



Big Data Infrastructure

CS 489/698 Big Data Infrastructure (Winter 2017)

Week 6: Analyzing Relational Data (1/3)

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These slides are available at <http://lintool.github.io/bigdata-2017w/>



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Structure of the Course

Analyzing Text

Analyzing Graphs

Analyzing
Relational Data

Data Mining

“Core” framework features
and algorithm design

Evolution of Enterprise Architectures

Next two sessions: techniques, algorithms, and optimizations for relational processing

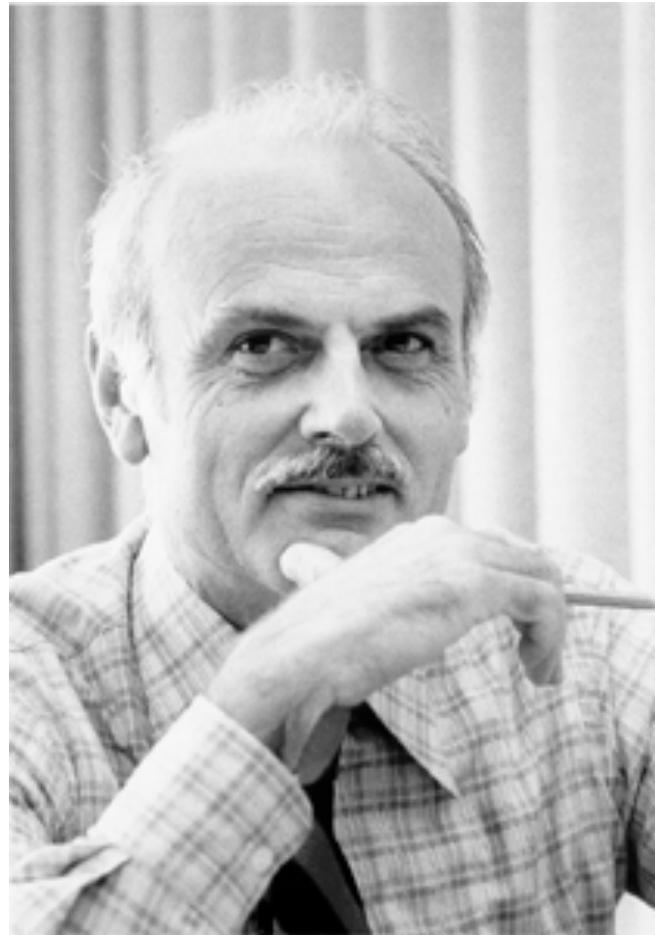
users

Monolithic
Application

users

Frontend

Backend



users

Frontend

Backend

database

Why is this a good idea?

Business Intelligence

An organization should retain data that result from carrying out its mission and exploit those data to generate insights that benefit the organization, for example, market analysis, strategic planning, decision making, etc.

Duh!?

users

Frontend

Backend

database

BI tools

analysts

users



Frontend

Backend

Why is my
application so slow?

database

BI tools

analysts

Why does my
analysis take so long?



Database Workloads

OLTP (online transaction processing)

Typical applications: e-commerce, banking, airline reservations

User facing: real-time, low latency, highly-concurrent

Tasks: relatively small set of “standard” transactional queries

Data access pattern: random reads, updates, writes (small amounts of data)

OLAP (online analytical processing)

Typical applications: business intelligence, data mining

Back-end processing: batch workloads, less concurrency

Tasks: complex analytical queries, often ad hoc

Data access pattern: table scans, large amounts of data per query

OLTP and OLAP Together?

Downsides of co-existing OLTP and OLAP workloads

- Poor memory management
- Conflicting data access patterns
- Variable latency

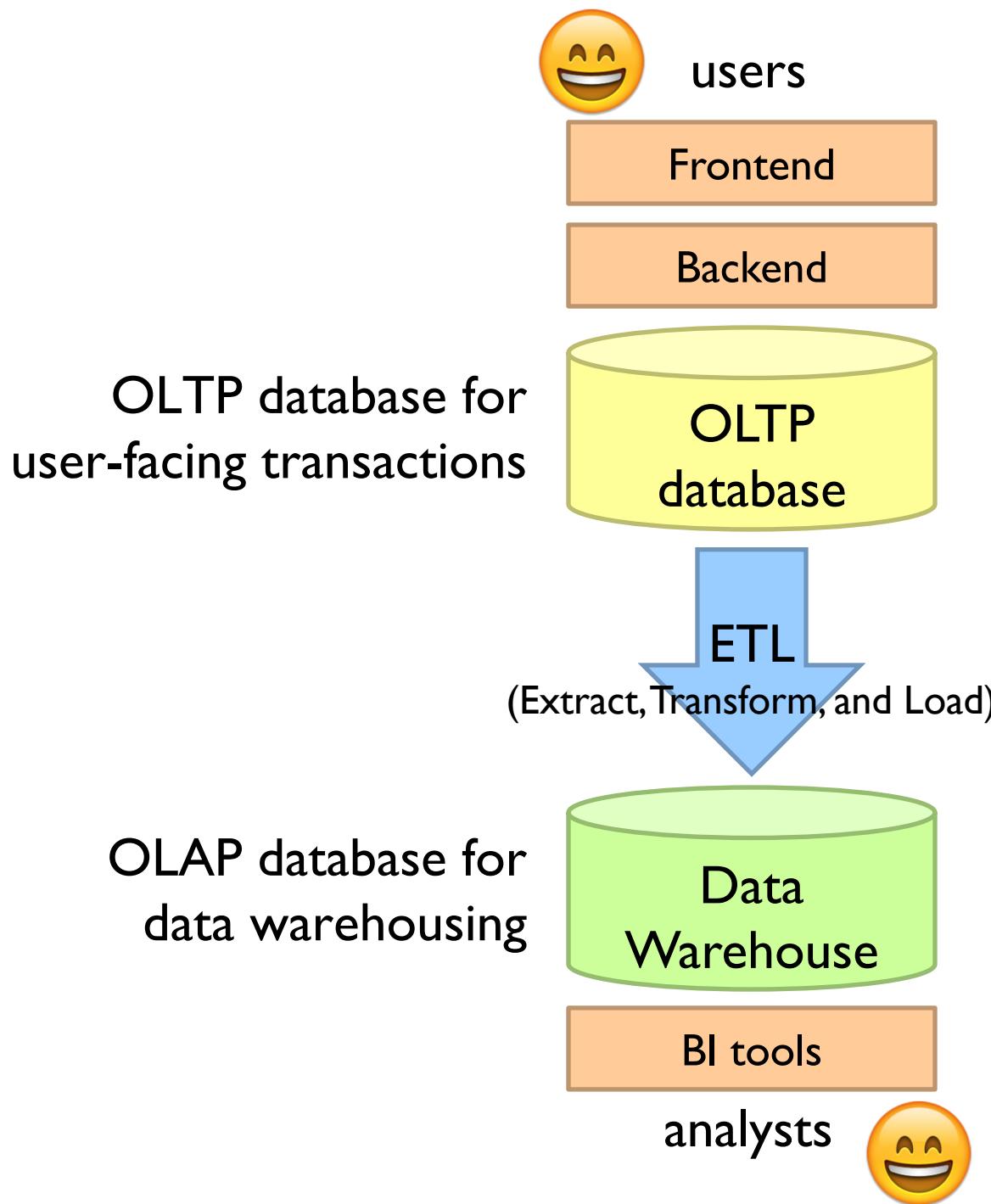


users and analysts

Solution?

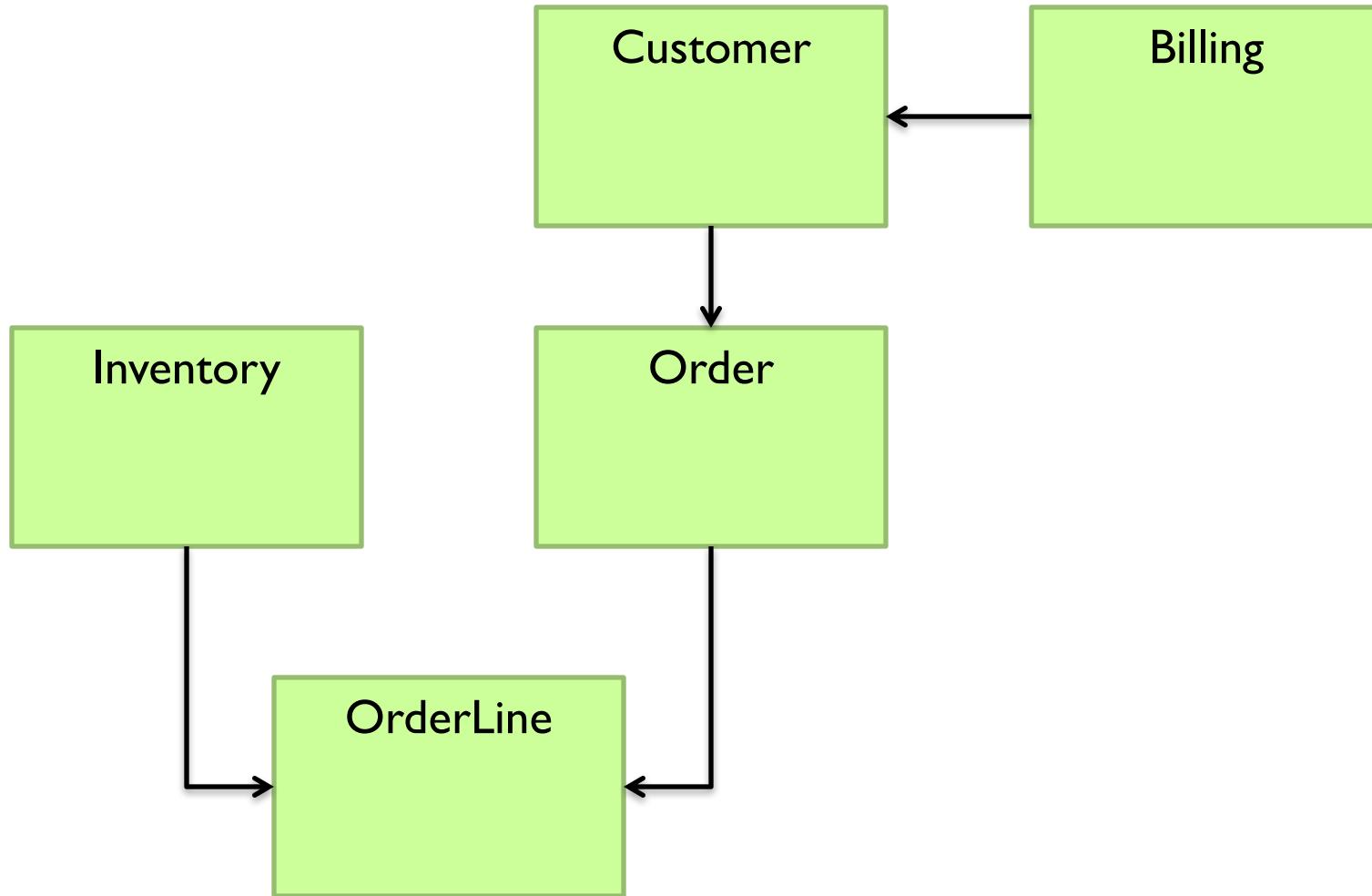


Build a data warehouse!

