BDAS and Spark

University of California, Berkeley

School of Information

IS 257: Database Management

Announcement

- Sign up for final project presentations
  - http://doodle.com/poll/46ivgbr5b73yzagr

Outline

- Review
  - Mapreduce
  - Pig
  - Hive
- BDAS and Spark

Map/Reduce ala Google

- map(key, val) is run on each item in set
  - emits new-key / new-val pairs

- reduce(key, vals) is run for each unique key emitted by map()
  - emits final output

From "MapReduce…" by Dan Weld

Programming model

- Input & Output: each a set of key/value pairs
- Programmer specifies two functions:
- map (in_key, in_value) -> list(out_key, intermediate_value)
  - Processes input key/value pair
  - Produces set of intermediate pairs
- reduce (out_key, list(intermediate_value)) -> list(out_value)
  - Combines all intermediate values for a particular key
  - Produces a set of merged output values (usually just one)

From "MapReduce: Simplified data Processing… ", Jeffrey Dean and Sanjay Ghemawat

count words in docs

– Input consists of (url, contents) pairs

– map(key=url, val=contents):
  - For each word *w* in contents, emit (w, "1")

– reduce(key=word, values=uniq_counts):
  - Sum all "1"s in values list
  - Emit result "(word, sum)"

From "MapReduce…" by Dan Weld

Count, Illustrated

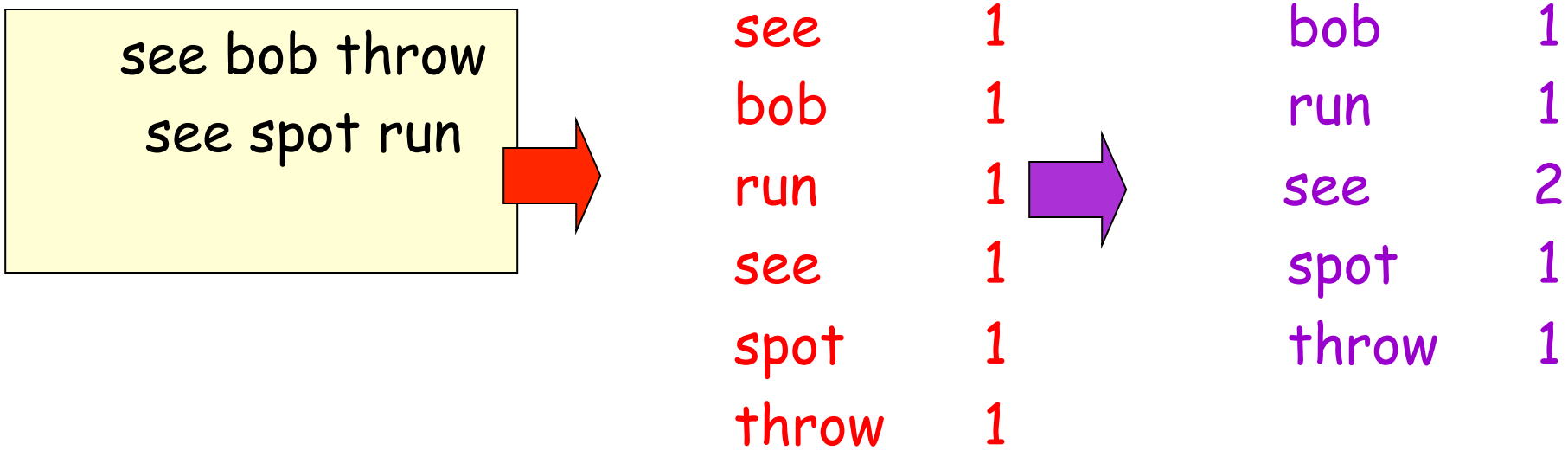
map(key=url, val=contents):

For each word *w* in contents, emit (w, "1")

reduce(key=word, values=uniq_counts):

Sum all "1"s in values list

Emit result "(word, sum)"



From "MapReduce…" by Dan Weld

Example

- Page 1: the weather is good
- Page 2: today is good
- Page 3: good weather is good.

