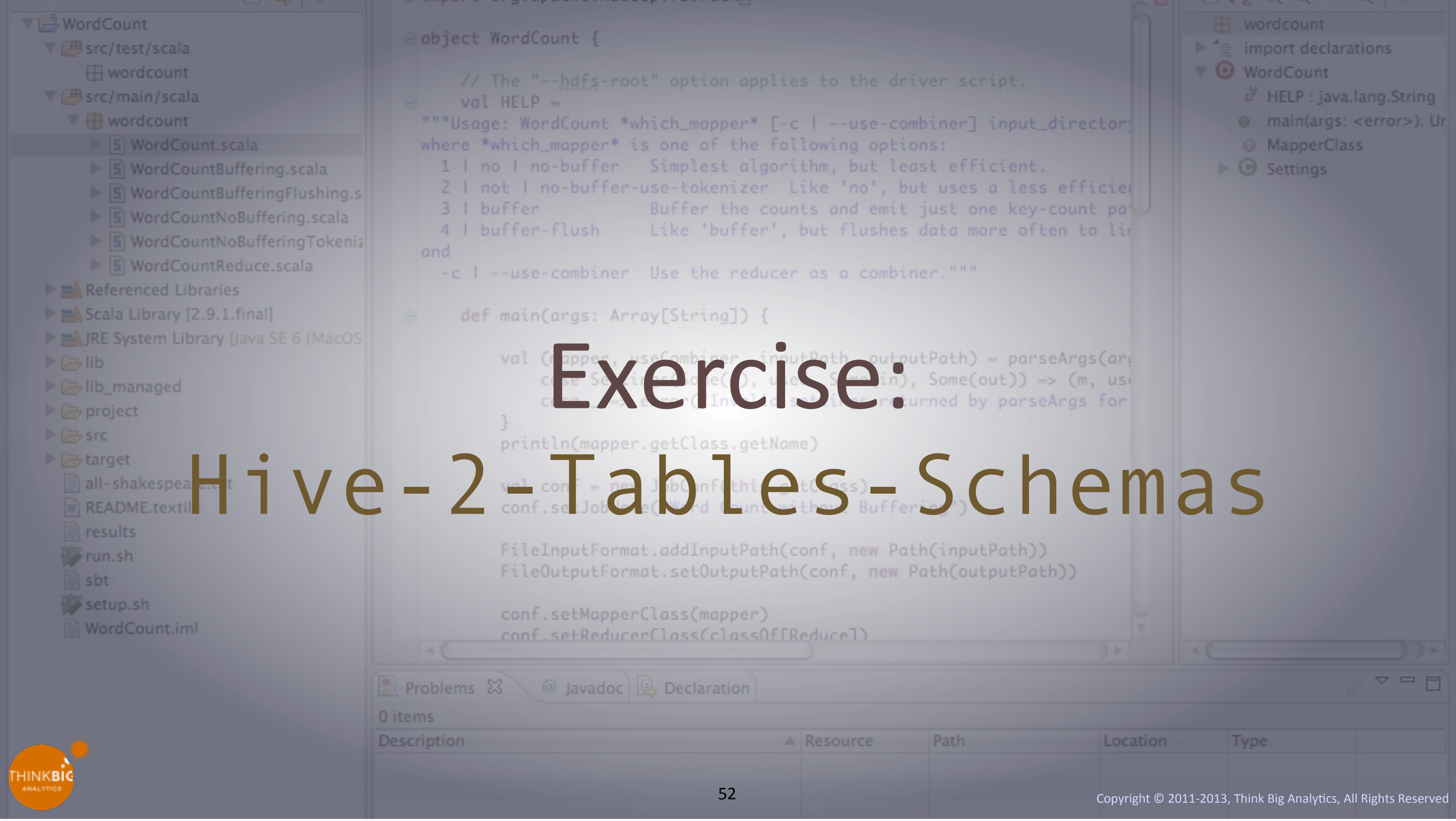

Table *Partitioning*

A tool for data organization and improving the performance of “range-bound” queries.

Partitioning

- Improve query *performance*.
- *Organize* your data.

Partitioning in Hive is similar to partitioning in many DB systems.

Partitioning

- Separate *directories* for each partition *column*.

```
CREATE TABLE message_log (
  status STRING, msg STRING, hms STRING)
PARTITIONED BY (
  year INT, month INT, day INT);
```

On disk:

```
message_log/year=2011/month=12/day=31/
message_log/year=2012/month=01/day=01/
...
message_log/year=2012/month=01/day=31/
message_log/year=2012/month=02/day=01/
...
```

This is an INTERNAL table and the directory structure shown will be in Hive's warehouse cluster directory. The actual directories, e.g., …/year=2012/month=01/day=01 (yes, that's the naming scheme), will be created when we load the data, discussed in the next module.
(Note that "hms" is the remaining hours-minutes-seconds…)

Partitioning

- Speed *queries* by limiting scans to the correct partitions specified in the `WHERE` clause.

```
SELECT * FROM message_log
WHERE year  = 2012 AND
      month = 01   AND
      day   = 31;
```

In SELECT and WHERE clauses, you use the partitions just like ordinary columns, but they significant performance implications.

Without "Partition Filtering"

```
SELECT * FROM message_log;
```

ALL these directories are read.

```
message_log/year=2011/month=12/day=31/
message_log/year=2012/month=01/day=01/
...
message_log/year=2012/month=01/day=31/
message_log/year=2012/month=02/day=01/
...
```

Without a WHERE clause that limits the result set, Hive has to read the files in EVERY DIRECTORY ever created for "message_log". Sometimes, that's what you want, but the point is that often, you're likely to do queries between time ranges, so scanning all the data is wasteful.

Filtering by Year

```
SELECT * FROM message_log
WHERE year  = 2012;
```

Just *366* directories
are read.

```
message_log/year=2011/month=12/day=31/
message_log/year=2012/month=01/day=01/
...
message_log/year=2012/month=01/day=31/
message_log/year=2012/month=02/day=01/
...
```

If you filter by year, you have to read only 365 or 366 directories, that is the days under the months which are under the year.

Filtering by Month

```
SELECT * FROM message_log
WHERE year  = 2012 AND
      month = 01;
```

Just *31* directories
are read.

```
message_log/year=2011/month=12/day=31/
message_log/year=2012/month=01/day=01/
...
message_log/year=2012/month=01/day=31/
message_log/year=2012/month=02/day=01/
...
```

If you filter by month, you need to read only those directories for that month, such as 31 directories for January.

Filtering by Day

```
SELECT * FROM message_log
WHERE year  = 2012 AND
      month = 01   AND
      day   = 31;
```

Just *one* directory is read.

```
message_log/year=2011/month=12/day=31/
message_log/year=2012/month=01/day=01/
...
message_log/year=2012/month=01/day=31/
message_log/year=2012/month=02/day=01/
...
```

Finally, if you filter by all three, year, month, and day, Hive only has to read one directory!
The point is that partitions drastically reduce the amount of data Hive has to scan through, but it's only useful if you pick a partitioning scheme that represents common WHERE clause filtering, like date ranges in this example.

External Tables (vs. *Managed* Tables)

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So far, we have used “managed” (a.k.a. internal) tables, where Hive owns the data. What if we want to share data with other tools and not give ownership to Hive? That’s where external tables come in...

External Tables

- When you *manage* the data *yourself*:
  - The data is used by other tools.
  - You have a custom ETL process.
- It's common to customize the file format, too...

```
CREATE EXTERNAL TABLE employees (
  name   STRING,
  ...)
LOCATION '/data/employees/input';
```

Creating *External* Tables

- Example for plain text files:

External table

```
CREATE EXTERNAL TABLE employees (
  name    STRING,
  ...)
LOCATION '/data/employees/input';
```

No *scheme* prefix, e.g., *hdfs://server/…*
So, defaults to directory in the cluster.
We own and manage that directory.

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Recall that previously we defined a MANAGED employees table we had to LOAD the data into it. If we already have the data in HDFS, we can just point a table to it.
Note that LOCATION is a directory. Hive will read all the files it contains.

Creating *External* Tables

- The locations can be *local*, in *HDFS*, or in *S3*.
- Joins can join table data from *any* such source!