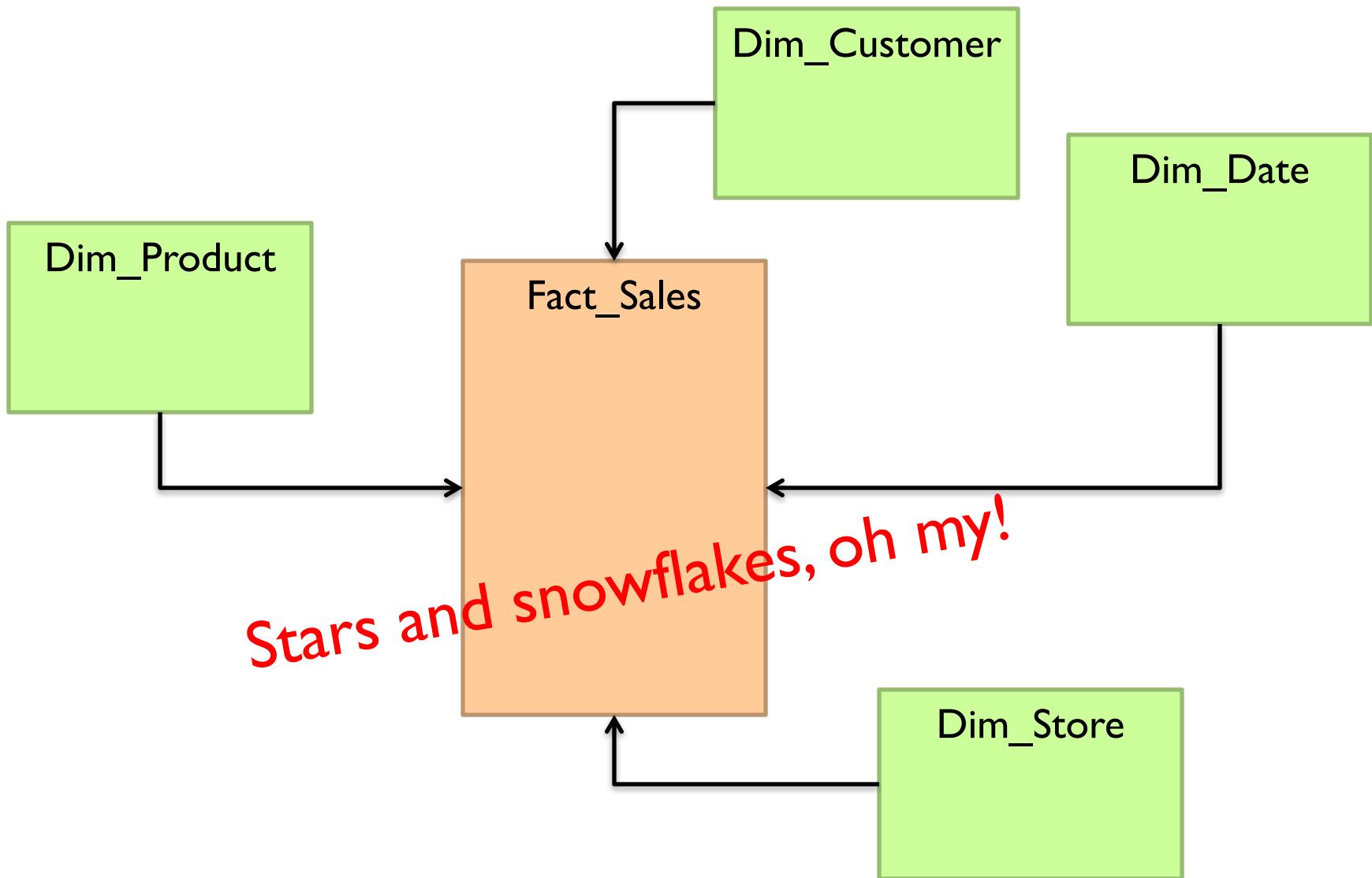


What's special about
OLTP vs. OLAP?

A Simple OLTP Schema



A Simple OLAP Schema



ETL

Extract

Transform

Data cleaning and integrity checking

Schema conversion

Field transformations

Load

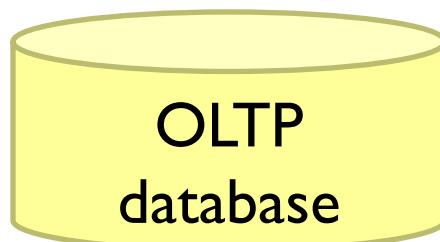
When does ETL happen?



users

Frontend

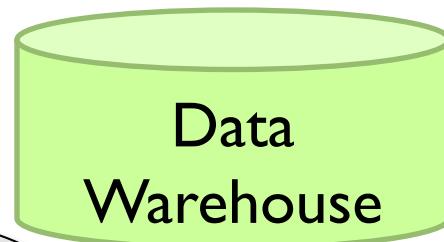
Backend



OLTP
database

ETL

(Extract, Transform, and Load)



Data
Warehouse

BI tools

analysts

My data is a
day old...

Meh.

external APIs

users

users

Frontend

Frontend

Frontend

Backend

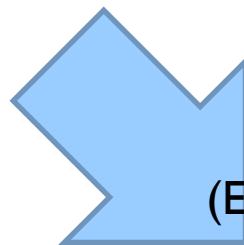
Backend

Backend

OLTP
database

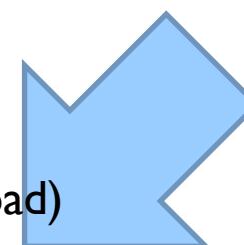
OLTP
database

OLTP
database



ETL

(Extract, Transform, and Load)



BI tools

analysts

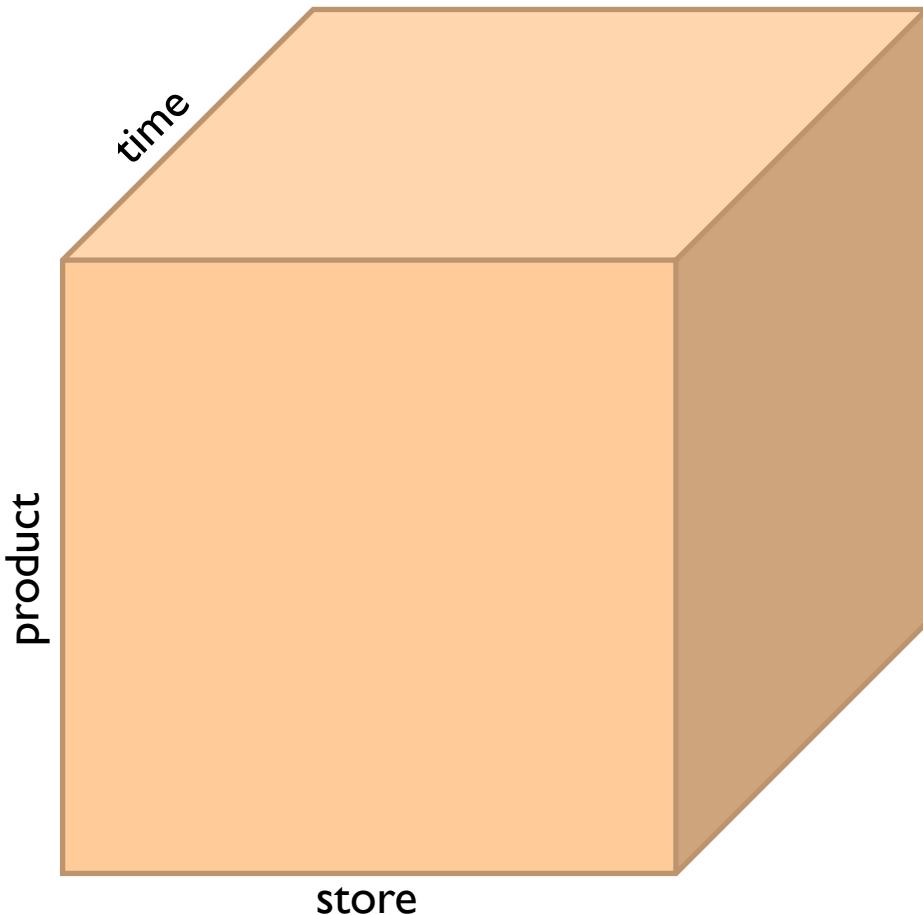
What do you actually do?

Report generation

Dashboards

Ad hoc analyses

OLAP Cubes



Common operations

slice and dice

roll up/drill down

pivot

OLAP Cubes: Challenges

Fundamentally, lots of joins, group-bys and aggregations
How to take advantage of schema structure to avoid repeated work?

Cube materialization

Realistic to materialize the entire cube?
If not, how/when/what to materialize?

external APIs



users



users

Frontend

Frontend

Frontend

Backend

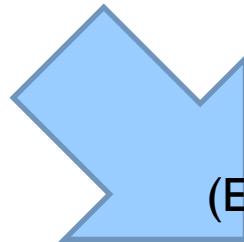
Backend

Backend

OLTP
database

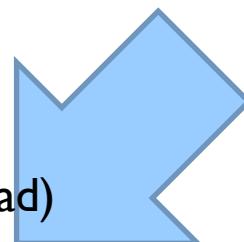
OLTP
database

OLTP
database



(Extract, Transform, and Load)

ETL



BI tools

analysts

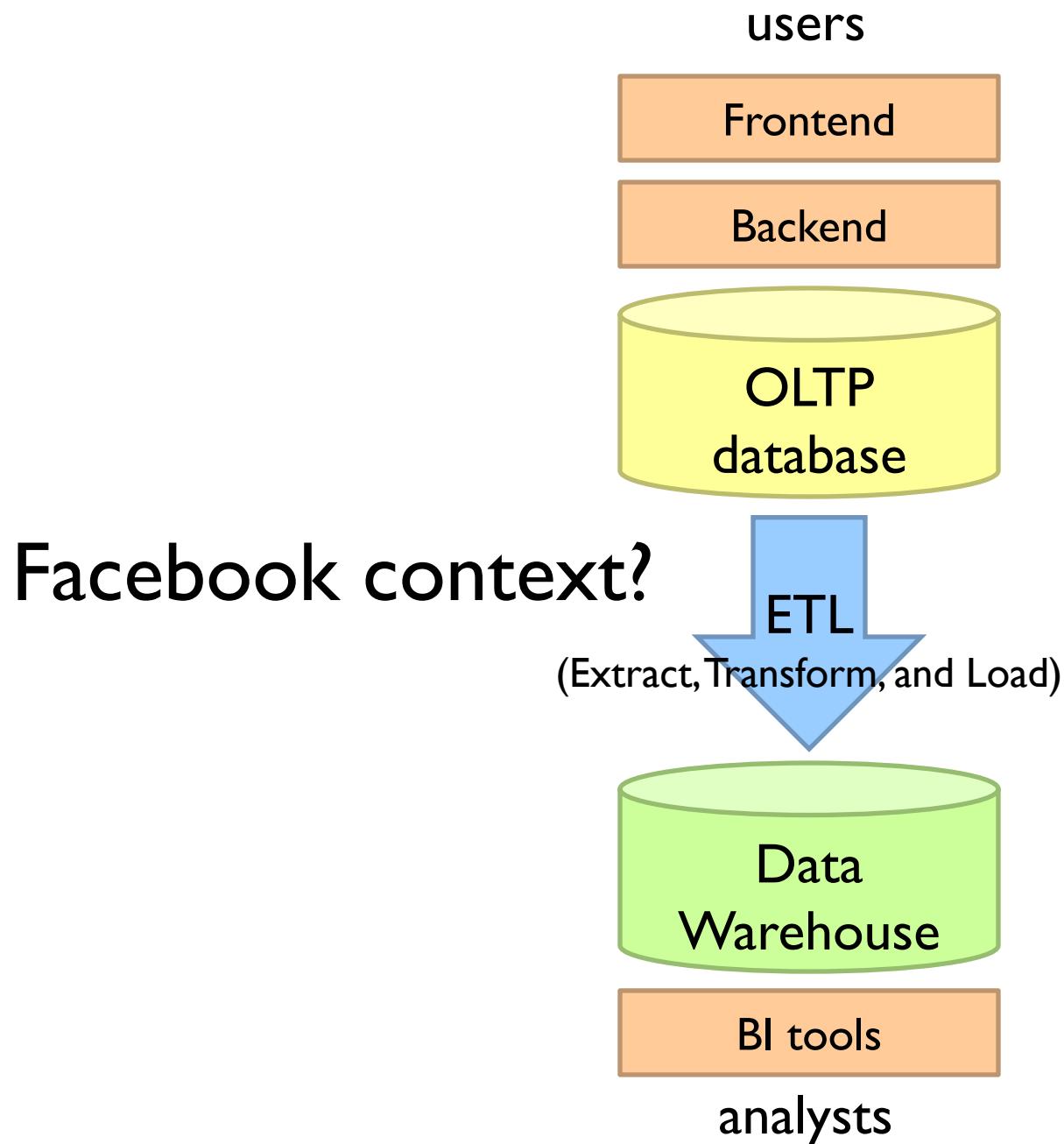


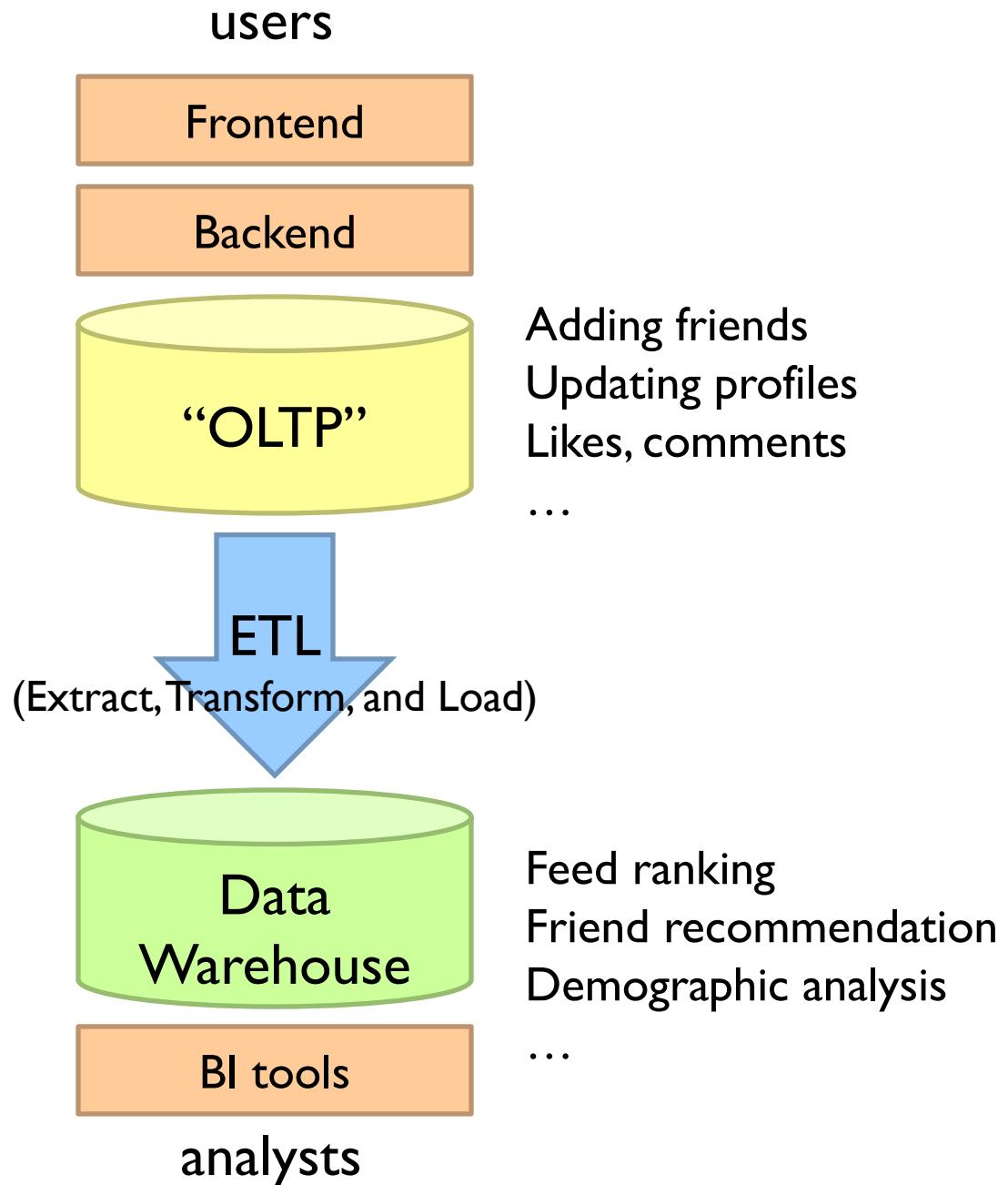
Fast forward...

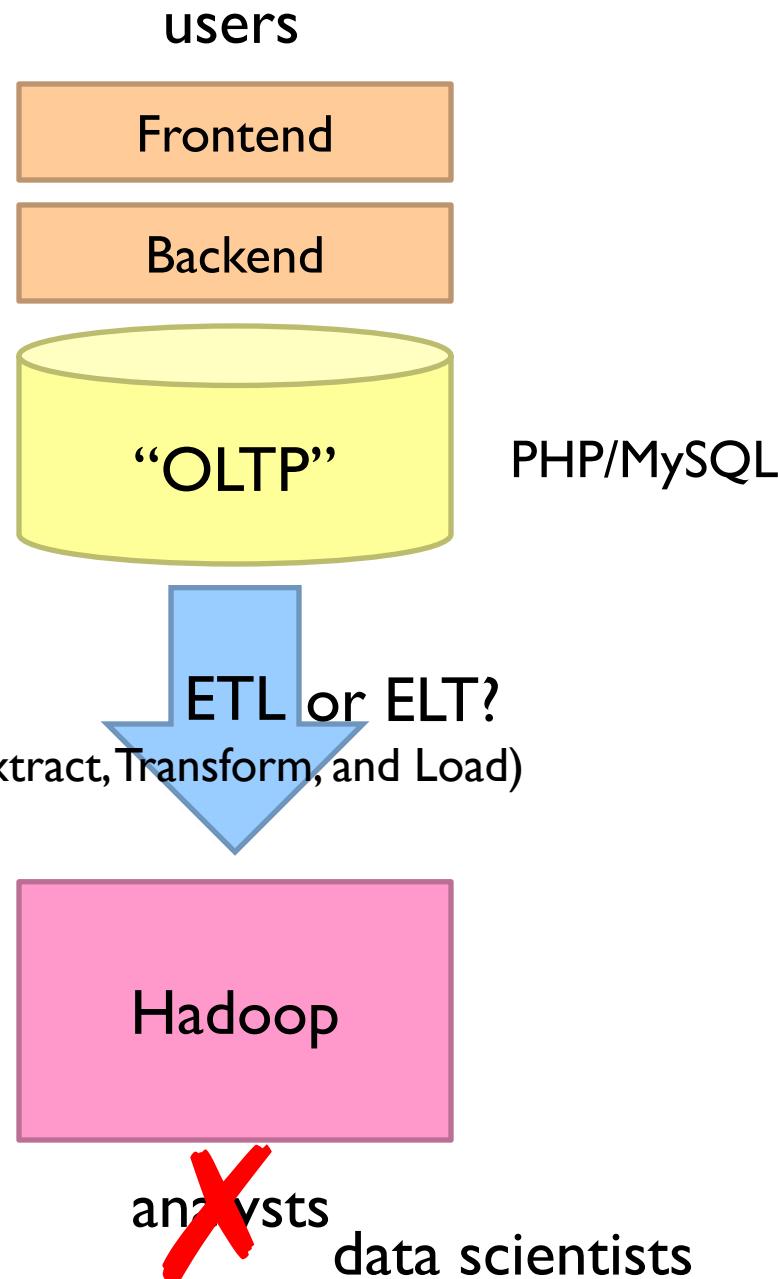


Jeff Hammerbacher, Information Platforms and the Rise of the Data Scientist.
In, *Beautiful Data*, O'Reilly, 2009.

“On the first day of logging the Facebook clickstream, more than 400 gigabytes of data was collected. The load, index, and aggregation processes for this data set really taxed the Oracle data warehouse. Even after significant tuning, we were unable to aggregate a day of clickstream data in less than 24 hours.”







What
Droppi
Cheaper to store everything



5 MB hard drive in 1956

What's changed?

Dropping cost of disks

Cheaper to store everything than to figure out what to throw away

Types of data collected

From data that's *obviously* valuable to data whose value is less apparent

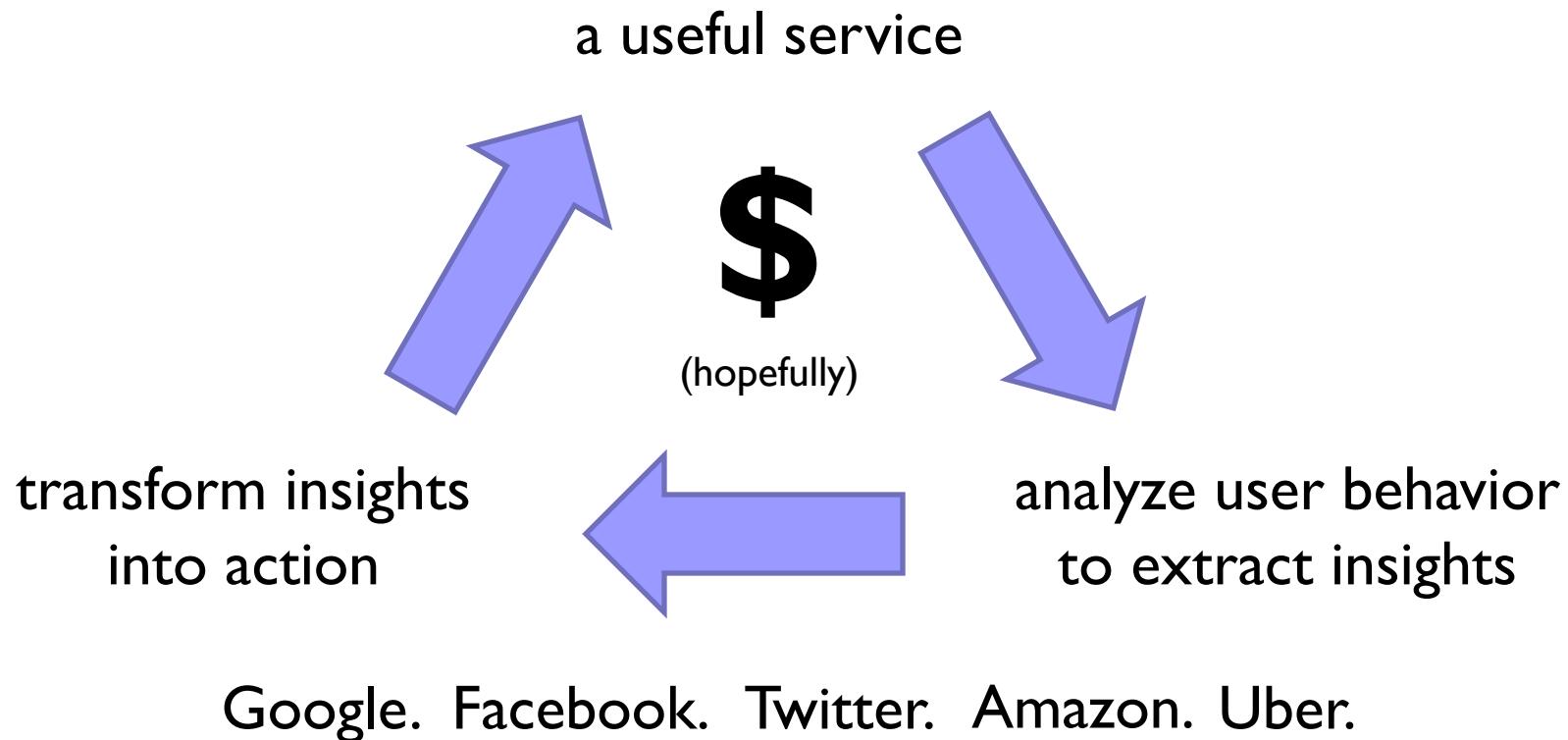
Rise of social media and user-generated content

Large increase in data volume

Growing maturity of data mining techniques

Demonstrates value of data analytics

Virtuous Product Cycle



What do you actually do?

Report generation

Dashboards

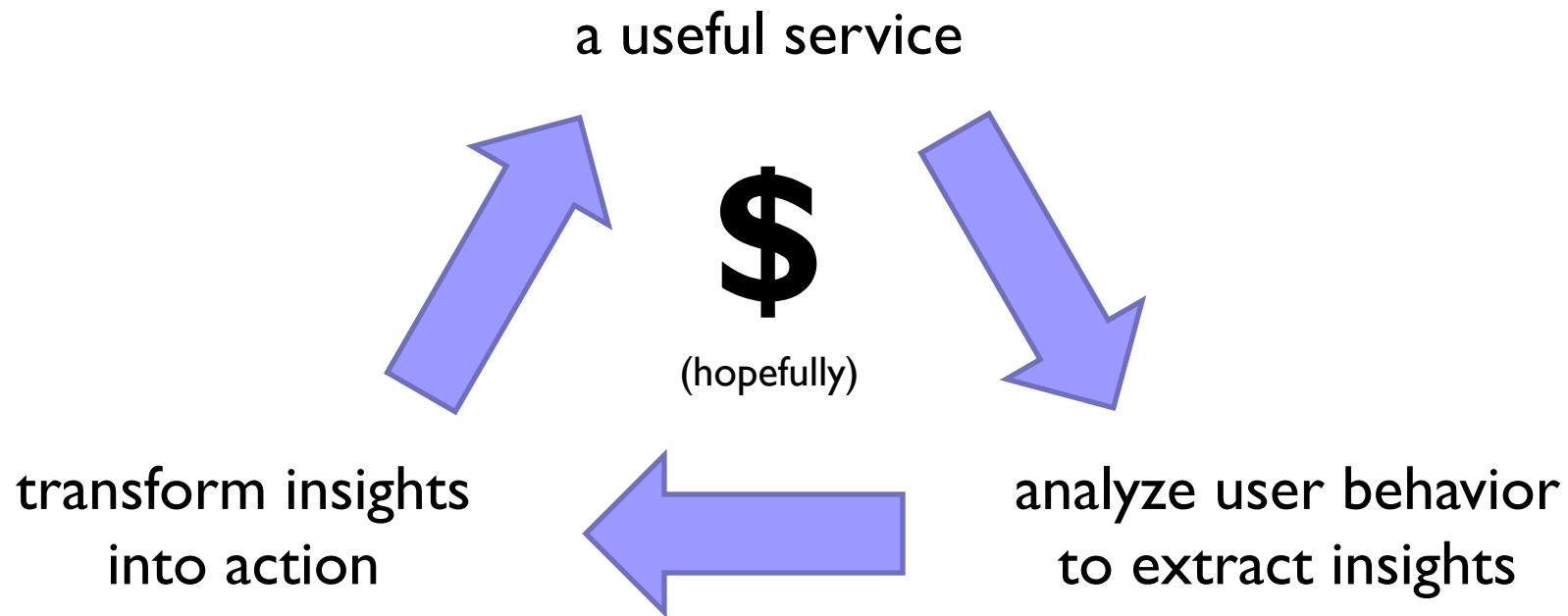
Ad hoc analyses

“Descriptive”