From "MapReduce: Simplified data Processing… ", Jeffrey Dean and Sanjay Ghemawat

Map output

- Worker 1:
  - (the 1), (weather 1), (is 1), (good 1).
- Worker 2:
  - (today 1), (is 1), (good 1).
- Worker 3:
  - (good 1), (weather 1), (is 1), (good 1).

From "MapReduce: Simplified data Processing… ", Jeffrey Dean and Sanjay Ghemawat

Reduce Input

- Worker 1:
  - (the 1)
- Worker 2:
  - (is 1), (is 1), (is 1)
- Worker 3:
  - (weather 1), (weather 1)
- Worker 4:
  - (today 1)
- Worker 5:
  - (good 1), (good 1), (good 1), (good 1)

From "MapReduce: Simplified data Processing… ", Jeffrey Dean and Sanjay Ghemawat

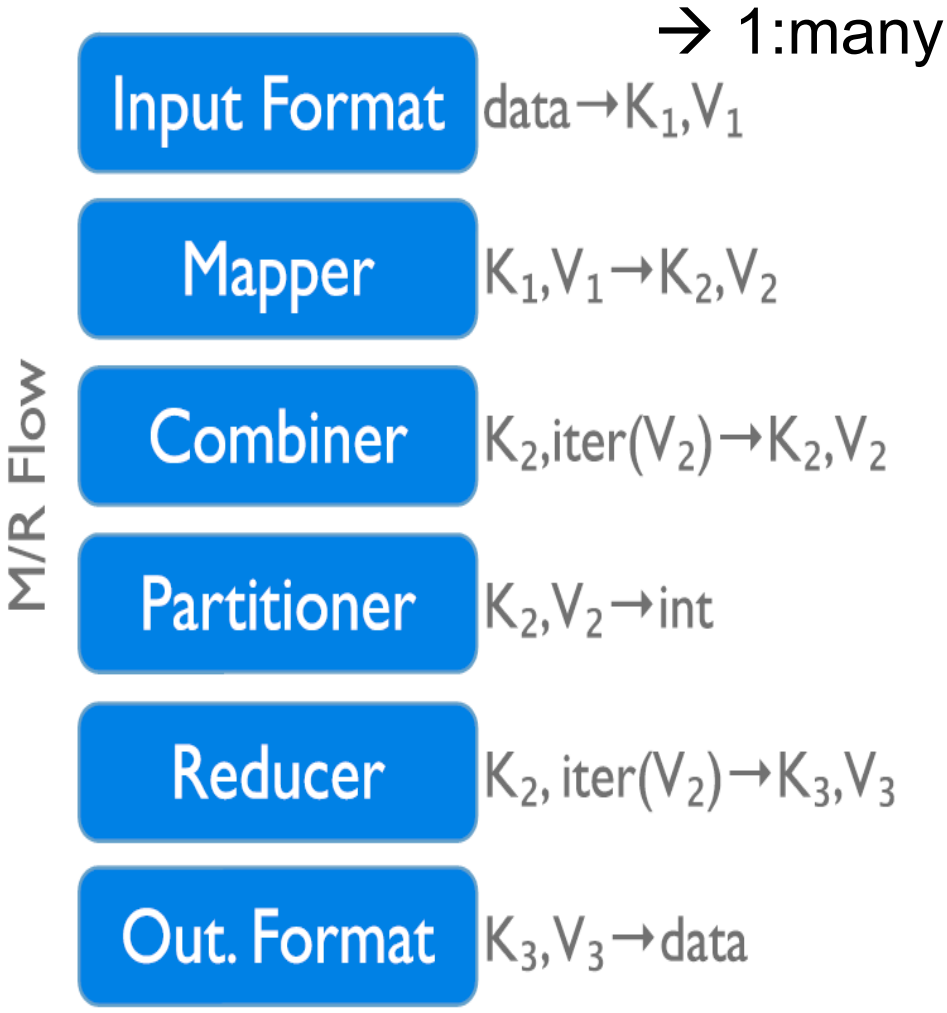
Reduce Output

- Worker 1:
  - (the 1)
- Worker 2:
  - (is 3)
- Worker 3:
  - (weather 2)
- Worker 4:
  - (today 1)
- Worker 5:
  - (good 4)