The URI's *scheme*.

```
...
LOCATION 'file:///path/to/data';...
...
LOCATION 'hdfs://server:port/path/to/data';
...
LOCATION 's3n://mybucket/path/to/data';
```

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So, you might have a table pointing to "hot" data in HDFS, a table pointing to a local temporary file created by an ETL staging process, and some longer-lived data in S3 and do joins on all of them!

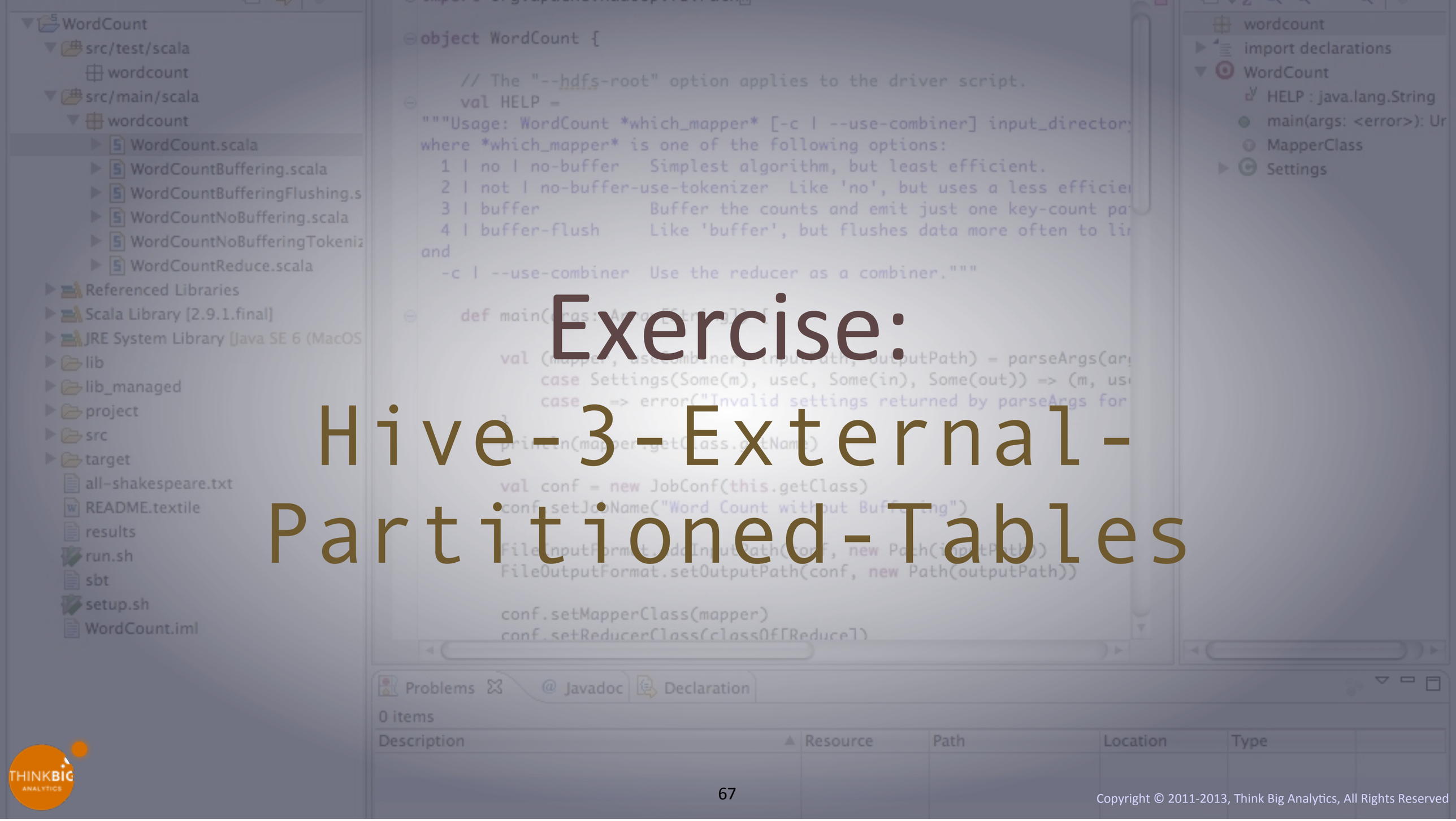
Dropping *External* Tables

- Because you *manage* the data *yourself*:
  - The table *data are not deleted* when you drop the table.
  - The table *metadata are deleted* from the *metastore*.

External, Partitioned Tables

- You can *partition* your *external* tables.
  - See the exercise...

Exercise:
Hive-3-External-Partitioned-Tables



Select Statements

https://cwiki.apache.org/confluence/display/Hive/LanguageManual+Select

Mostly what you already know… The link is to the online Hive documentation that discusses Hive's version of the SELECT statement.

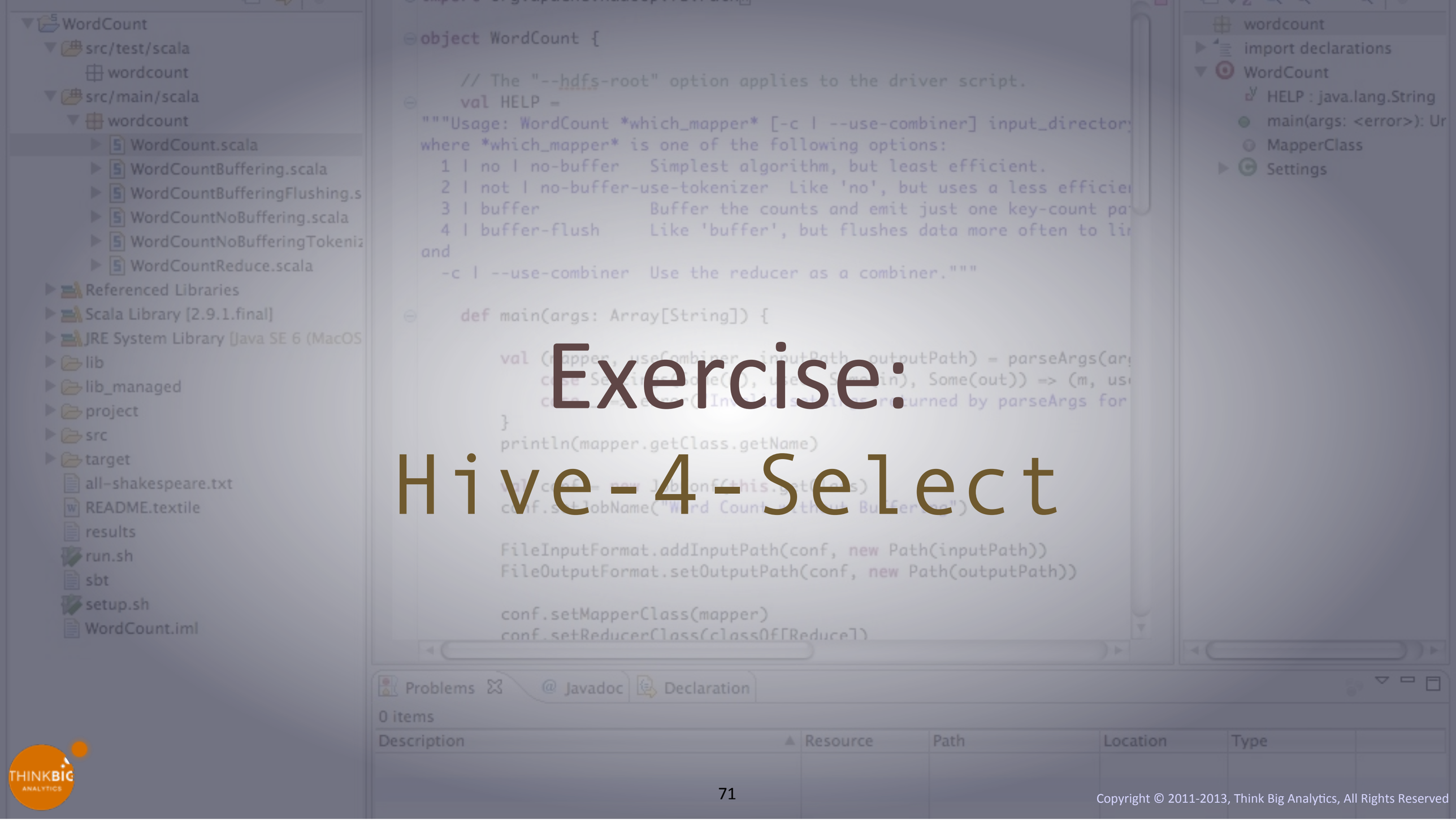
Select

- Many of the standard SQL features are supported.
- See the list of operators and functions in the *Hive Cheat Sheet* and here:
  - https://cwiki.apache.org/confluence/display/Hive/Tutorial#Tutorial-Builtinoperatorsandfunctions

Select

- We've already seen simple examples.
- Let's dive into the details in the exercise.

Exercise:
Hive-4-Select



Key Points

- Use *partition filters* to prune sections of data from

```
SELECT ymd, symbol FROM stocks
WHERE exchange = 'NASDAQ' AND
      symbol   = 'AAPL' ;
```

Well chosen partitions can greatly improve the query performance of common queries, by narrowing the range of data that has to be scanned.

Key Points

- When MapReduce is not required:

```
SELECT ymd, symbol FROM stocks
WHERE exchange = 'NASDAQ' AND
      symbol   = 'AAPL' ;
```

MapReduce required for *projections*.

```
SELECT * FROM stocks
WHERE exchange = 'NASDAQ' AND
      symbol   = 'AAPL' ;
```

No MR job required, despite the WHERE clause!

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Well chosen partitions can greatly improve the query performance of common queries, by narrowing the range of data that has to be scanned.
In fact, if you're showing all columns and filtering only on partitions, Hive skips MR altogether! However, if the WHERE clause includes non-partition clauses, then MR is required. (For tables without partitions, "select * from tbl_name;" will also work without MR.)

Key Points

- Use of DISTINCT with *partition* columns does *NOT* work in Hive before *v0.9.0*:

```
hive> SELECT DISTINCT symbol FROM stocks;
OK
Time taken: 10.273 seconds
```

Be aware that earlier versions of Hive have this bug.

Key Points

- Use *aggregate functions* to "roll up" data:

```
SELECT count(*) FROM stocks
WHERE exchange = 'NASDAQ' AND
      symbol   = 'AAPL' ;

SELECT avg(price_close) FROM stocks
WHERE exchange = 'NASDAQ' AND
      symbol   = 'AAPL' ;
```

Well chosen partitions can greatly improve the query performance of common queries, by narrowing the range of data that has to be scanned.

Key Points

- Use GROUP BY to cluster data together:
  - Return the yearly average price for AAPL.

```
SELECT year(ymd),
avg(price_close)
FROM stocks
WHERE exchange = 'NASDAQ' AND
      symbol   = 'AAPL' ;
GROUP BY year(ymd);
```

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Well chosen partitions can greatly improve the query performance of common queries, by narrowing the range of data that has to be scanned.

Key Points

- Be aware of *gotchas* in FLOAT and DOUBLE comparisons!

```
SELECT name, deductions['… Taxes']
FROM employees
WHERE deductions['… Taxes'] > 0.2;
```

This happens because the 0.2 is a double, but the actual representation in binary is (roughly) 0.2000000012 (I made up the number of zeros and the “12”, but it’s some small delta above 0.2), while 0.2 as float is 0.2000012; the extra “12” occurs “sooner”. When Hive casts this float to double, it is greater than the literal 0.2 double!

Hive *Joins*

https://cwiki.apache.org/confluence/display/Hive/LanguageManual+Joins

Joins

- Four kinds supported:
  - *Inner* Joins.
  - *Outer* Joins.
  - *Left Semi* Joins (not discussed here).
  - *Map-side* Joins (an optimization of others).

We'll define what these mean in the next few slides.

Inner Joins

ssn	name	address
ssn1	name1	address1
ssn2	name2	address2
ssn3	name3	address3

ssn	salary	taxes
ssn1	salary1	taxes1
ssn3	salary3	taxes3
ssn4	salary4	taxes4

Inner Join on ssn

ssn	name	address	salary	taxes
ssn1	name1	address1	salary1	taxes1
ssn3	name3	address3	salary3	taxes3

Blue records dropped.

We're doing a join that requires an identical ssn value in both tables. Records without a match in both tables are discarded.

The tan color shows the column names. The green are records that make it through the join, while the blue are the records that are removed because they don't satisfy the match condition.

Left Outer Joins

ssn	name	address
ssn1	name1	address1
ssn2	name2	address2
ssn3	name3	address3

ssn	salary	taxes
ssn1	salary1	taxes1
ssn3	salary3	taxes3
ssn4	salary4	taxes4

Left Outer Join on ssn

ssn	name	address	salary	taxes
ssn1	name1	address1	salary1	taxes1
ssn2	name2	address2	null	null
ssn3	name3	address3	salary3	taxes3

Blue records dropped.

null fields.

Now, we keep all the left-hand side records and if there isn't a corresponding record in the right-hand side, we just use null for those fields.

Right Outer Joins

ssn	name	address
ssn1	name1	address1
ssn2	name2	address2
ssn3	name3	address3

ssn	salary	taxes
ssn1	salary1	taxes1
ssn3	salary3	taxes3
ssn4	salary4	taxes4

Right Outer Join on ssn

ssn	name	address	salary	taxes
ssn1	name1	address1	salary1	taxes1
ssn3	name3	address3	salary3	salary3
ssn4	null	null	salary4	taxes4

Blue records dropped.

null fields.

Now, we keep all the right-hand side records and if there isn't a corresponding record in the left-hand side, we just use null for those fields.

Full Outer Joins

ssn	name	address
ssn1	name1	address1
ssn2	name2	address2
ssn3	name3	address3

ssn	salary	taxes
ssn1	salary1	taxes1
ssn3	salary3	taxes3
ssn4	salary4	taxes4

Full Outer Join on ssn

ssn	name	address	salary	taxes
ssn1	name1	address1	salary1	taxes1
ssn2	name2	address2	null	null
ssn3	name3	name3	salary3	taxes3
ssn4	null	null	salary4	taxes4

No records dropped.

null fields.

Now, we keep all the right-hand side records and if there isn't a corresponding record in the left-hand side, we just use null for those fields.

Dividend Data

- Like the *stock* data we've been using, let's introduce *dividend* data.

```
CREATE EXTERNAL TABLE IF NOT EXISTS
 dividends (ymd STRING, dividend FLOAT)
PARTITIONED BY (
  exchange STRING, symbol STRING)
ROW FORMAT DELIMITED FIELDS
 TERMINATED BY ',';
```

We'll actually create this table in the exercise.

General Features

- Syntax requires JOIN and ON clauses.

```
SELECT s.ymd, s.symbol,
 s.price_close, d.dividend
FROM stocks s
JOIN dividends d
ON s.ymd = d.ymd AND
   s.symbol = d.symbol
WHERE s.ymd > '2010-01-01';
```

Note that the a.ymd > '…' is in the WHERE clause, not the ON clause for the JOIN.
Some SQLs would "infer" the JOIN from just the SELECT clause shown.
Actually you can omit the ON clause, but then you get a MxN cross product!!

General Features

- Only equality (x = y) conditions allowed.
  - Equi-joins
- Hard to implement other conditions in MR.

```
SELECT s.ymd, s.symbol,
 s.price_close, d.dividend
FROM stocks s
JOIN dividends d
ON s.ymd = d.ymd AND
    s.symbol = d.symbol
WHERE s.ymd > '2010-01-01';
```

Note that the a.ymd > '…' is in the WHERE clause, not the ON clause for the JOIN.

General Features

- Attempt to use general *theta join* condition.

```
FAILED: Error in semantic analysis: …

Both left and right aliases encountered in JOIN 'ymd'
```

```
SELECT s.ymd, s.symbol,
 s.price_close, d.dividend
FROM stocks s
JOIN dividends d
ON s.ymd <> d.ymd AND
    s.symbol = d.symbol
WHERE s.ymd > '2010-01-01';
```

Trying to use a non-equality operator in the ON clause causes the weird error shown.

General Features

- Joining more than two tables.
- Will use *one* MR job if the *same* column for every table is used in the join clause.

A *self join*.

Same column from a used, same from b, and same from c.

```
SELECT ...
FROM stocks a
JOIN stocks b ON a.ymd = b.ymd
JOIN stocks c ON a.ymd = c.ymd
WHERE a.symbol = 'AAPL' AND
      b.symbol = 'IBM'  AND
      c.symbol = 'INTC' AND
      a.ymd    > '2010-01-01';
```

If I used a different column from a in the second join, 2 MR jobs would be required. Note this doesn't mean I have to "key" for all tables, just the same column for each table throughout, not more than one column from any of the tables.

General Features

- Put the *biggest* table *last*.
- Reducer will *stream* the last table; *buffer* the others.

```
SELECT s.ymd, s.symbol,
 s.price_close, d.dividend
FROM stocks s
JOIN dividends d
ON s.ymd = d.ymd AND
   s.symbol = d.symbol
WHERE s.ymd > '2010-01-01';
```

Streamed column

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In this join, we made a bad choice putting dividends last, since it's a much smaller table than stocks!

General Features

- But you can override which table is *streamed*.

```
SELECT /*+ STREAMTABLE(s) */ ...
 s.price_close, d.dividend
FROM stocks s
JOIN dividends d
  ON s.ymd = d.ymd AND
     s.symbol = d.symbol
  WHERE s.ymd > '2010-01-01';
```

We'll see a few other "comments" like this.

Inner Joins

- Row must exist in *both* tables (*inner* join).
  - A *self join* on the *same* table.

No extra keyword
=> inner join

```
SELECT s.ymd, s.symbol,
 s.price_close, d.dividend
FROM stocks s
JOIN dividends d
ON s.ymd = d.ymd AND
   s.symbol = d.symbol
WHERE s.ymd > '2010-01-01';
```

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Note that the a.ymd > '…' is in the WHERE clause, not the ON clause for the JOIN.
The other types of JOINs will have additional keywords before JOIN.

Left Outer Joins

- Returns all rows for left-hand table (subject to WHERE) even when there are no right-hand matchs. (NULLs returned for those fields.)

```
SELECT s.ymd, s.symbol,
 s.price_close, d.dividend
FROM stocks s
LEFT OUTER JOIN dividends d
ON s.ymd = d.ymd AND
    s.symbol = d.symbol
WHERE s.symbol = 'AAPL';
```

Left Outer Joins

- This query returns:

```
…
1988-02-10 AAPL 41.00 NULL
1988-02-11 AAPL 40.63 NULL
1988-02-12 AAPL 41.00 0.02
1988-02-16 AAPL 41.25 NULL
1988-02-17 AAPL 41.88 NULL
…
```

A *three-day* gap for President's Day weekend...

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Here's an example of what the output should look like.

Left Outer Joins

- Let's optimize the query with a *partition filter*.

```
SELECT s.ymd, s.symbol,
 s.price_close, d.dividend
FROM stocks s
LEFT OUTER JOIN dividends d
ON s.ymd = d.ymd AND
   s.symbol = d.symbol
WHERE s.symbol = 'AAPL' AND
      d.symbol = 'AAPL' AND
      s.exchange = 'NASDAQ' AND
      d.exchange = 'NASDAQ';
```

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We'll partition dividends like we do stocks, by exchange and symbol, so add the new clauses to the WHERE should speed it up!

Different Output!!

- What we got *before*:

```
…
1988-02-11 AAPL 40.63 NULL
1988-02-12 AAPL 41.00 0.02
1988-02-16 AAPL 41.25 NULL
…
```

- What we get *now*:

```
…
1987-11-17 AAPL 35.0  0.02
1988-02-12 AAPL 41.0  0.02
1988-05-16 AAPL 41.25 0.02
1988-08-15 AAPL 41.25 0.02
…
```

Only the days of a dividend payment!

Our “optimization” changed the results!

Outer Join Gotcha

- *Why?* Because WHERE is evaluated *after* JOIN, so d.* are *NULL except on dividend days*!

```
SELECT s.ymd, s.symbol,
 s.price_close, d.dividend
FROM stocks s
LEFT OUTER JOIN dividends d
ON s.ymd = d.ymd AND
   s.symbol = d.symbol
WHERE s.symbol = 'AAPL' AND
      d.symbol = 'AAPL' AND
      s.exchange = 'NASDAQ' AND
      d.exchange = 'NASDAQ';
```

Effectively back to an *inner join*!

d.exchange will be NULL when there are no dividend records for a given day, so the WHERE clause will effectively discard ALL stock records on day's when AAPL didn't pay a dividend! So, we're back to an equi-join, not an outer join.
This is actually common behavior in most SQLs.

Outer Join Gotcha Fix

- *Fix*: Remove the d.* predicates from the WHERE clause.

```
SELECT s.ymd, s.symbol,
 s.price_close, d.dividend
FROM stocks s
LEFT OUTER JOIN dividends d
ON s.ymd = d.ymd AND
    s.symbol = d.symbol
WHERE s.symbol = 'AAPL'AND
      s.exchange = 'NASDAQ';
```

Outer Join Gotcha Fix

- *Doesn't work*: Move the `JOIN` `s.exchange` and `d.exchange` predicates *inside* the `JOIN` clause.

```
SELECT s.ymd, s.symbol,
 s.price_close, d.dividend
FROM stocks s
LEFT OUTER JOIN dividends d
ON s.ymd      = d.ymd AND
   s.symbol   = d.symbol AND
s.symbol      = 'AAPL' AND
d.symbol      = 'AAPL' AND
s.exchange    = 'NASDAQ' AND
d.exchange    = 'NASDAQ';
```

The highlighted tests have no effect! So the records for ALL stocks are returned.

Outer Join Gotcha Fix

- In general, not all WHERE clause predicates work in ON clauses.
- *WARNING*: The Hive Wiki claims these should work!

```
…
    s.symbol    = 'AAPL' AND
    d.symbol    = 'AAPL' AND
    s.exchange = 'NASDAQ' AND
    d.exchange = 'NASDAQ';
```

The highlighted tests have no effect for outer joins! However, the Hive wiki (https://cwiki.apache.org/confluence/display/Hive/LanguageManual+Joins) claims this should work as a valid filter. It doesn't. However, it does appear to work for inner joins.

Or Use Nested Queries

```
SELECT s.ymd, s.symbol,
 s.price_close, d.dividend
FROM (
 SELECT ymd, symbol, price_close
 FROM stocks WHERE
  exchange = 'NASDAQ' AND symbol = 'AAPL') s
LEFT OUTER JOIN (
 SELECT ymd, symbol, dividend
 FROM dividends WHERE
   exchange = 'NASDAQ' AND symbol = 'AAPL') d
ON s.ymd    = d.ymd AND
   s.symbol = d.symbol;
```

Outer Join Gotcha

- This gotcha applies to all OUTER JOINs.

Right Outer Joins

- Returns all rows for right-hand table (subject to WHERE) even when there is no left-hand match. (NULLs returned for those fields.)

```
SELECT s.ymd, s.symbol,
 s.price_close, d.dividend
FROM dividends d
RIGHT OUTER JOIN stocks s
ON s.ymd = d.ymd AND
    s.symbol = d.symbol
WHERE s.symbol = 'AAPL'AND
        s.exchange = 'NASDAQ';
```

Here, we trivially reversed the order of the dividend and stock tables in the query.

Full Outer Joins

- Returns all rows for both tables (subject to WHERE) even when records on either side don't match.

```
SELECT s.ymd, s.symbol,
 s.price_close, d.dividend
FROM dividends d
FULL OUTER JOIN stocks s
ON s.ymd = d.ymd AND
    s.symbol = d.symbol
WHERE s.symbol = 'AAPL'AND
        s.exchange = 'NASDAQ';
```

This query's results will be the same as for the *right join* query.

Because there is always a stock record on the same day as every dividend record, the output of the FULL OUTER JOIN will be the same as the output of the RIGHT OUTER JOIN, in this case.

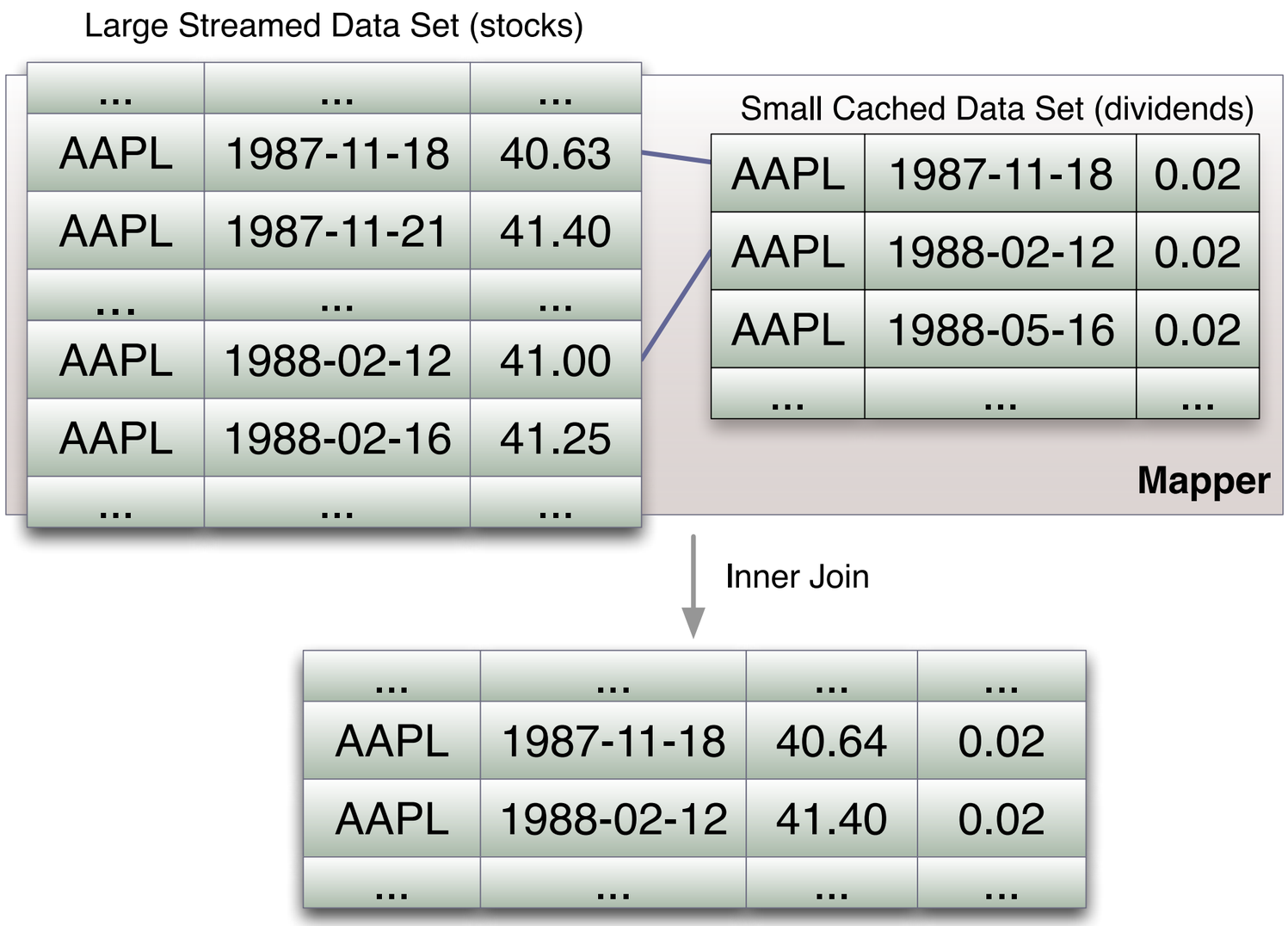
Map-side Joins

- Join tables in the mapper.
- Optimization that eliminates the reduce step.
- Useful if all but one table is small.
- Useful for sorted and “bucketized” data.

```
SELECT s.ymd, s.symbol,
  s.price_close, d.dividend
FROM dividends d
JOIN stocks s
ON s.ymd = d.ymd AND
   s.symbol = d.symbol;
```

A small table, so Hive can apply the optimization.

This query prints all the closing prices for a stock on any day when it pays a dividend.
If all but one table is small enough, the mapper can load the small tables in memory and do the joins there, rather than invoking an expensive reduce step.



Our stocks-dividends inner join, visualized as a map-side join.

Map-side Joins

- In versions of Hive before v0.7.0, you had to add this directive after SELECT:
  - /*+ MAPJOIN(d) */ (now deprecated)
- The optimization is automatic if:
  - set hive.auto.convert.join = true;

You should set this property either in a .hql file that you automatically load when starting the Hive CLI or put it at the top of HQL scripts where you want the optimization to be invoked.

Map-side Joins

- Can't be used with RIGHT/FULL OUTER joins.
- See the wiki page for additional optimizations possible when data is CLUSTERED and/or SORTED.

This query prints all the closing prices for a stock on any day when it pays a dividend.
https://cwiki.apache.org/confluence/display/Hive/LanguageManual+Joins

Exercise:
Hive-5-Joins

Built-in Functions and *User-Defined* Functions (UDFs)

https://cwiki.apache.org/confluence/display/Hive/LanguageManual+UDF

Hive documentation labels ALL functions UDFs, including built-ins!

UDFs

```
hive> SHOW FUNCTIONS;
!
!=
…
abs
acos
…
year
…
```

Lists all built-ins and any you have defined (we'll see how that's done shortly).

UDFs;

```
hive> DESCRIBE FUNCTION year;
year(date) - Returns the year of date

hive> DESCRIBE FUNCTION EXTENDED year;
year(date) - Returns the year of date
date is a string in the format of 'yyyy-MM-dd HH:mm:ss'
or 'yyyy-MM-dd'.
Example:
 > SELECT year('2009-03-07') FROM src LIMIT 1;
2009
```

User Defined Function (UDF)

- Works on a single row.
  - One or more columns or results from other UDFs.
- Example from Hive's built-in UDFs:

```
SELECT year(ymd) FROM
stocks;
```

Hive also uses "UDF" for the specific case of functions that take a single row (or columns) and return a single value. That is, it's one-to-one mapping, as far as rows go...

User Defined Aggregate Function (UDAF)

- Takes a collection of rows or values and aggregates them into a new row or value.
- Example from Hive's built-in UDFs:

```
SELECT year(ymd),
avg(price_close) FROM stocks
WHERE symbol = 'AAPL'
GROUP BY year(ymd);
```

User Defined Table Generating Function (UDTF)

- Takes a single row of values and generates multiple output rows, effectively a new table.
- Example from Hive's built-in UDTFs:

Required Column Alias!

```
SELECT explode(subordinates) AS
subs FROM employees;
```

User Defined Table Generating Function (UDTF)

- Limitations:
  - No other columns allowed in SELECT.
  - UDTFs can't be nested.
  - GROUP BY, CLUSTER BY, etc. not supported.

Have some limitations so they aren't used often in this form of a SELECT statement.

Lateral Views

- More flexible way to use UDTFs:

```
SELECT name, sub
FROM employees
LATERAL VIEW explode(subordinates)
subView AS sub;
```

For more on Lateral Views: (https://cwiki.apache.org/confluence/display/Hive/LanguageManual+LateralView)

Lateral Views

- More flexible way to use UDTFs:

```
SELECT name, sub
FROM employees
 LATERAL VIEW explode(subordinates)
subView AS sub;
```

Whole FROM Clause

View Alias

Column Alias

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Have some limitations so they aren't used a lot. There is a feature we aren't discussing called Lateral Views (https://cwiki.apache.org/confluence/display/Hive/LanguageManual+LateralView) that provides more flexibility for similar computations.

Writing Custom UDFs

```
// Java
import org.apache.hadoop.hive.ql.exec.UDF;

public class NowUDF extends UDF {
 public long evaluate() {
  return System.currentTimeMillis();
 }
}
```

- You compile this Java code and build a jar file...

You compile the code into a jar and include in the HIVE_CLASSPATH as required before starting Hive.

Writing Custom UDFs

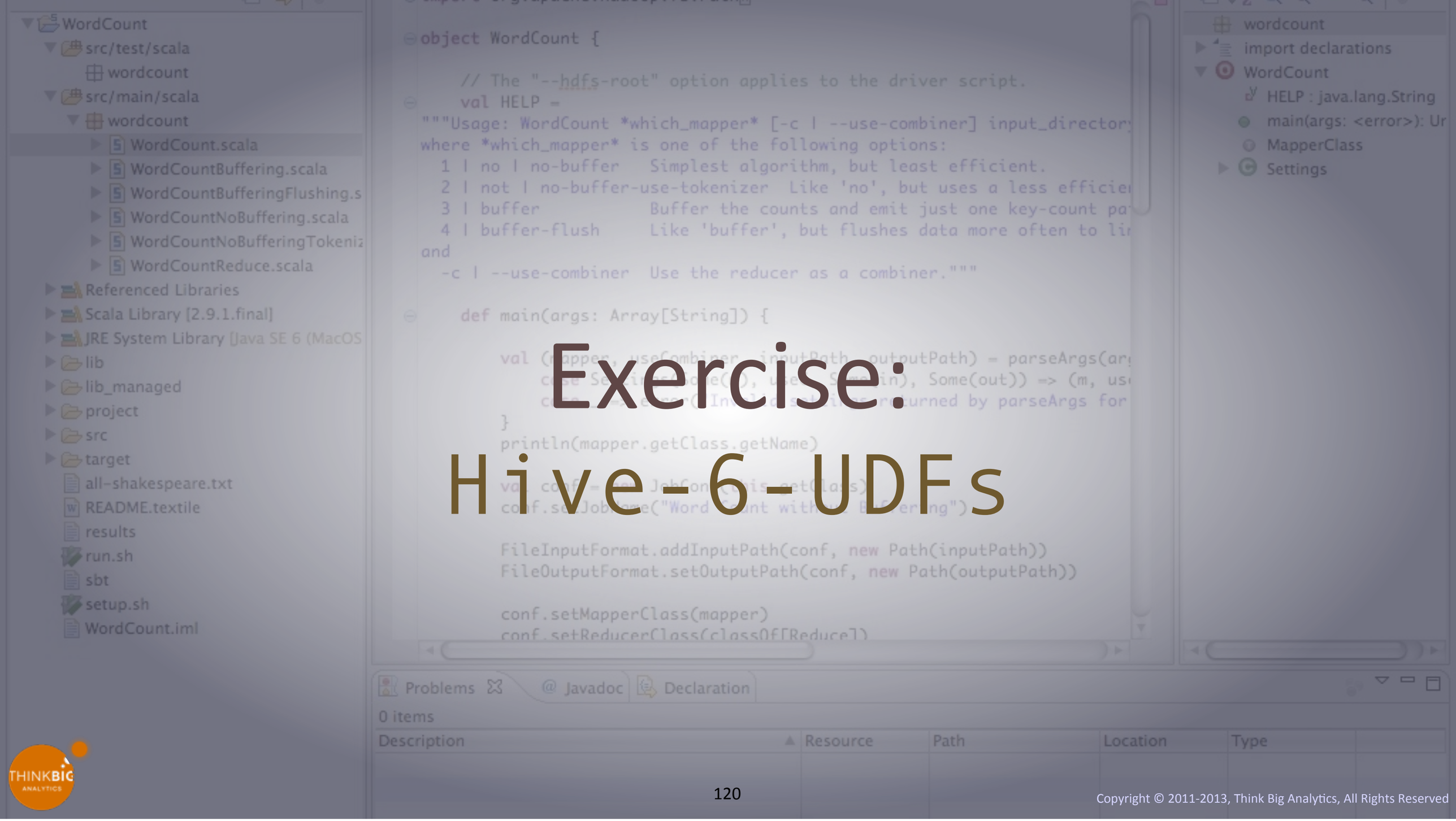
```
-- HQL
ADD JAR path_to_jar;

CREATE TEMPORARY FUNCTION now
AS 'com...NowUDF';
```

There is no CREATE PERMANENT FUNCTION...

```
SELECT epoch_millis FROM …
WHERE epoch_millis < now() …;
```


You compile the code into a jar and include in the HIVE_CLASSPATH using ADD JAR, then create a TEMPORARY FUNCTION, then PROFIT!

Exercise:
Hive-6-UDFs



File and *Record* Formats

https://cwiki.apache.org/confluence/display/Hive/SerDe

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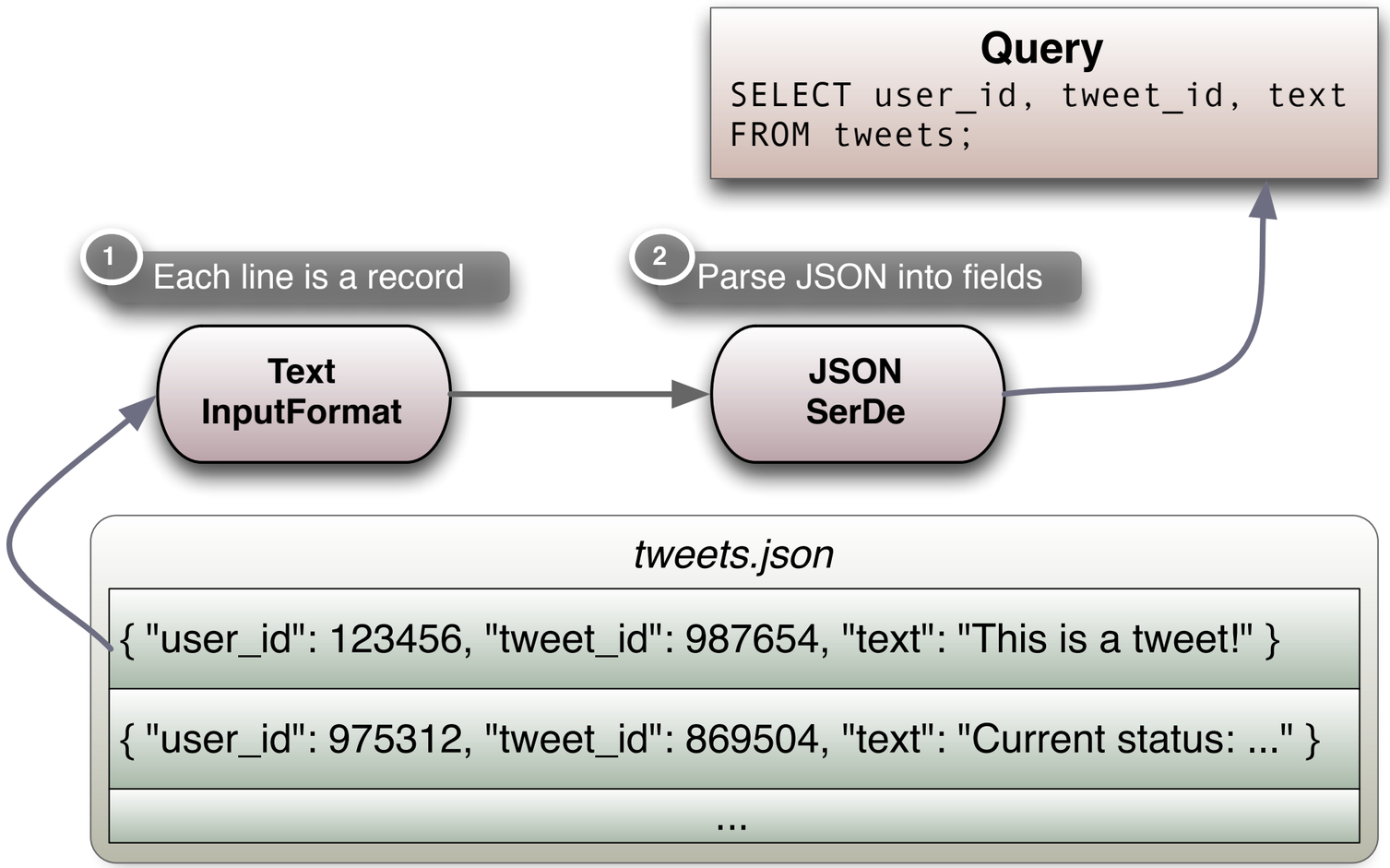
How to support new file and record formats. We have used the defaults almost exclusively today, but the file and record formats, and whether or not (and how) you compress files have important benefits for disk space and network IO overhead, MR performance, how easy it is to work with files using other tools (either within or outside the Hadoop "ecosystem"), etc. These choices are usually made by the IT team when architecting the whole system and particular data usage scenarios. We discuss these choices in depth in our Developer Course aimed at Java Developers. Also, the Bonus Material section contains an expanded version of this section.

File and *Record* Formats



All the InputFormat does is split the file into records. It knows nothing about the format of those records. The SerDe (serializer/deserializer) parses each record into fields/columns.

File and *Record* Formats

- INPUTFORMAT and OUTPUTFORMAT:
  - How *records* are stored in *files* and query results are written.
- SERDE: (serializer-deserializer)
  - How *records* are stored in *columns*.

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This is an important distinction; how records are encoded in files and how columns/fields are encoded in records.
INPUTFORMATs are responsible for splitting an input stream into records.
OUTPUTFORMATs are responsible for writing records to an output stream (i.e., query results). Two separate classes are used.
SERDEs are responsible for tokenizing a record into columns/fields and also encoding columns/fields into records. Unlike the *PUTFORMATs, there is one class for both tasks.

Built-in File Formats

- The default is TEXTFILE.

```
CREATE TABLE tbl_name (col1 TYPE, …)
…
STORED AS TEXTFILE;
```

- There are other built-in formats...

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We have been using TEXTFILE, the default, all day.
We'll discuss several of the most common options, but there are many more to choice from. In your projects, the whole development team will want to pick the most appropriate formats that balance the various concerns of disk space and network utilization, sharing with other tools, etc.

Built-in File Formats

- SEQUENCEFILE is a binary, space-efficient format supported by Hadoop.

```
CREATE TABLE tbl_name (col1 TYPE, …)
…
STORED AS SEQUENCEFILE;
```

- Easiest to use with pre-existing SEQUENCEFILEs or INSERT … SELECT.

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SEQUENCEFILE is a Hadoop MapReduce format that uses binary encoding of fields, rather than plain text, so it's more space efficient, but less convenient for sharing with non-Hadoop tools.

Built-in File Formats

- Enable SEQUENCEFILE block compression.

```
SET io.seqfile.compression.type=BLOCK;
CREATE TABLE tbl_name (col1 TYPE, …)
…
STORED AS SEQUENCEFILE;
```

- *BZip2* supports block compression!

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We won't discuss file compression in more detail here. (Our Hadoop training for Java Developers covers this topic in depth.) Compression gives further space and network IO savings. Compressing files by "block" (chunks of rows or bytes), rather than all at once has important practical consequences for MapReduce's ability to split a file into "splits", where each split is sent to a separate Map process. If a file can't be split, then no matter how big it is, it has to be sent to one task, reducing the benefit of a cluster! Block compressed files can be split by MR on block boundaries. Not all compression schemes support block compression. BZip2 does, but GZip does not. SEQUENCEFILEs lend themselves well to block compression.

Custom File Formats

- You might have your data in a *custom format*.

```
CREATE TABLE tbl_name (col1 TYPE, …)
…
STORED AS INPUTFORMAT '…' INPUTFORMAT '…';
```

You can also use other formats not built into Hive by specifying Java classes that implement them.

Custom File Formats

- Must specify both `INPUTFORMAT` and `OUTPUTFORMAT`.

```
CREATE TABLE tbl_name (col1 TYPE, …)
…
STORED AS INPUTFORMAT
'org.apache.hadoop.mapreduce.lib.input.TextInputFormat'
OUTPUTFORMAT
'org.apache.hadoop.hive.ql.io.HiveIgnoreKeyTextOutputFormat';
```

The Hive defaults for TEXTFILE

Used for query results

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Note that the default INPUTFORMAT is a general Hadoop MapReduce type, while the OUTPUTFORMAT is Hive-specific type.
If you specify INPUTFORMAT, you must also specify OUTPUTFORMAT.

SerDes: JSON “Records”

```
CREATE TABLE tbl_name (id BIGINT, …)
…
STORED AS ROW FORMAT SERDE
'org.apache.hadoop.hive.contrib.serde2.JsonSerde'
WITH SERDEPROPERTIES (
   "id"="$.id",
   "user"="$.user.name", …)
);
```

A SerDe for JSON

Mechanism for configuring SerDes (when they support it.)

We’ll explore this example in the exercise.

JSON SerDe

- There are several versions of this "contrib" *JSON* Serde.
- *Think Big Analytics* extended it to support SERDEPROPERTIES (among other things).

https://github.com/thinkbiganalytics/hive-json-serde

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The second project has an interesting JavaBean introspection library that makes it very easy to provide for more dynamic schemas, depending on what JavaBean properties are introspected.
We used the hive-json-serde just now, of course.

Exercise:
Hive-7-SerDe

Back to *UDFs*: *NGrams* and *Statistics*

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Let's look at a few more built-in functions, for doing n-gram analysis of text, an important tool for natural-language processing (machine learning), and also statistics, specifically histogram calculations.

Exercise:

Hive-8-NGrams-Stats

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… and we'll just right to the exercise.

Hive *SELECT-TRANSFORM* or *MAP-REDUCE* Syntax

https://cwiki.apache.org/confluence/display/Hive/LanguageManual+Transform

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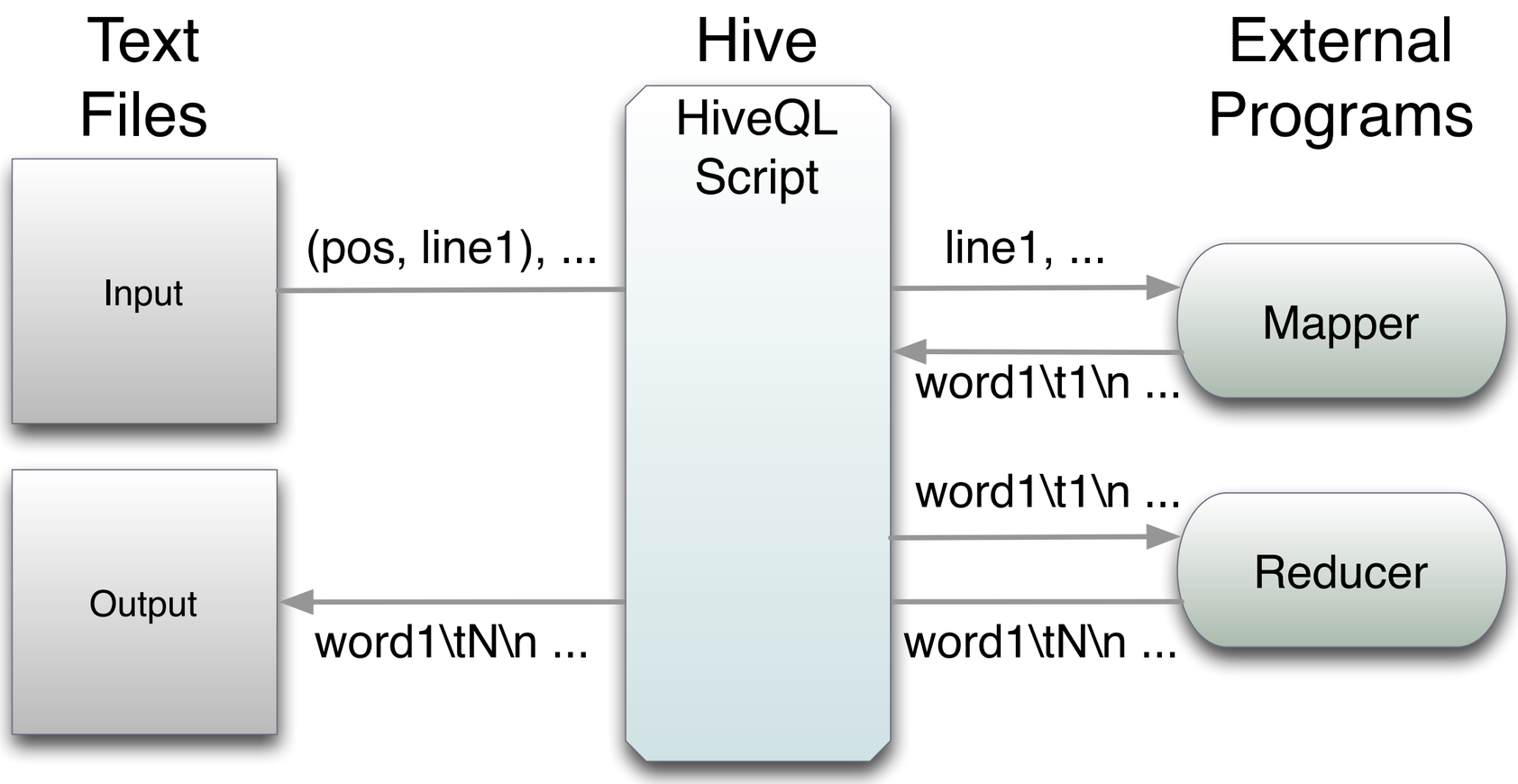
A technique for integrating external programs with Hive.

Calling External Scripts



Using the WordCount example for the key-value pairs shown.

Select Transform or Map Reduce

- A technique for calling out to external programs to perform map and reduce operations.

A way of reusing 3rd-party code you already have or extending the capabilities in Hive when a UDF isn't quite enough.

Word Count Example

- We'll use *mapper* and *reducer* scripts written in *Python* to compute the *Word Count* for *Shakespeare's plays*.

Word Count Example

```
# mapper.py
import sys

for line in sys.stdin:
    words = line.strip().split()
    for word in words:
        print "%s\t1" % (word.lower())
```

The *details* don't matter for our purposes.

Don't worry if you don't know Python. We read input from "stdin" ("standard in"), a line at a time. For each line, we "strip" whitespace off the beginning and end, then "split" the string on whitespace to create a list of words. Finally, we iterate through the words and print the word in lower case, followed by a tab character, followed by the number 1.
(We could rewrite the last line as
print "%s\t1" % (word.lower())

Word Count Example

- The reducer.py script:
  - Each key-value pair will be on a separate line in the input, but the keys will be sorted
  - So, we'll see this:

```
word1   1
word1   1
word2   1
word2   1
word3   1
...
```

Don't worry if you don't know Python. We read input from "stdin" ("standard in"), a line at a time. For each line, we "strip" whitespace off the beginning and end, then "split" the string on whitespace to create a list of words. Finally, we iterate through the words and print the word in lower case, followed by a tab character, followed by the number 1. (We could rewrite the last line as

print "%s\t1" % (word.lower())

Word Count Example

```
# reducer.py
import sys
(last_key, last_count) = (None, 0)
for line in sys.stdin:
  (key, count) = line.strip().split("\t")
  if last_key and last_key != key:
    print "%s\t%d" % (last_key, last_count)
    (last_key, count) = (key, int(count))
  else:
    last_key = key
    last_count += int(count)

if last_key:
    print "%s\t%d" % (last_key, last_count)
```

Mostly *bookkeeping details*.

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This one is obviously more complicated, mostly because of the way we received the key-value pairs from the map process, as discussed on the previous slide. We have to keep track of the last key (from the previous line), so we can detect when we start getting lines with the next key. We also track the count for the last key. We loop through the input lines, removing leading and trailing whitespace, then splitting on the tab character to extract the current key and count (which is always 1 for our case).

Next, we test to see if the new key is different from the last key. If so, we print out the last key and its total count, then reset the last key and count to be what we just read in. Otherwise, if we're still receiving the same key, we update the count and make sure the last_key is assigned (needed for the very first line on input). Finally, after the loop finishes, we write out whatever is left, if any.

(There are certainly improvements you could make to this script, like extracting the "print" statement into a function…)

Word Count Example

- First we need tables for the input text and output word count:

```
CREATE EXTERNAL TABLE
 shakespeares_plays (line STRING)
LOCATION '/data/shakespeare/input';

CREATE TABLE shakespeares_plays_wc (
   word STRING, count INT)
ROW FORMAT
DELIMITED FIELDS TERMINATED BY '\t';
```

The “input” directory contains a file with all of Shakespeare’s plays. We will treat each line as a “record” with one field – the line of text.
The output table will have word-count records, a text file separated by tabs, which makes it easy to use with the Python scripts.

Word Count Example

```
ADD FILE /.../mapper.py;
ADD FILE /.../reducer.py;
FROM (
 FROM shakespeares_plays
 MAP line USING 'mapper.py'
 AS word, count
 CLUSTER BY word) wc
INSERT OVERWRITE TABLE shakespeares_plays_wc
REDUCE wc.word, wc.count USING 'reducer.py'
AS word, count;
```

Word Count Example

```
ADD FILE /.../mapper.py;
ADD FILE /.../reducer.py;
FROM (
 FROM shakespeares_plays
 MAP line USING 'mapper.py'
 AS word, count
 CLUSTER BY word) wc
INSERT OVERWRITE TABLE shakespeares_plays_wc
REDUCE wc.word, wc.count USING 'reducer.py'
AS word, count;
```

Copy scripts around cluster

There is no SELECT clause; every “field” output by the MAP step will be “selected”.
The map step is invoked in a nested query of the same FROM form.
It is necessary to here to cluster the map output by word, which means we want all (word,count) pairs for a given value of “word” to go to the same reducer step invocation, a requirement for the WordCount algorithm to work.

Word Count Example

```
ADD FILE /.../mapper.py;
ADD FILE /.../reducer.py;
FROM (
 FROM shakespeares_plays
 MAP line USING 'mapper.py'
 AS word, count
 CLUSTER BY word) wc
INSERT OVERWRITE TABLE shakespeares_plays_wc
REDUCE wc.word, wc.count USING 'reducer.py'
AS word, count;
```

Nested query.

Must cluster the map output

There is no SELECT clause; every “field” output by the MAP step will be “selected”.
The map step is invoked in a nested query of the same FROM form.
It is necessary to here to cluster the map output by word, which means we want all (word,count) pairs for a given value of “word” to go to the same reducer step invocation, a requirement for the WordCount algorithm to work.

Word Count Example

```
ADD FILE /.../mapper.py;
ADD FILE /.../reducer.py;
FROM (
 FROM shakespeares_plays
 MAP line USING 'mapper.py'
 AS word, count
 CLUSTER BY word) wc
INSERT OVERWRITE TABLE shakespeares_plays_wc
 REDUCE wc.word, wc.count USING 'reducer.py'
 AS word, count;
```

The *map* step.

The *reduce* step.

Note the MAP … USING and REDUCE … USING clauses. Note the absolute path; Hive doesn't appear to use your PATH setting and it doesn't appear to use your current working directory, if the script is there.

Word Count Example

```
ADD FILE /.../mapper.py;
ADD FILE /.../reducer.py;
FROM (
 FROM shakespeares_plays
 SELECT TRANSFORM (line) USING 'mapper.py'
 AS word, count
 CLUSTER BY word) wc
INSERT OVERWRITE TABLE shakespeares_plays_wc
 SELECT TRANSFORM (wc.word, wc.count) USING
'reducer.py'
 AS word, count;
```

The more generic SELECT TRANSFORM syntax.

Using MAP… and REDUCE… is actually *misleading*.

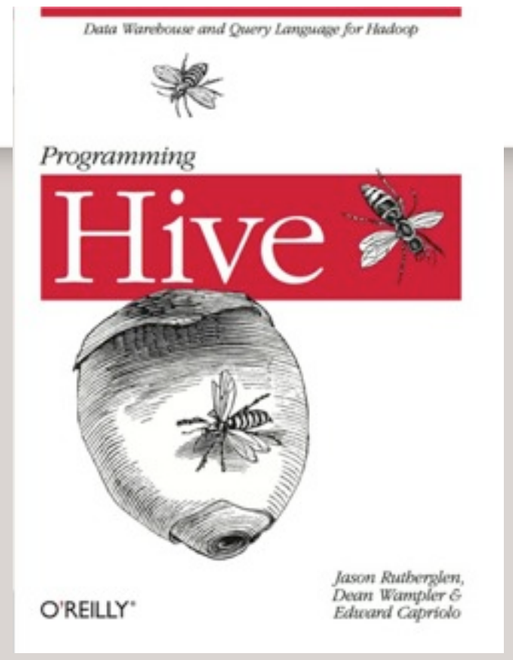
Using MAP … and REDUCE … keywords is a bit misleading, because Hive doesn't guarantee that "mapper.py" is invoked in a Map task, nor that "reducer.py" is invoked in a Reduce task.

Exercise: Hive-9-Select-Transform

THINKBIG ANALYTICS

info@thinkbiganalytics.com
http://thinkbiganalytics.com

http://bit.ly/Strata2013HiveTutorial



Thanks for attending!

Questions?