“Predictive”

Data products

Virtuous Product Cycle



Google. Facebook. Twitter. Amazon. Uber.

data products

data science



Jeff Hammerbacher, Information Platforms and the Rise of the Data Scientist.
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“On the first day of logging the Facebook clickstream, more than 400 gigabytes of data was collected. The load, index, and aggregation processes for this data set really taxed the Oracle data warehouse. Even after significant tuning, we were unable to aggregate a day of clickstream data in less than 24 hours.”

users

Frontend

Backend

“OLTP”

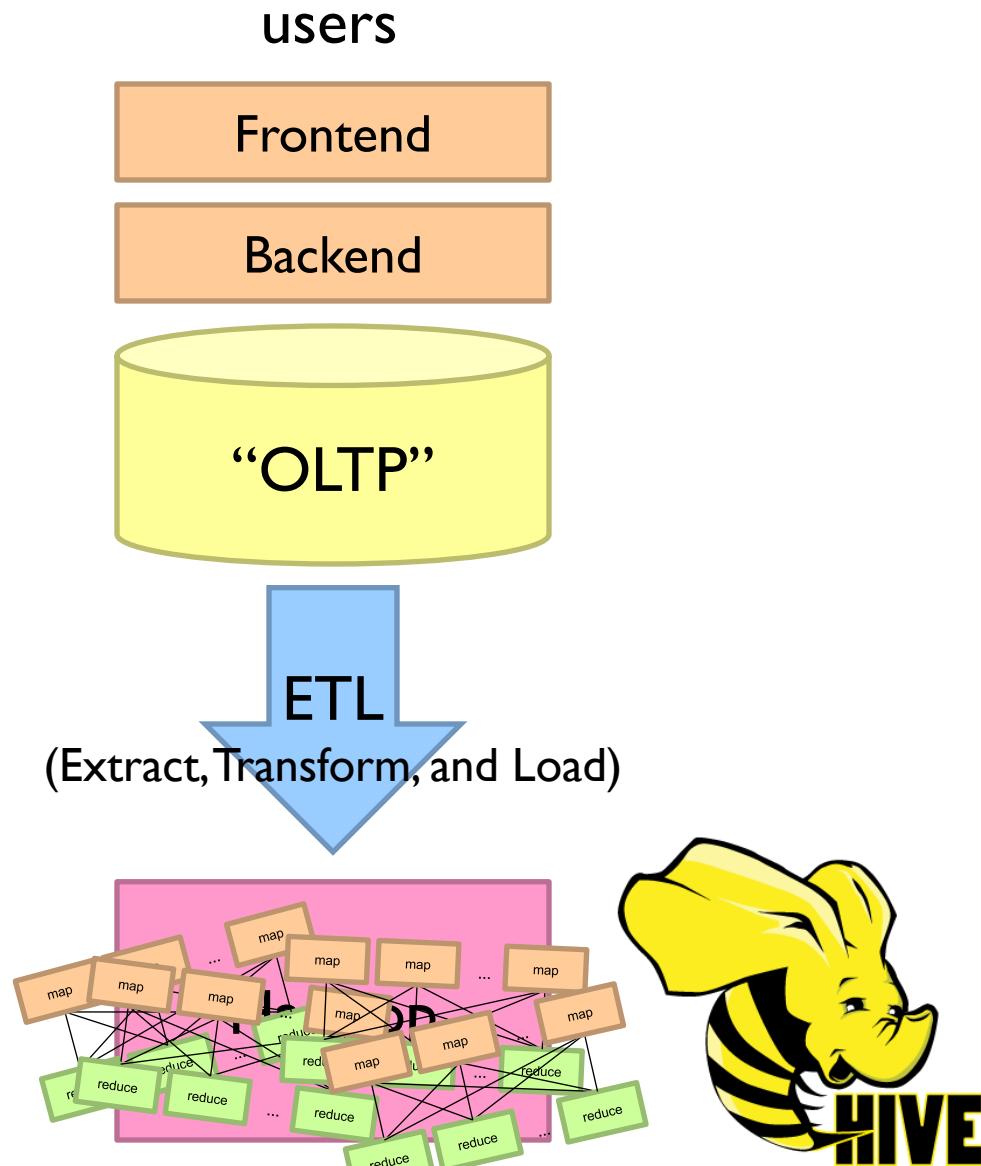
ETL

(Extract, Transform, and Load)

Hadoop

data scientists

The Irony...



data scientists

Wait, so why not use a database to begin with?

Why not just use a database?
SQL is awesome

Scalability. Cost.

Databases are great...

If your data has structure (and you know what the structure is)

If your data is reasonably clean

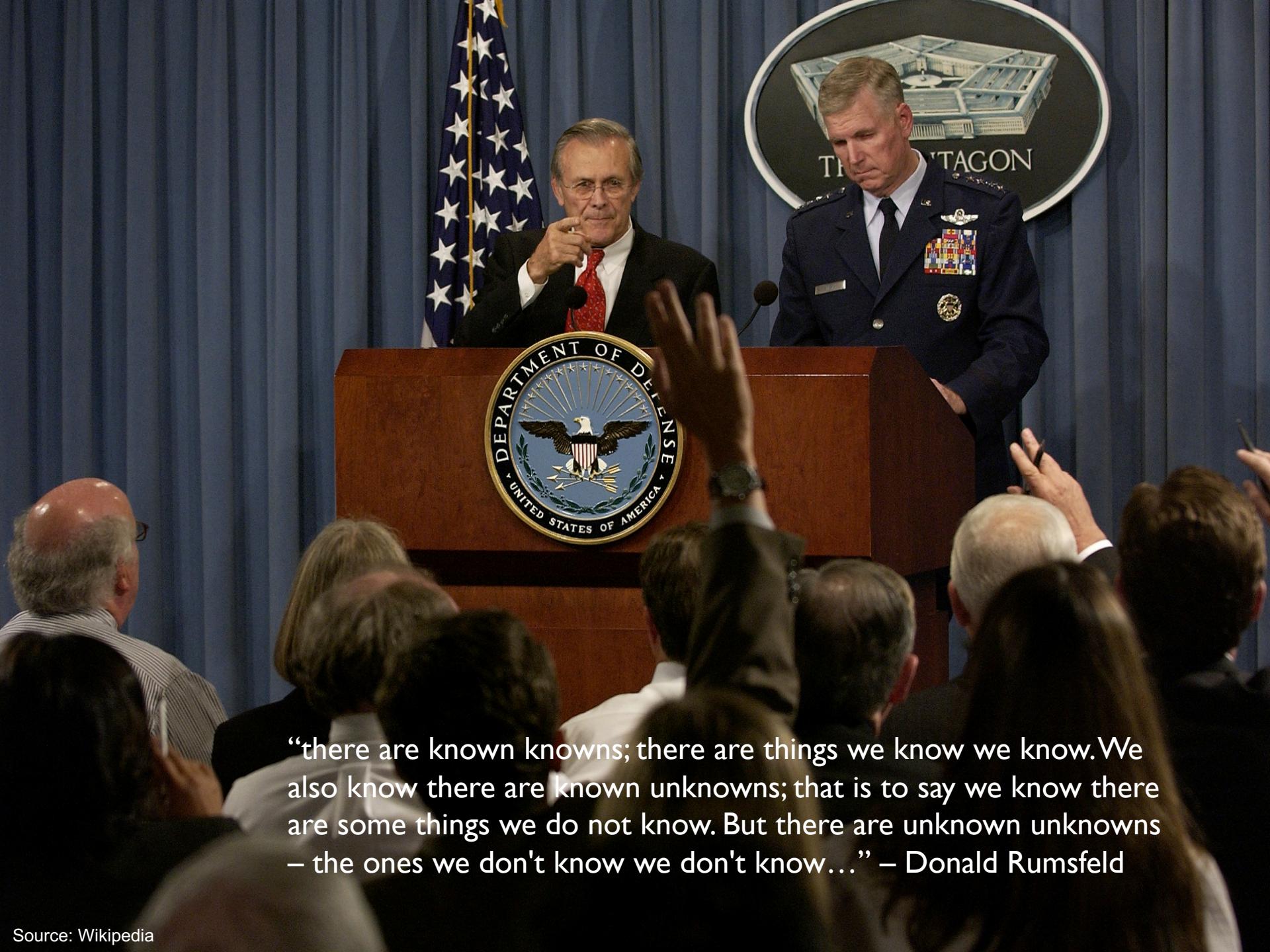
If you know what queries you're going to run ahead of time

Databases are not so great...

If your data has little structure (or you don't know the structure)

If your data is messy and noisy

If you don't know what you're looking for



“there are known knowns; there are things we know we know. We also know there are known unknowns; that is to say we know there are some things we do not know. But there are unknown unknowns – the ones we don't know we don't know...” – Donald Rumsfeld

Databases are great...

If your data has structure (and you know what the structure is)

If your data is reasonably clean

If you know what queries you're going to run ahead of time

Known unknowns!

Databases are not so great...

If your data has little structure (or you don't know the structure)

If your data is messy and noisy

If you don't know what you're looking for

Unknown unknowns!

Advantages of Hadoop dataflow languages

Don't need to know the schema ahead of time

Raw scans are the most common operations

Many analyses are better formulated imperatively

Much faster data ingest rate

What do you actually do?

Report generation

Dashboards

Ad hoc analyses

“Descriptive”

“Predictive”

Data products

Which are known unknowns and
unknown unknowns?