From "MapReduce: Simplified data Processing… ", Jeffrey Dean and Sanjay Ghemawat

Data Flow in a MapReduce Program in Hadoop

- InputFormat
- Map function
- Partitioner
- Sorting & Merging
- Combiner
- Shuffling
- Merging
- Reduce function
- OutputFormat



Fault tolerance

- On worker failure:
  - Detect failure via periodic heartbeats
  - Re-execute completed and in-progress *map* tasks
  - Re-execute in progress *reduce* tasks
  - Task completion committed through master
- Master failure:
  - Could handle, but don't yet (master failure unlikely)

From "MapReduce: Simplified data Processing… ", Jeffrey Dean and Sanjay Ghemawat

Refinement

- Different partitioning functions.
- Combiner function.
- Different input/output types.
- Skipping bad records.
- Local execution.
- Status info.
- Counters.

From "MapReduce: Simplified data Processing… ", Jeffrey Dean and Sanjay Ghemawat

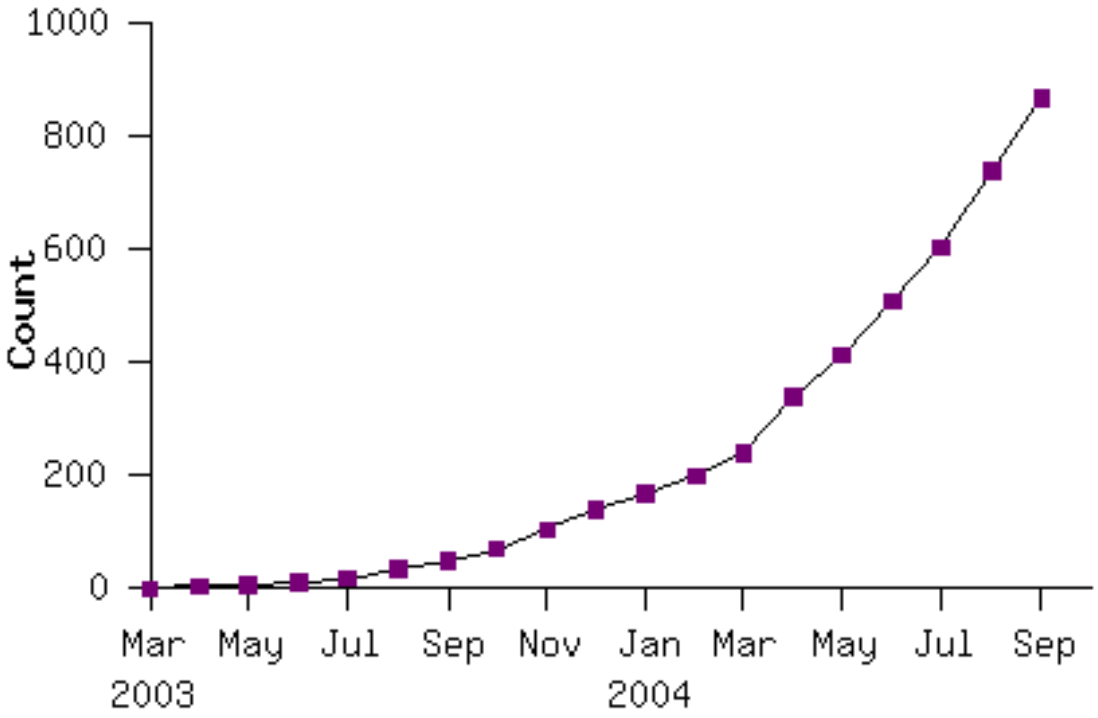
Performance

- Scan 10^10 100-byte records to extract records matching a rare pattern (92K matching records) : 150 seconds.

- Sort 10^10 100-byte records (modeled after TeraSort benchmark) : normal 839 seconds.

From "MapReduce: Simplified data Processing… ", Jeffrey Dean and Sanjay Ghemawat

More and more mapreduce



From "MapReduce: Simplified data Processing… ", Jeffrey Dean and Sanjay Ghemawat

But – Raw Hadoop means code

- Most people don't want to write code if they don't have to
- Various tools layered on top of Hadoop give different, and more familiar, interfaces
- Hbase – intended to be a NoSQL database abstraction for Hadoop
- Hive and it's SQL-like language

PIG – A data-flow language for MapReduce

MapReduce too complex?

- Restrict programming model
  - Only two phases
  - Job chain for long data flow
- Put the logic at the right phase
  - In MR programmers are responsible for this
- Too many lines of code even for simple logic
  - How many lines do you have for word count?

Pig…

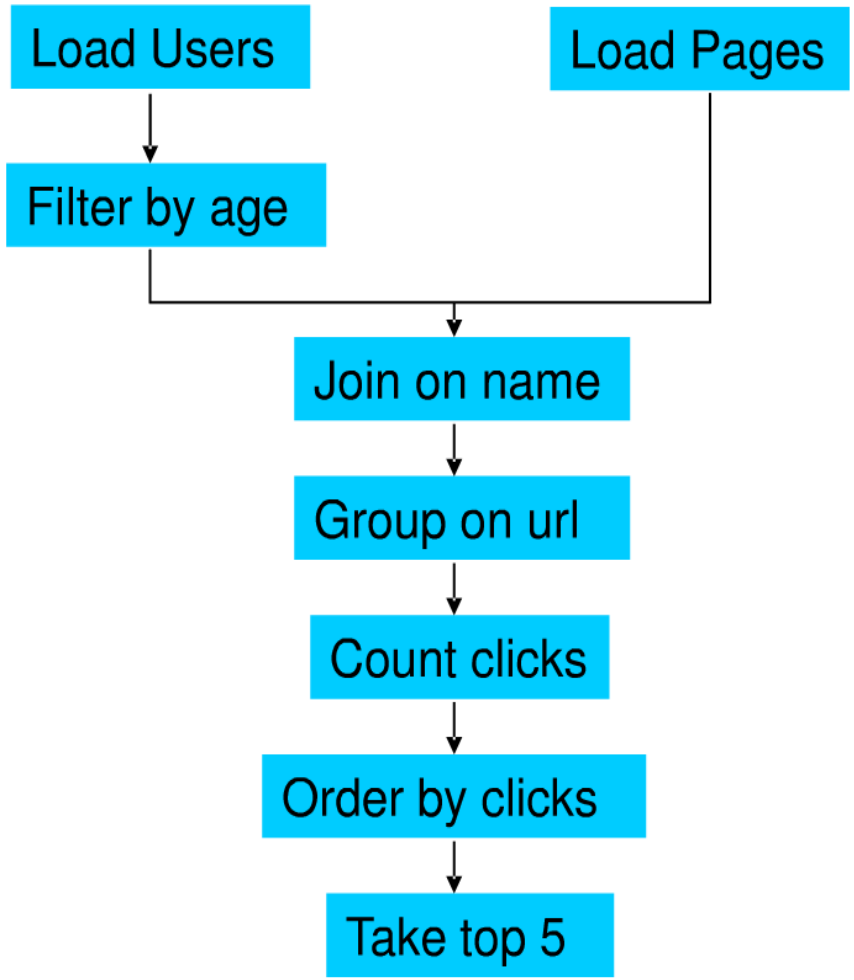
- High level dataflow language (Pig Latin)
  - Much simpler than Java
  - Simplify the data processing
- Put the operations at the apropriate phases (map, shuffle, etc.)
- Chains multiple MapReduce jobs
- Similar to relational algebra, but on files instead of relations

Pig Latin

- Data flow language
  - User specifies a sequence of operations to process data
  - More control on the processing, compared with declarative language
- Various data types are supported
- ”Schema”s are supported
- User-defined functions are supported

Motivation by Example

- