Hive: SQL for Hadoop

Dean Wampler

hadoop

Wednesday, May 14, 14

I'll argue that Hive is indispensable to people creating "data warehouses" with Hadoop, because it gives them a "similar" SQL interface to their data, making it easier to migrate skills and even apps from existing relational tools to Hadoop.

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Why Hive?

Since your team *knows SQL* and all your *Data Warehouse* apps are written in *SQL*, *Hive* minimizes the effort of migrating to *Hadoop*.

Hive

- Ideal for *data warehousing*.
  - *Ad-hoc queries* of data.
  - Familiar *SQL* dialect.
  - Analysis of *large* data sets.
  - Hadoop *MapReduce* jobs.

Hive is a killer app, in our opinion, for data warehouse teams migrating to Hadoop, because it gives them a familiar SQL language that hides the complexity of MR programming.

Hive

- Invented at *Facebook*.
- Open sourced to *Apache* in 2008.
- http://hive.apache.org

A Scenario:
Mining Daily Click Stream Logs

Ingest & Transform:

- From: `file://server1/var/log/clicks.log`

```
Jan  9 09:02:17 server1 movies[18]:
1234: search for “vampires in love”.
…
```


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As we copy the daily click stream log over to a local staging location, we transform it into the Hive table format we want.

Ingest & Transform:

- From: `file://server1/var/log/clicks.log`

```
Jan  9 09:02:17 server1 movies[18]:
1234: search for “vampires in love”.
…
```

Timestamp

Ingest & Transform:

- From: `file://server1/var/log/clicks.log`

```
Jan  9 09:02:17 server1 movies[18]:
1234: search for “vampires in love”.
…
```

The server

Ingest & Transform:

- From: `file://server1/var/log/clicks.log`

```
Jan  9 09:02:17 server1 movies[18]:
1234: search for “vampires in love”.
…
```

The process
(“movies search”)
and the process id.

Ingest & Transform:

- From: `file://server1/var/log/clicks.log`

```
Jan  9 09:02:17 server1 movies[18]:
1234: search for “vampires in love”.
…
```

Customer id

Ingest & Transform:

- From: `file://server1/var/log/clicks.log`

```
Jan  9 09:02:17 server1 movies[18]:
1234: search for “vampires in love”.
…
```

The log “message”

Ingest & Transform:

- From: `file://server1/var/log/clicks.log`

```
Jan  9 09:02:17 server1 movies[18]:
1234: search for “vampires in love”.
…
```

- To: `/staging/2012-01-09.log`

```
09:02:17^Aserver1^Amovies^A18^A1234^Asea
rch for “vampires in love”.
…
```


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As we copy the daily click stream log over to a local staging location, we transform it into the Hive table format we want.

Ingest & Transform:

- To: `/staging/2012-01-09.log`

```
09:02:17^Aserver1^Amovies^A18^A1234^Asea
rch for “vampires in love”.
…
```

- *Removed* month (`Jan`) and day (`09`).
- Added `^A` as *field* separators (Hive convention).
- Separated process *id* from process *name*.

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The transformations we made. (You could use many different Linux, scripting, code, or Hadoop-related ingestion tools to do this.

Ingest & Transform:

- Put in HDFS:

```
hadoop fs -put /staging/2012-01-09.log \
    /clicks/2012/01/09/log.txt
```

- (The final file name doesn't matter…)

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Here we use the hadoop shell command to put the file where we want it in the file system. Note that the name of the target file doesn't matter; we'll just tell Hive to read all files in the directory, so there could be many files there!

Back to Hive...

- Create an *external* Hive table:

```
CREATE EXTERNAL TABLE clicks (
   hms          STRING,
   hostname     STRING,
   process      STRING,
   pid          INT,
   uid          INT,
   message      STRING)
 PARTITIONED BY (
   year         INT,
   month        INT,
   day          INT);
```

You don't have to use EXTERNAL and PARTITIONED together….

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Now let's create an "external" table that will read those files as the "backing store". Also, we make it partitioned to accelerate queries that limit by year, month or day. (You don't have to use external and partitioned together…)

Back to Hive...

- Add a *partition* for 2012-01-09:

```
ALTER TABLE clicks ADD IF NOT EXISTS
 PARTITION (
   year=2012,
   month=01,
   day=09)
 LOCATION '/clicks/2012/01/09';
```

- A *directory* in HDFS.

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We add a partition for each day. Note the LOCATION path, which is a the directory where we wrote our file.

Now, Analyze!!

- What's with the *kids* and *vampires*??

```
SELECT hms, uid, message FROM clicks
 WHERE message LIKE '%vampire%' AND
       year  = 2012 AND
       month = 01   AND
       day   = 09;
```

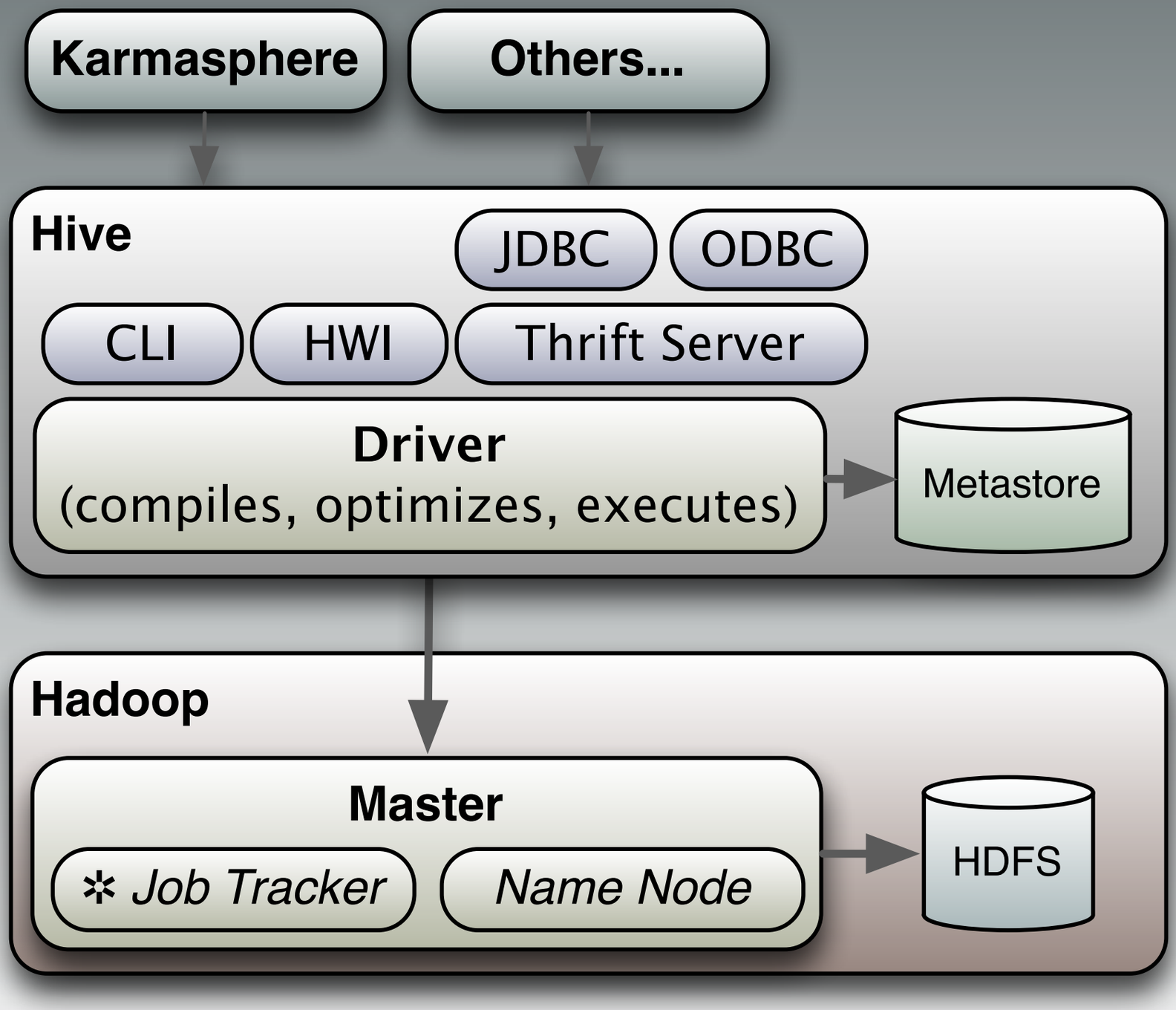
- After some *MapReduce* crunching...

```
…
09:02:29 1234 search for “twilight of the vampires”
09:02:35 1234 add to cart “vampires want their genre back”
…
```


And we can run SQL queries!!

Recap

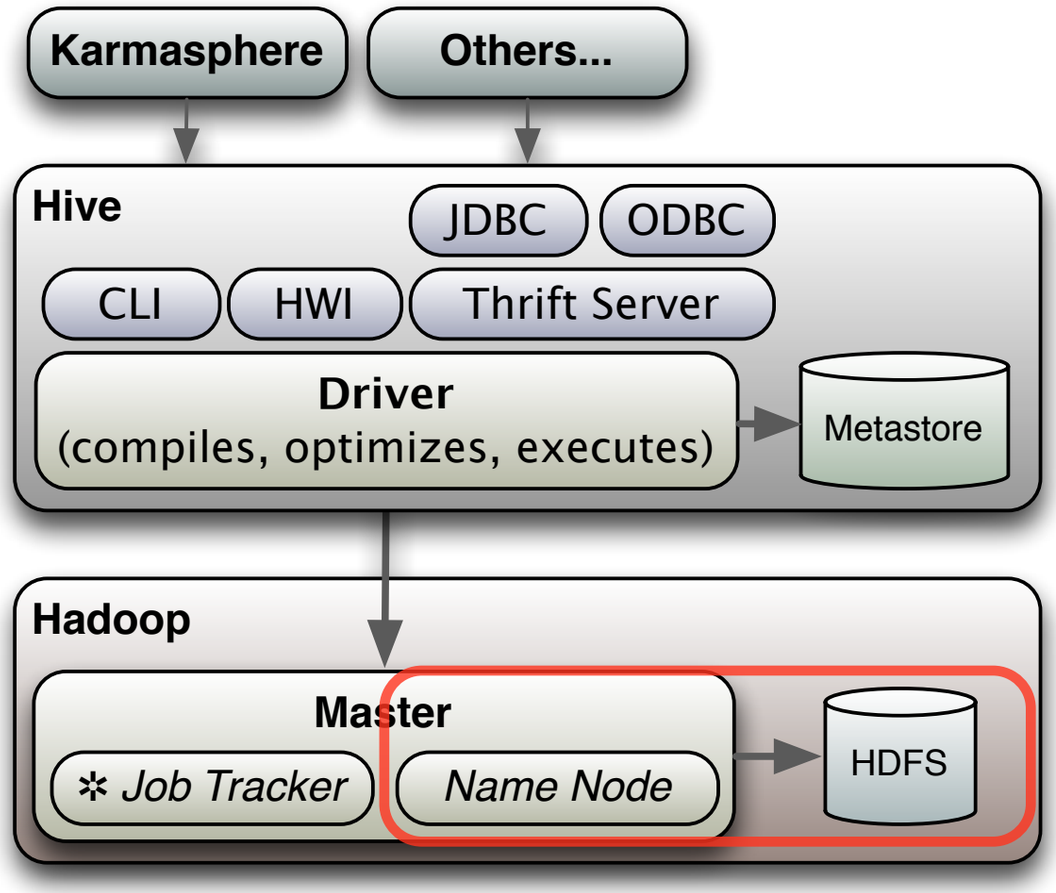
- *SQL analysis* with Hive.
- *Other tools* can use the data, too.
- *Massive scalability* with Hadoop.



Hive queries generate MR jobs. (Some operations don't invoke Hadoop processes, e.g., some very simple queries and commands that just write updates to the metastore.)
CLI = Command Line Interface.
HWI = Hive Web Interface.

Tables

- *HDFS*
- *MapR*
- *S3*
- *HBase* (new)
- *Others*...



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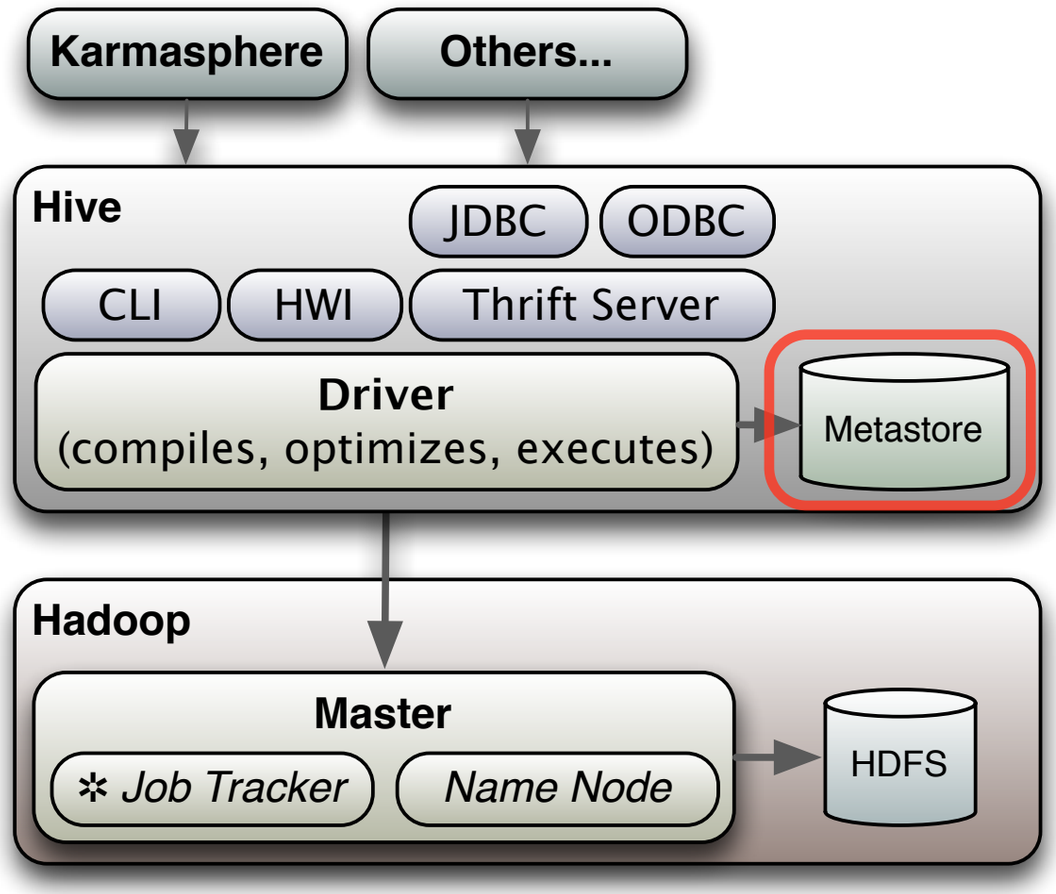
There is “early” support for using Hive with HBase. Other databases and distributed file systems will no doubt follow.

Tables

- Table *metadata* stored in a *relational DB*.



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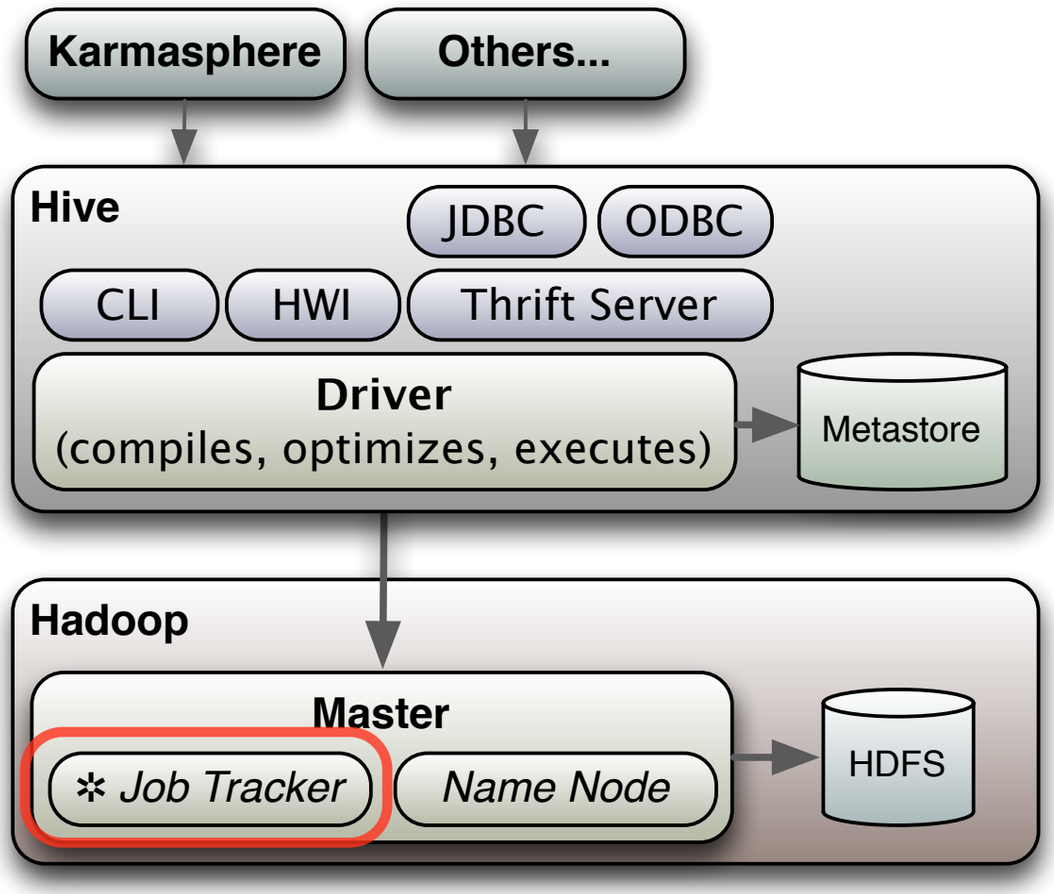
For production, you need to set up a MySQL or PostgreSQL database for Hive's metadata. Out of the box, Hive uses a Derby DB, but it can only be used by a single user and a single process at a time, so it's fine for personal development only.

Queries

- Most queries use *MapReduce* jobs.



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Hive generates MapReduce jobs to implement all the but the simplest queries.

MapReduce Queries

- *Benefits*
  - Horizontal scalability.
- *Drawbacks*
  - Latency!

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The high latency makes Hive unsuitable for “online” database use. (Hive also doesn’t support transactions and has other limitations that are relevant here…) So, these limitations make Hive best for offline (batch mode) use, such as data warehouse apps.

HDFS Storage

- *Benefits*
  - Horizontal scalability.
  - Data redundancy.
- *Drawbacks*
  - No *insert*, *update*, and *delete*!

You can generate new tables or write to local files. Forthcoming versions of HDFS will support appending data.

HDFS Storage

- *Schema on Read*
  - Schema enforcement at *query* time, not *write* time.

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Especially for external tables, but even for internal ones since the files are HDFS files, Hive can't enforce that records written to table files have the specified schema, so it does these checks at query time.

Other Limitations

- No *Transactions*.
- Some *SQL* features not implemented (yet).

More on Tables and Schemas

Data Types

- The usual *scalar* types:
  - `TINYINT`, ..., `BIGNT`.
  - `FLOAT`, `DOUBLE`.
  - `BOOLEAN`.
  - `STRING`.

Like most databases...

Data Types

- The unusual *complex* types:
  - STRUCT.
  - MAP.
  - ARRAY.

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Structs are like “objects” or “c-style structs”. Maps are key-value pairs, and you know what arrays are ;)

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


subordinates references other records by the employee name. (Hive doesn't have indexes, in the usual sense, but an indexing feature was recently added.) Deductions is a key-value list of the name of the deduction and a float indicating the amount (e.g., %). Address is like a "class", "object", or "c-style struct", whatever you prefer.

File & Record Formats

```
CREATE TABLE employees (…)
  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 for text files!

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Suppose our employees table has a custom format and field delimiters. We can change them, although here I'm showing all the default values used by Hive!

Select, Where, Group By, Join,...

Common SQL...

- You get most of the usual suspects for `SELECT`, `WHERE`, `GROUP BY` and `JOIN`.

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We'll just highlight a few unique features.

"User Defined Functions"

```
ADD JAR MyUDFs.jar;

CREATE TEMPORARY FUNCTION
  net_salary
  AS 'com.example.NetCalcUDF';


SELECT name,
   net_salary(salary, deductions)
  FROM employees;
```


Following a Hive defined API, implement your own functions, build, put in a jar, and then use them in your queries. Here we (pretend to) implement a function that takes the employee's salary and deductions, then computes the net salary.

ORDER BY vs. SORT BY

- A *total* ordering - one reducer.

```
SELECT name, salary
  FROM employees
  ORDER BY salary ASC;
```

- A *local* ordering - sorts within each reducer.

```
SELECT name, salary
  FROM employees
  SORT BY salary ASC;
```


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For a giant data set, piping everything through one reducer might take a very long time. A compromise is to sort “locally”, so each reducer sorts it’s output. However, if you structure your jobs right, you might achieve a total order depending on how data gets to the reducers. (E.g., each reducer handles a year’s worth of data, so joining the files together would be totally sorted.)

Inner Joins

- Only *equality* (x = y).

```
SELECT ...
  FROM clicks a JOIN clicks b ON (
    a.uid = b.uid, a.day = b.day)
 WHERE a.process = 'movies'
   AND b.process = 'books'
   AND a.year > 2012;
```


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Note that the a.year > '...' is in the WHERE clause, not the ON clause for the JOIN. (I'm doing a correlation query; which users searched for movies and books on the same day?)
Some outer and semi join constructs supported, as well as some Hadoop-specific optimization constructs.

A Final Example of Controlling MapReduce...

Specify Map & Reduce Processes

- Calling out to *external programs* to perform *map* and *reduce* operations.

Example

```
FROM (
 FROM clicks
  MAP message
  USING '/tmp/vampire_extractor'
  AS item_title, count
  CLUSTER BY item_title) it
INSERT OVERWRITE TABLE vampire_stuff
 REDUCE it.item_title, it.count
 USING '/tmp/thing_counter.py'
 AS item_title, counts;
```


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Note the MAP … USING and REDUCE … USING. We're also using CLUSTER BY (distributing and sorting on "item_title").

Example

```
FROM (
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  MAP message
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 AS item_title, counts;
```

Call specific map and reduce processes.

Note the MAP … USING and REDUCE … USING. We're also using CLUSTER BY (distributing and sorting on "item_title").

… And Also:

```
FROM (
 FROM clicks
  MAP message
  USING '/tmp/vampire_extractor'
  AS item_title, count
  CLUSTER BY item_title) it
INSERT OVERWRITE TABLE vampire_stuff
 REDUCE it.item_title, it.count
 USING '/tmp/thing_counter.py'
 AS item_title, counts;
```

Like GROUP BY, but directs output to specific reducers.

Note the MAP … USING and REDUCE … USING. We're also using CLUSTER BY (distributing and sorting on "item_title").

… And Also:

```
FROM (
 FROM clicks
  MAP message
  USING '/tmp/vampire_extractor'
  AS item_title, count
  CLUSTER BY item_title) it
INSERT OVERWRITE TABLE vampire_stuff
  REDUCE it.item_title, it.count
  USING '/tmp/thing_counter.py'
  AS item_title, counts;
```

How to populate an "internal" table.

Note the MAP … USING and REDUCE … USING. We're also using CLUSTER BY (distributing and sorting on "item_title").

Hive: Conclusions

Hive Disadvantages

- *Not* a *real SQL Database*.
  - Transactions, updates, etc.
  - … but features will grow.
- *High latency* queries.
- Documentation poor.

Hive Advantages

- Indispensable for *SQL users*.
- *Easier* than *Java* MR API.
- Makes *porting* data warehouse apps to Hadoop much *easier*.

Questions?

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- Hire me!