external APIs

users

users

Frontend

Frontend

Frontend

Backend

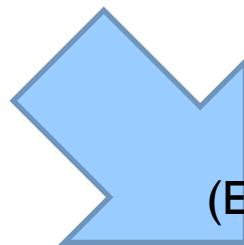
Backend

Backend

OLTP
database

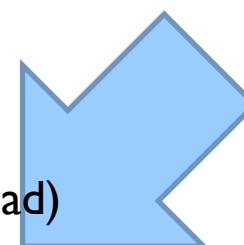
OLTP
database

OLTP
database



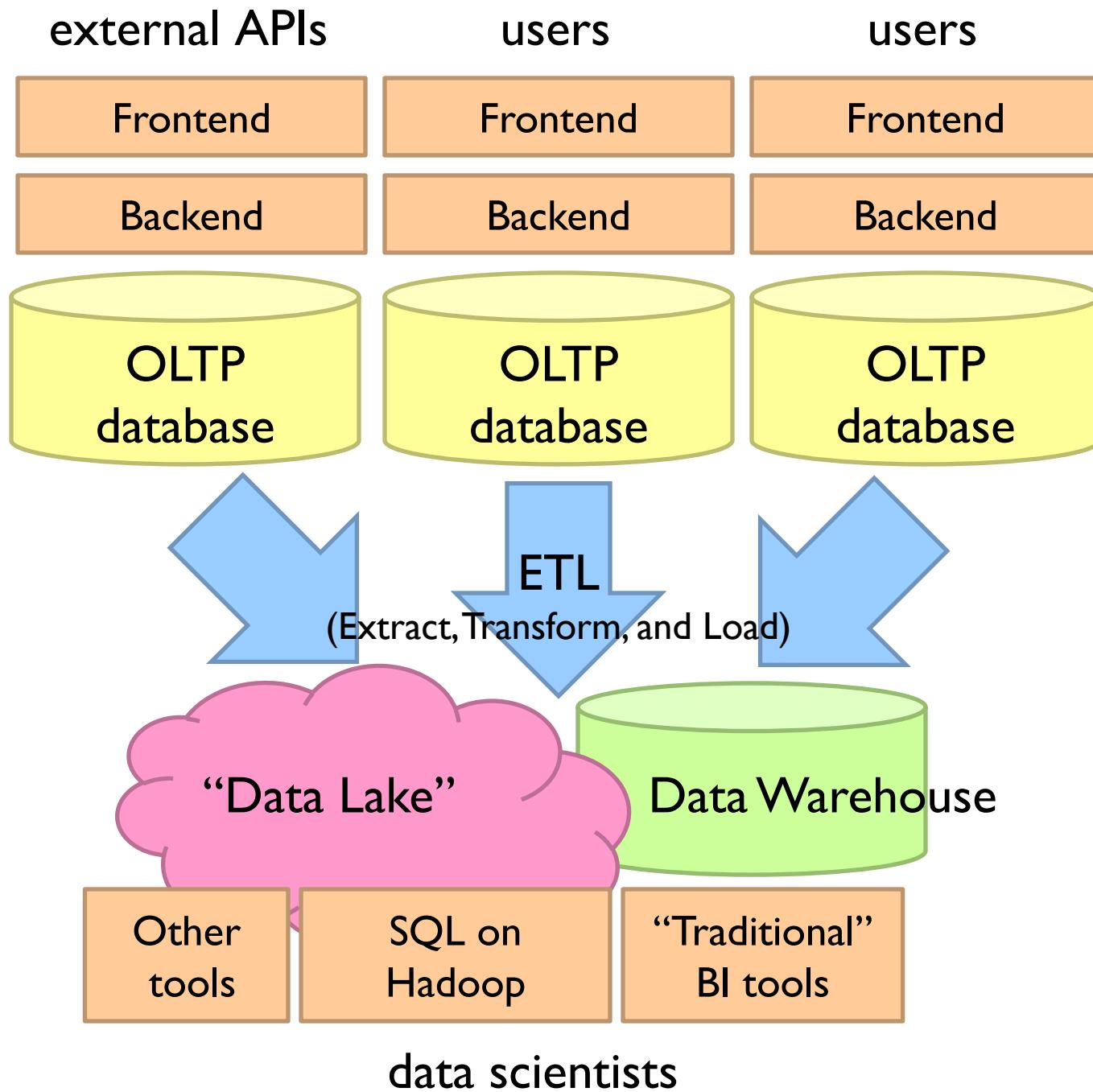
ETL

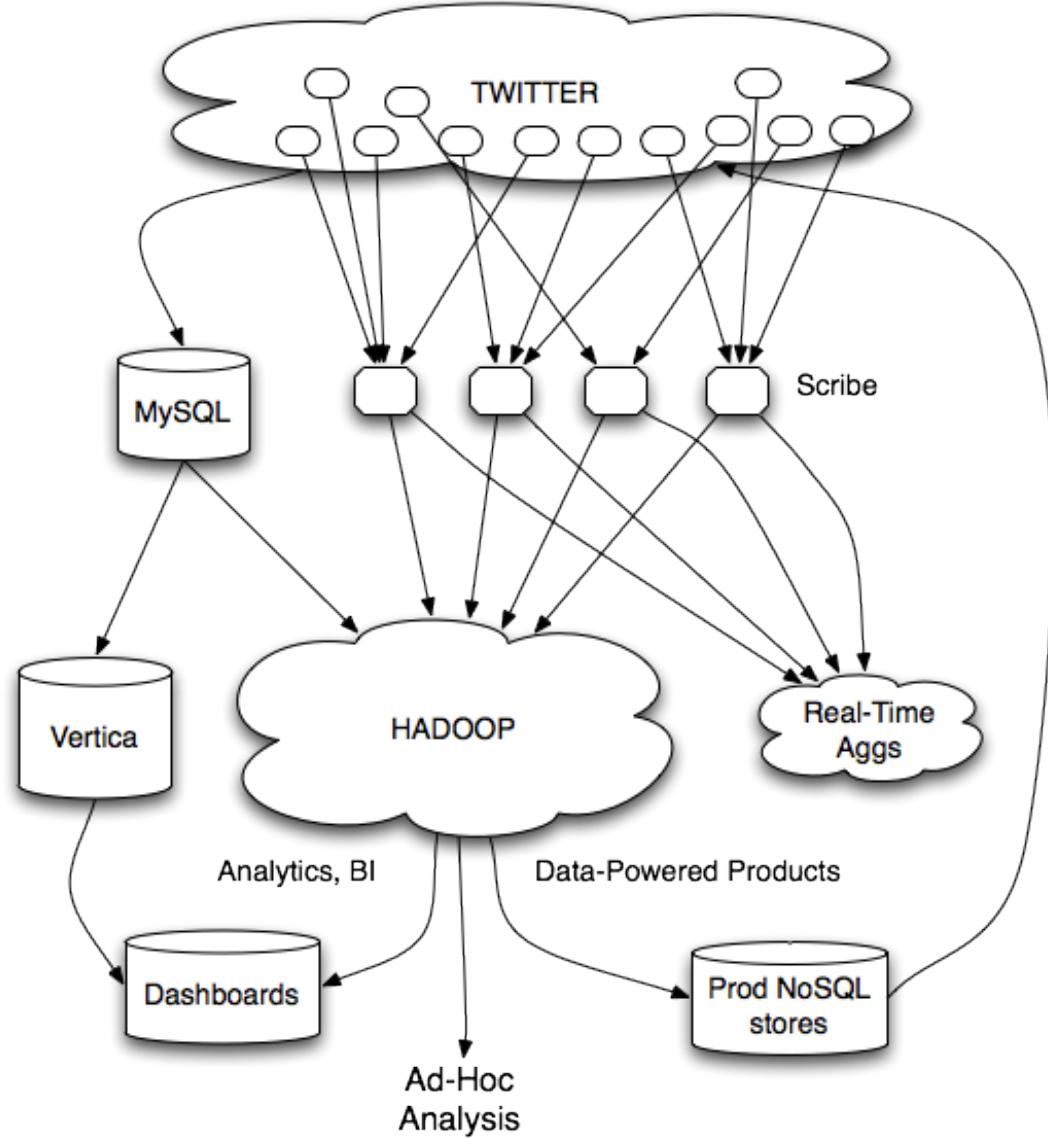
(Extract, Transform, and Load)



BI tools

analysts





Twitter's data warehousing architecture (circa 2012)

circa ~2010

~150 people total

~60 Hadoop nodes

~6 people use analytics stack daily

circa ~2012

~1400 people total

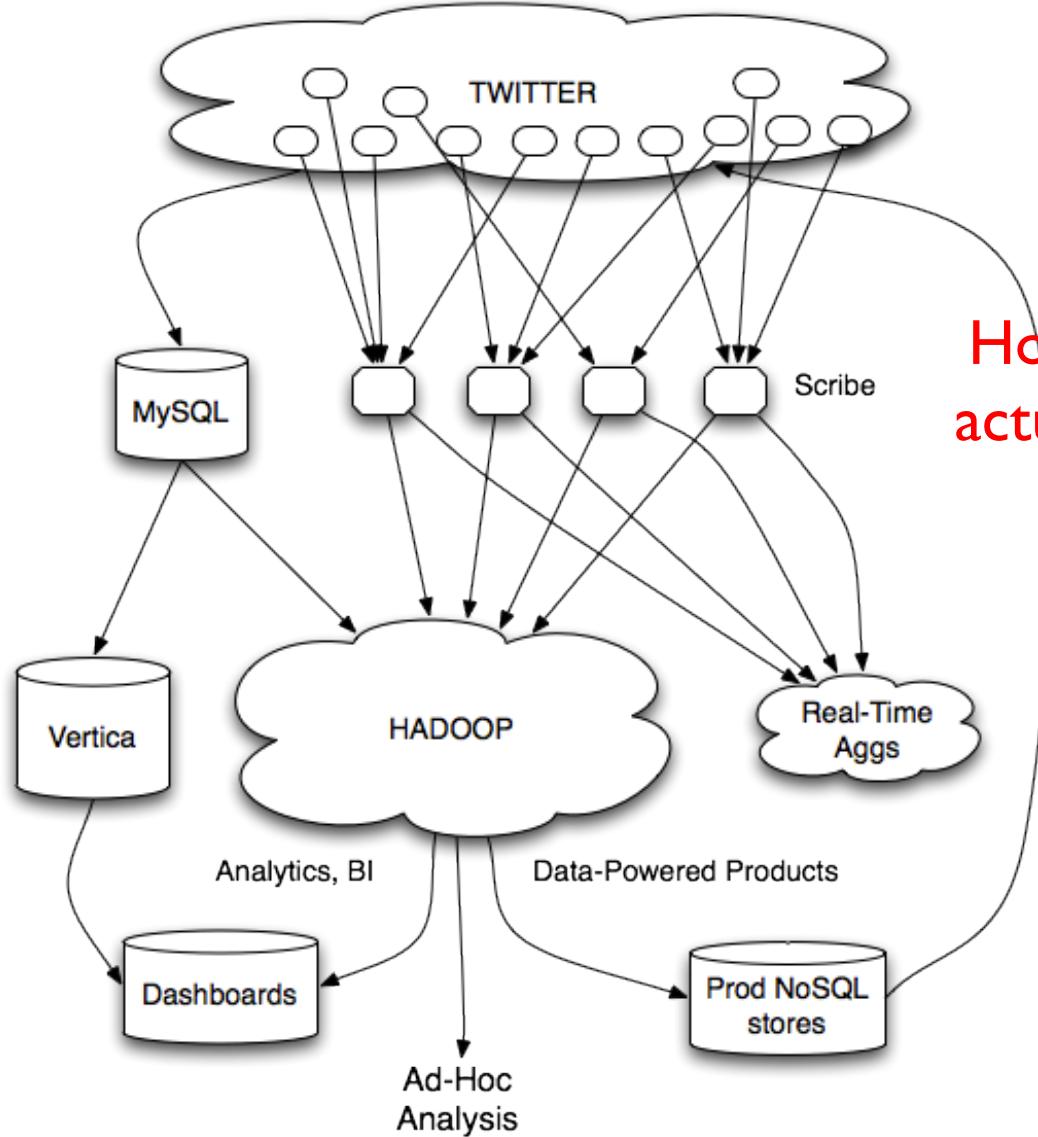
10s of Ks of Hadoop nodes, multiple DCs

10s of PBs total Hadoop DW capacity

~100 TB ingest daily

dozens of teams use Hadoop daily

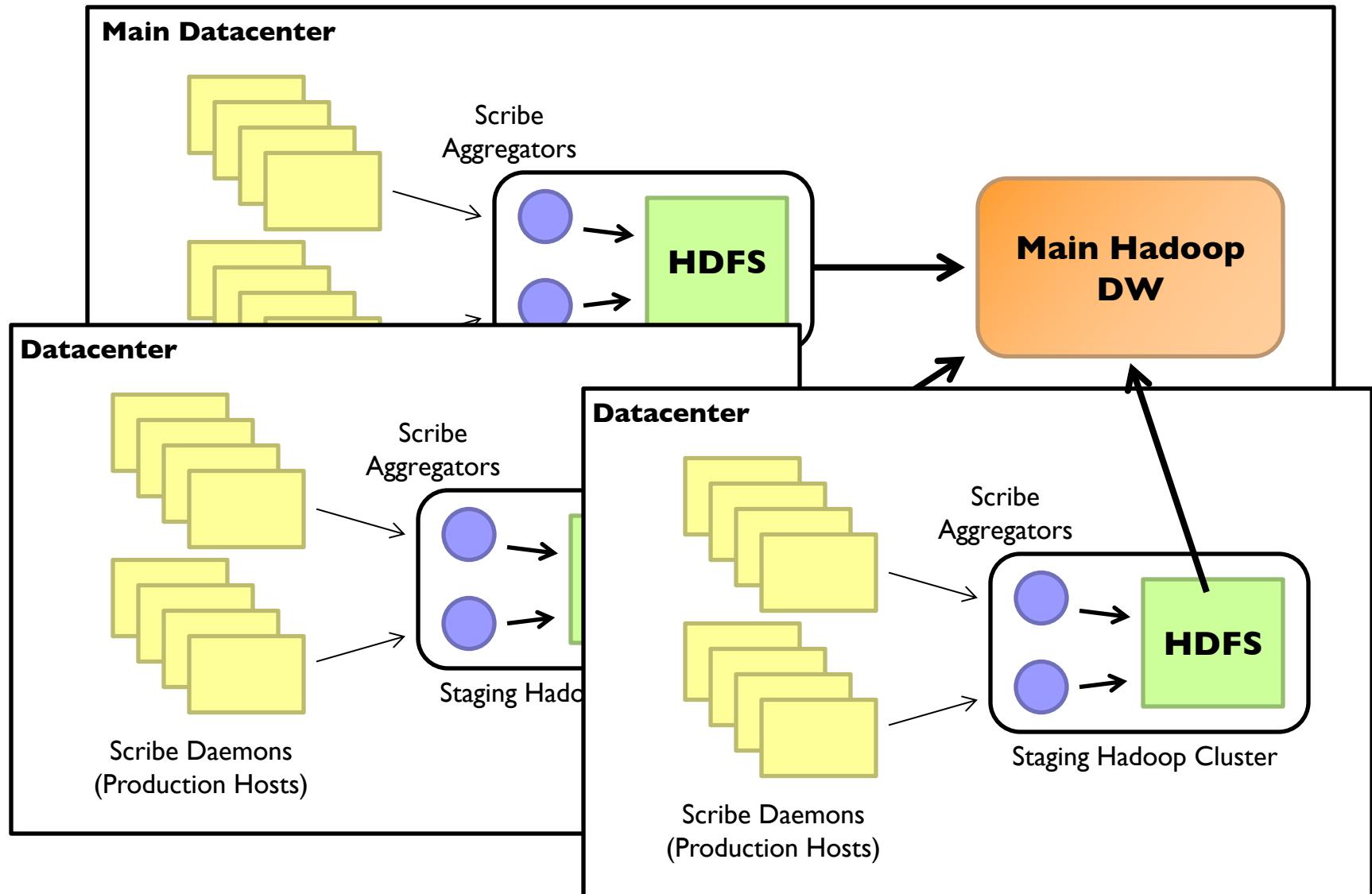
10s of Ks of Hadoop jobs daily



How does ETL
actually happen?

Twitter's data warehousing architecture (circa 2012)

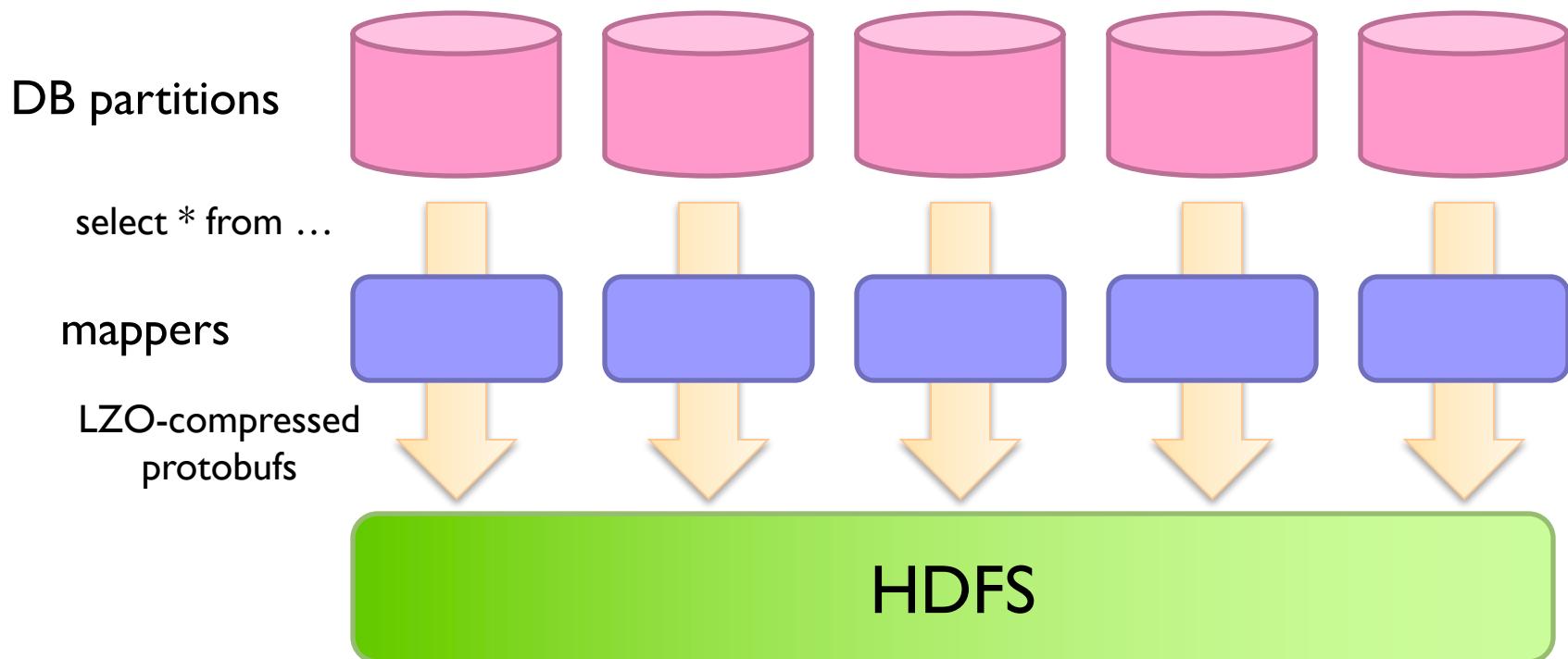
Importing Log Data



Importing Log Data*

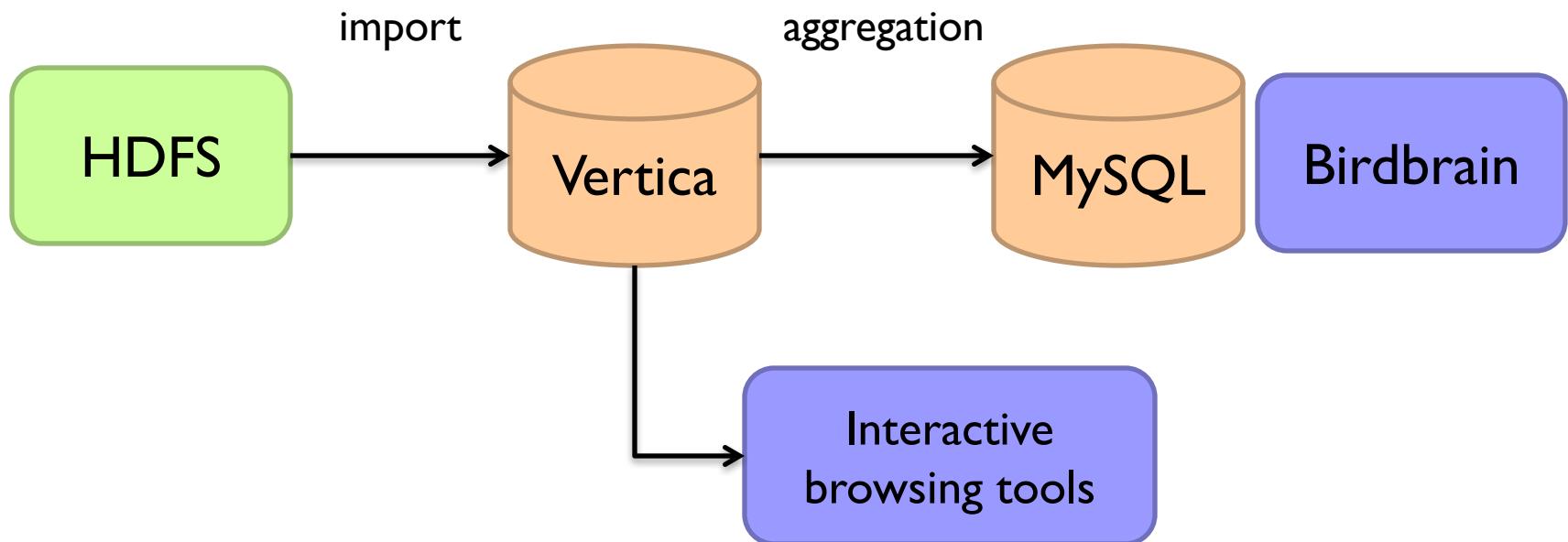
Tweets, graph, users profiles

Different periodicity (e.g., hourly, daily snapshots, etc.)



Important: Must carefully throttle resource usage...

Vertica Pipeline*



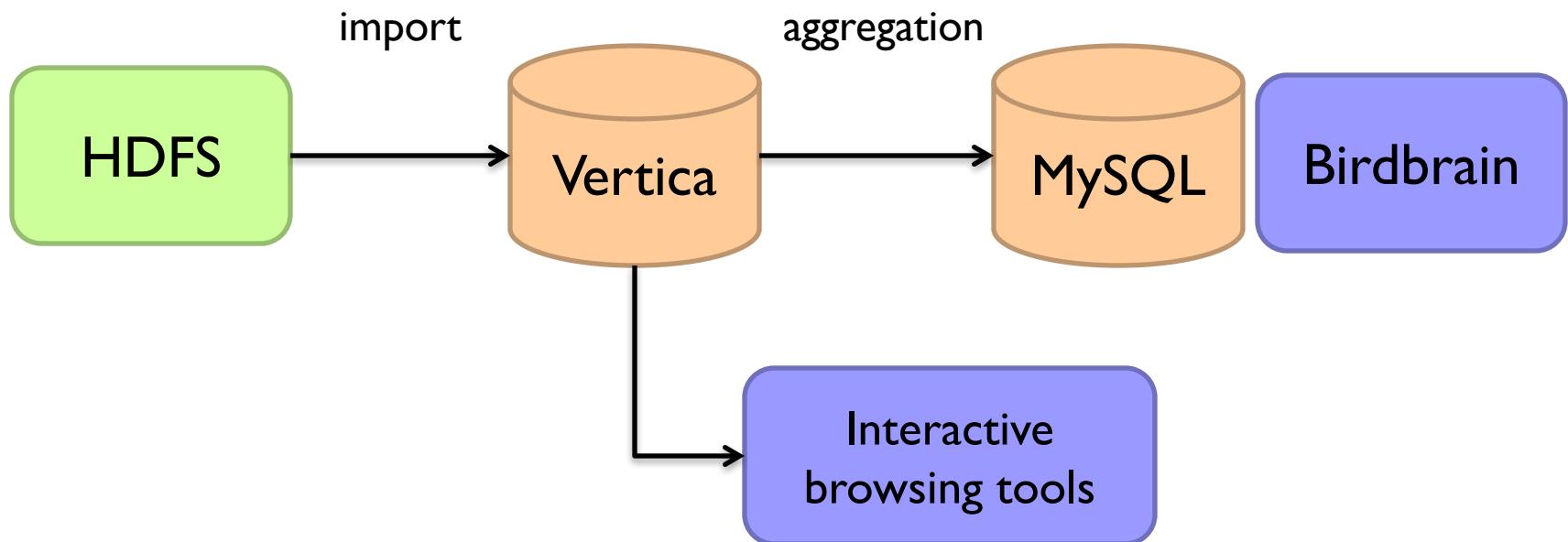
Why?

Vertica provides *orders of magnitude* faster aggregations!

“Basically, we use Vertica as a cache for HDFS data.”

@squarecog

Vertica Pipeline*

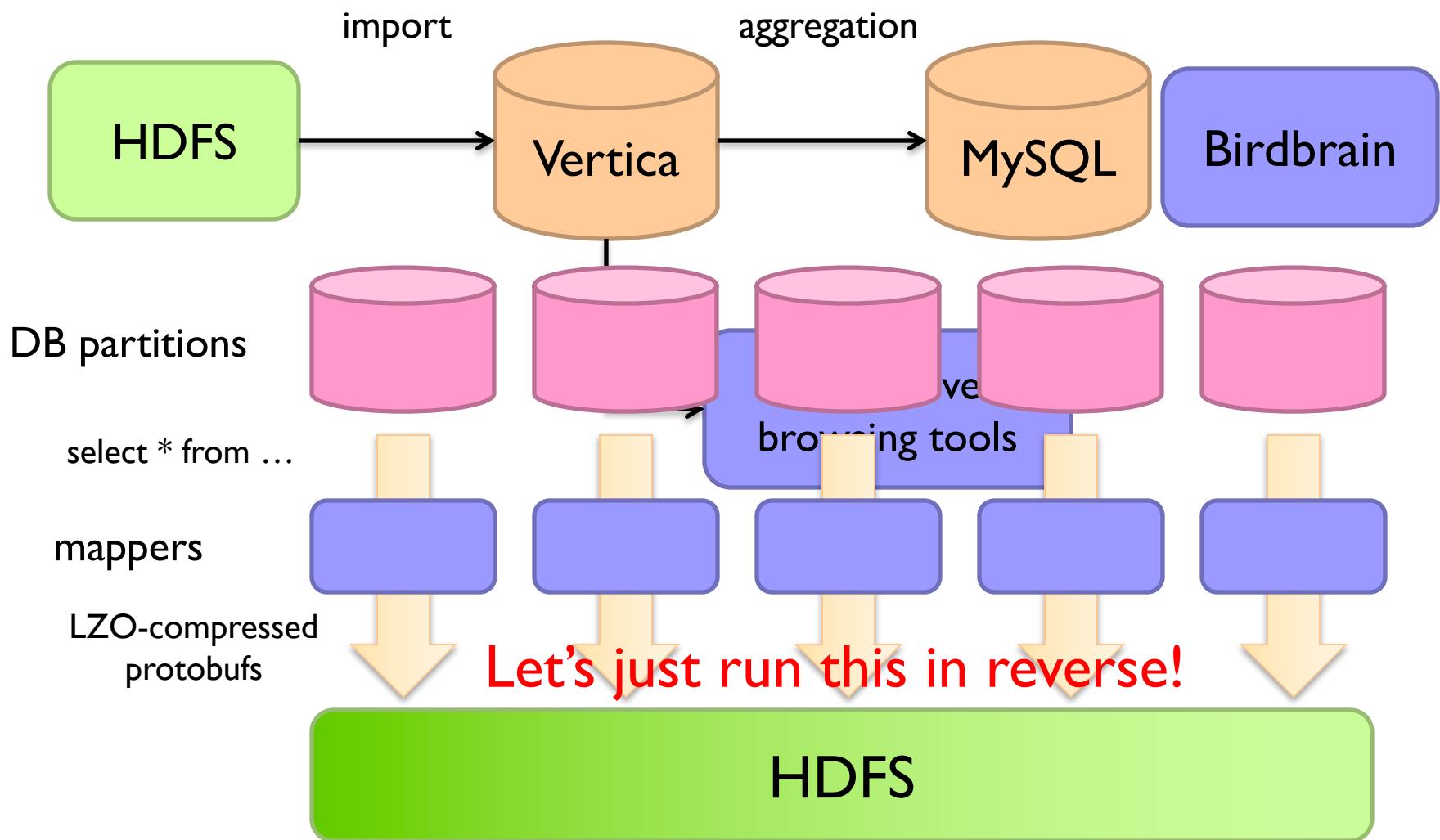


The catch...

Performance must be balanced against integration costs

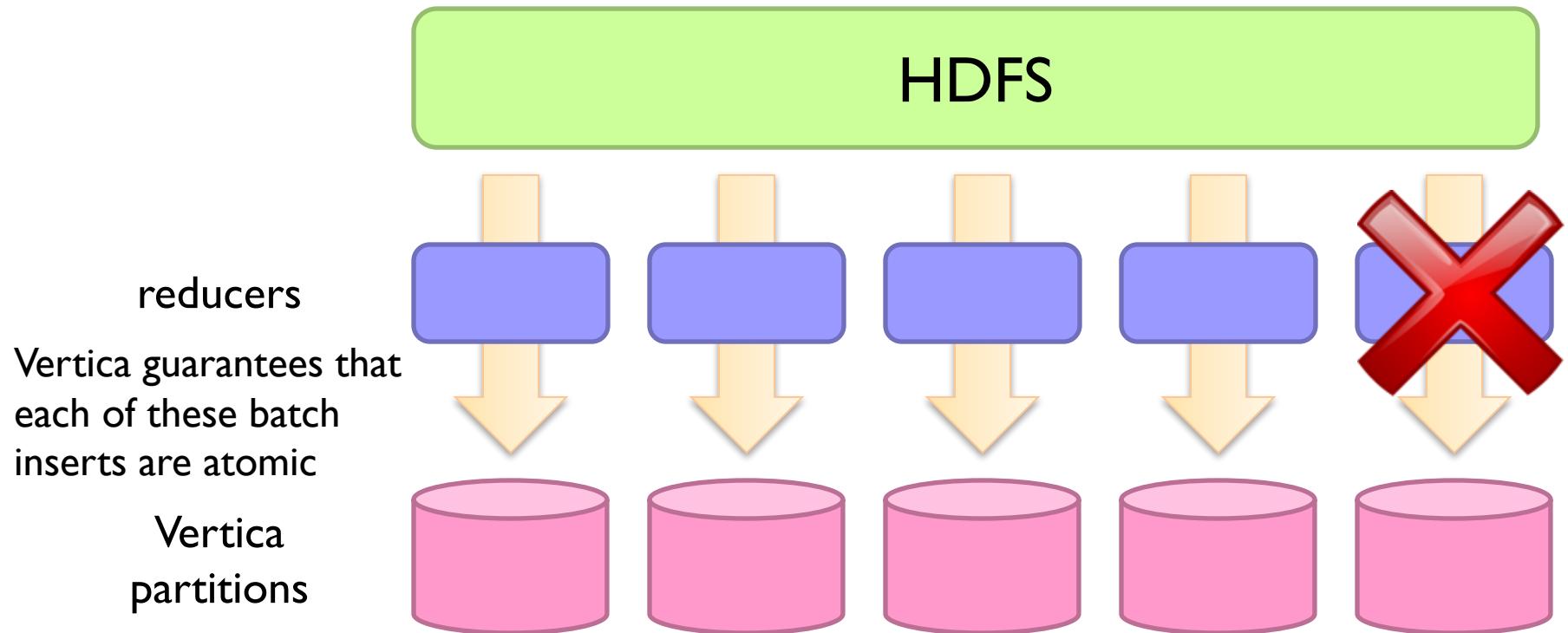
Vertica integration is non-trivial

Vertica Data Ingestion



* Out of date – for illustration only

Vertica Pig Storage*

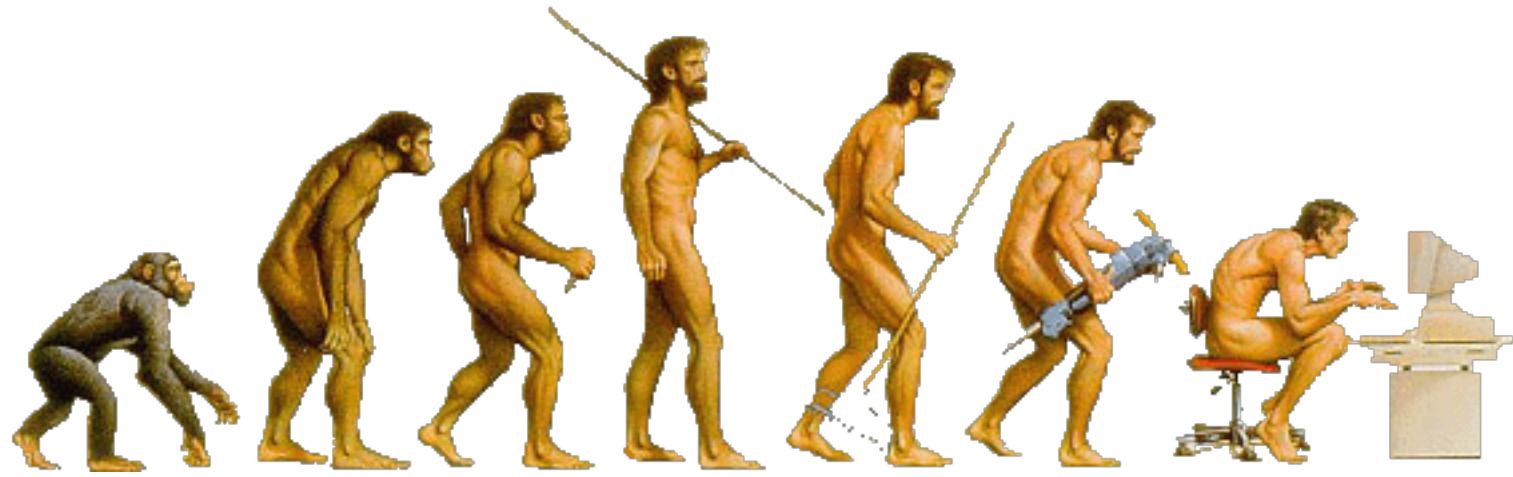


So what's the challenge?

Did you remember to turn off speculative execution?

What happens when a task dies?

* Out of date – for illustration only



What's Next?

Two developing trends...

users

Frontend

Backend

database

BI tools

analysts

external APIs

users

users

Frontend

Frontend

Frontend

Backend

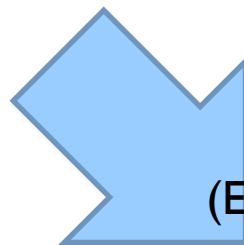
Backend

Backend

OLTP
database

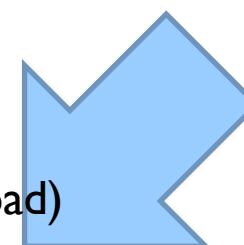
OLTP
database

OLTP
database



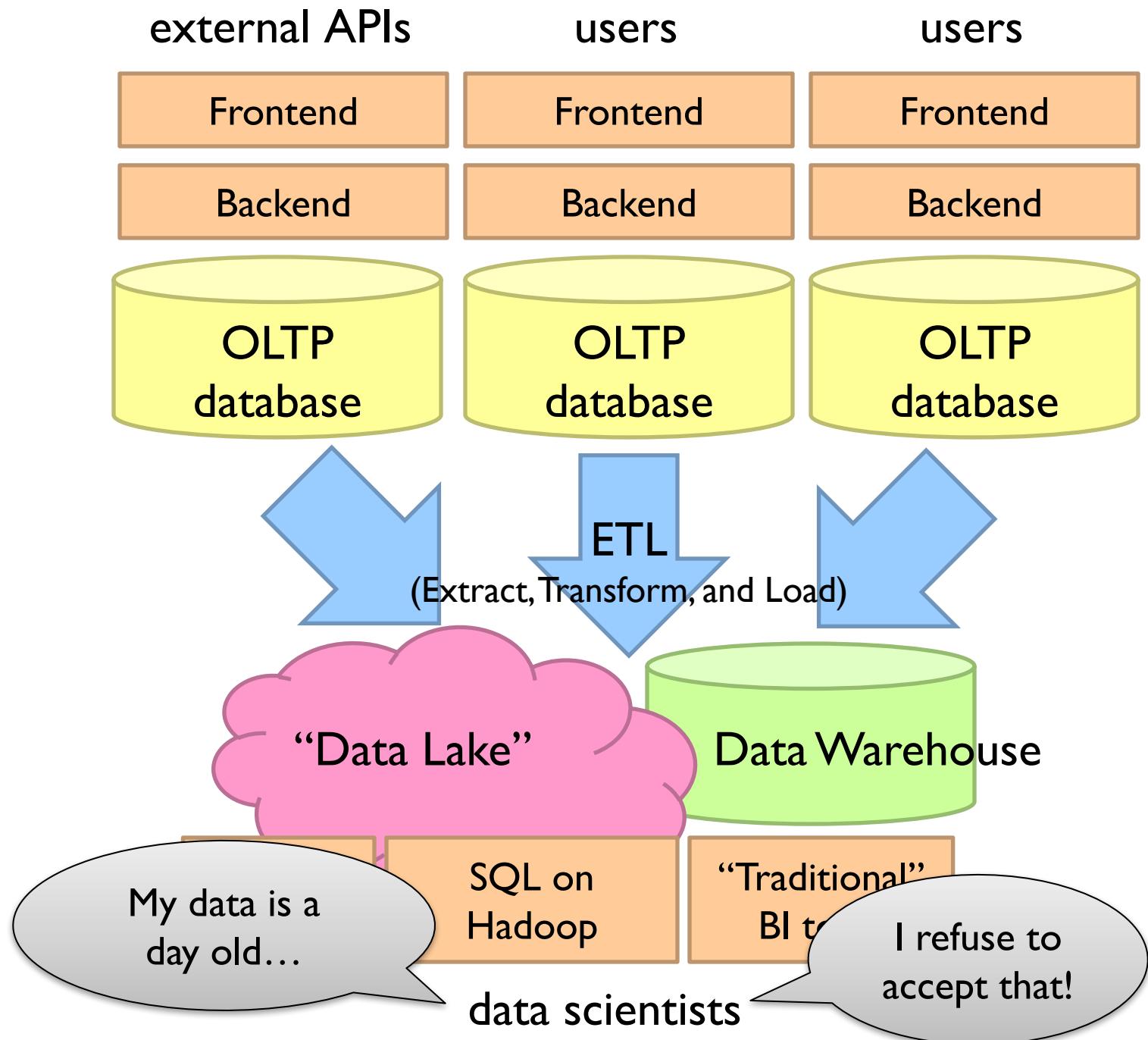
ETL

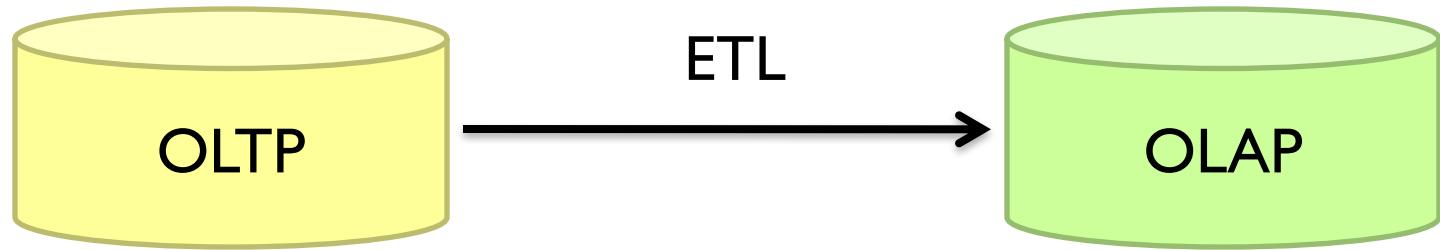
(Extract, Transform, and Load)



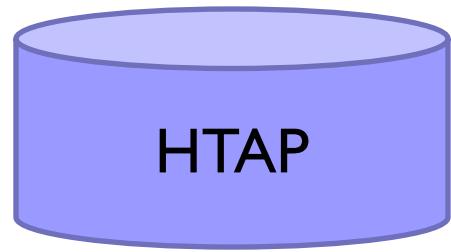
BI tools

analysts



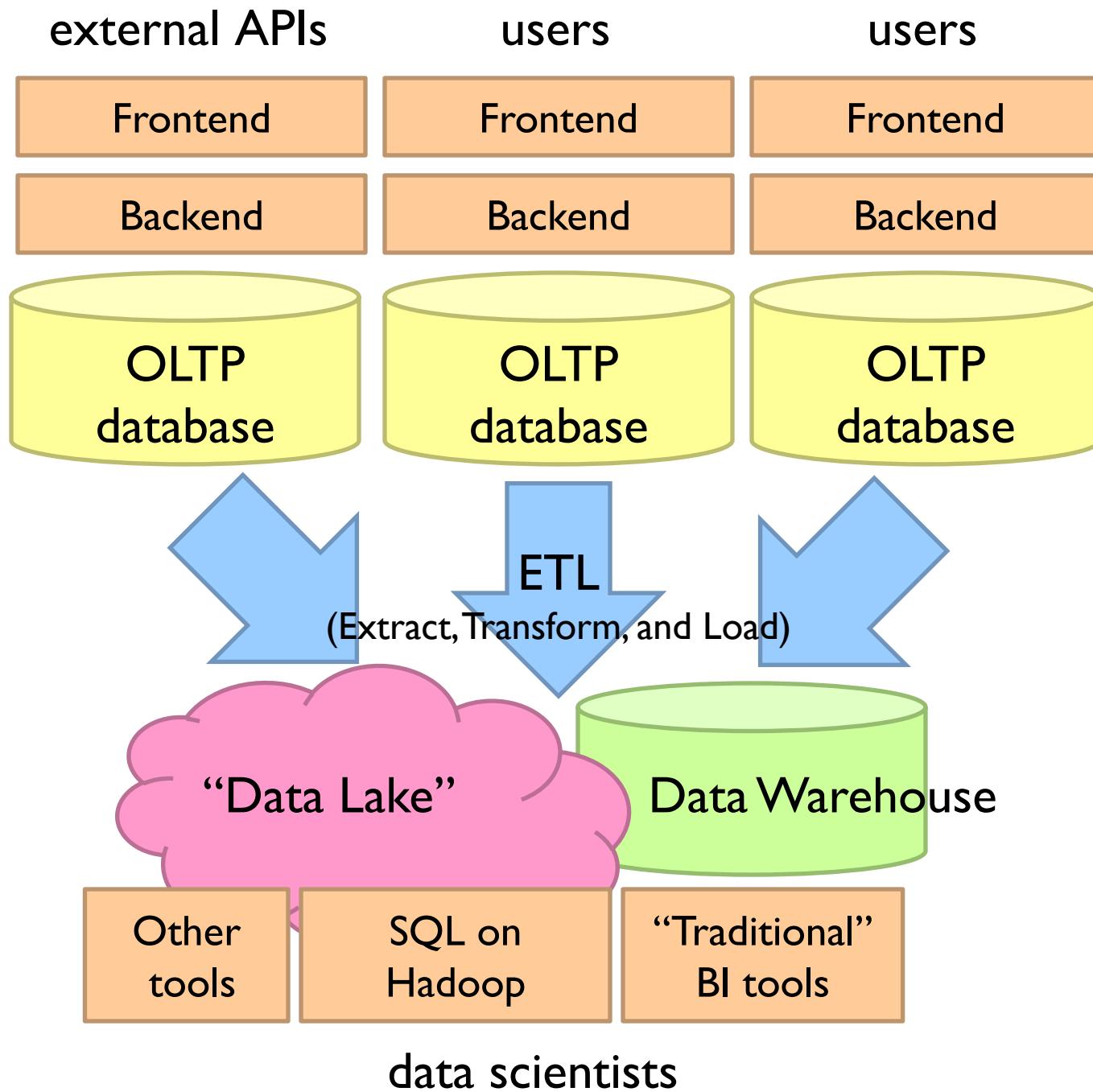


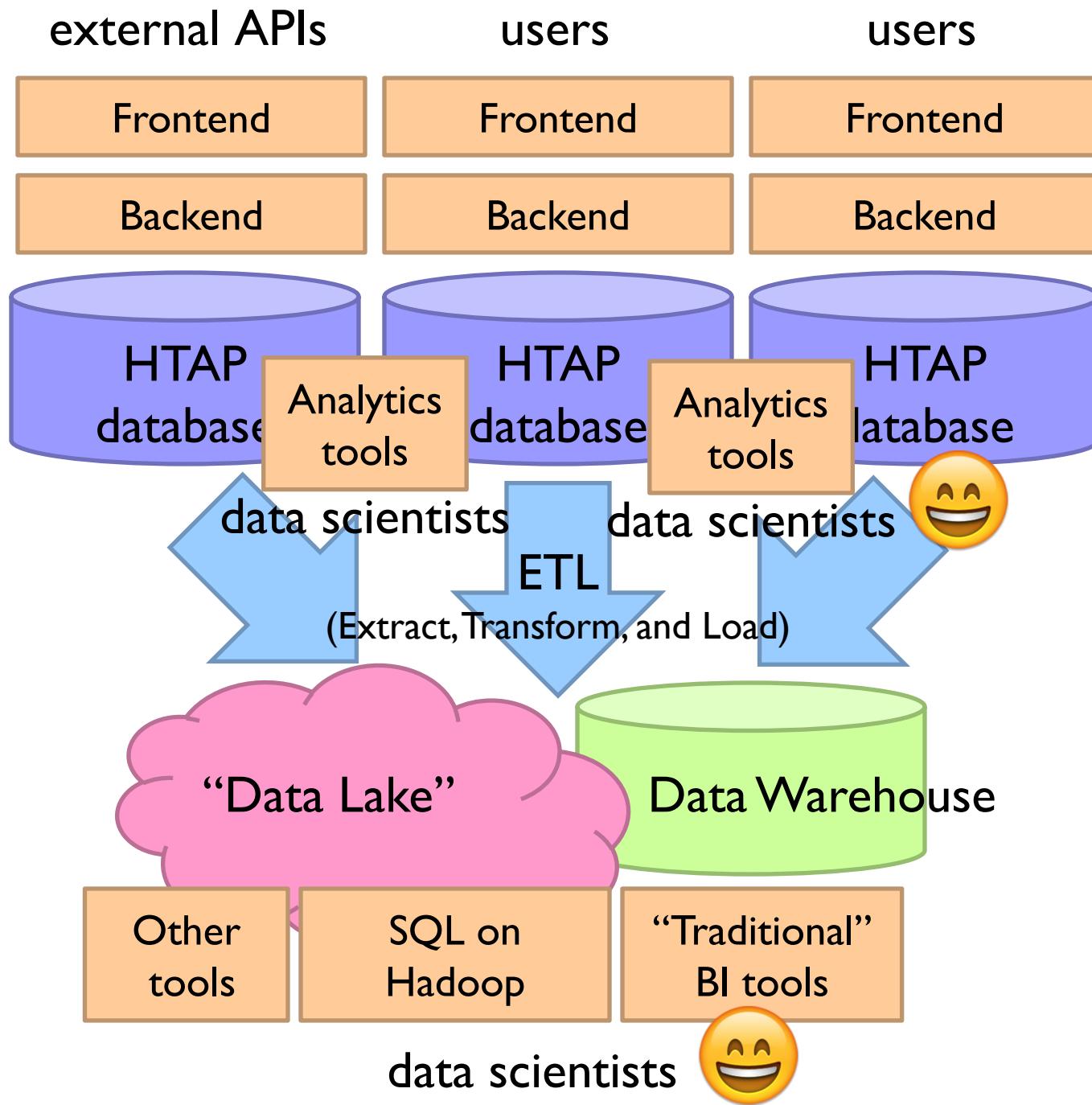
What if you didn't have to do this?

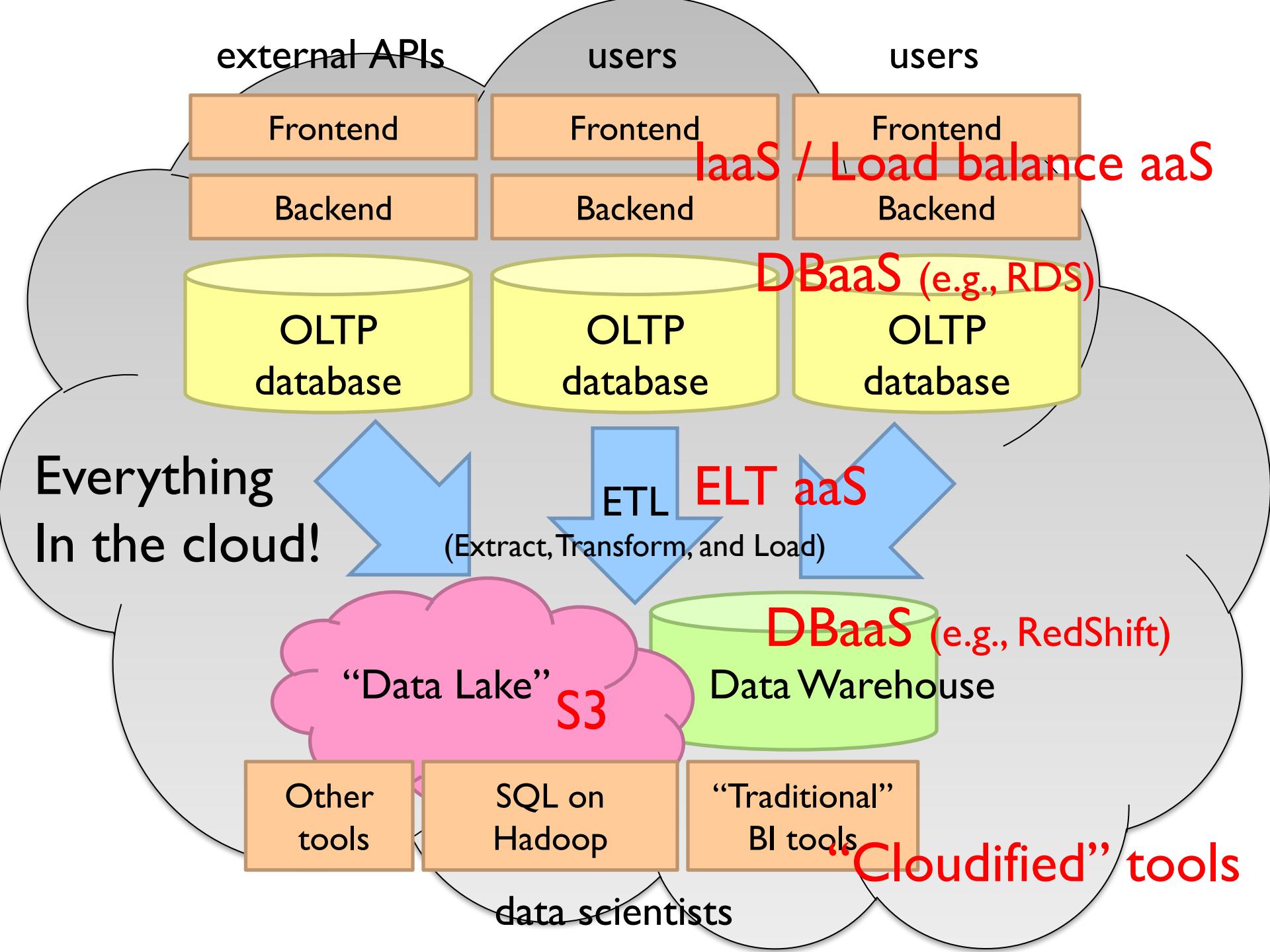


Hybrid Transactional/Analytical Processing (HTAP)

Coming back full circle?







A photograph of a traditional Japanese rock garden. In the foreground, a gravel path is raked into fine, parallel lines. Several large, dark, irregular stones are scattered across the garden. A small, shallow pond is visible in the middle ground, surrounded by more stones and some low-lying green plants. In the background, there are more stones, some small trees, and the wooden buildings of a residence with tiled roofs.

Questions?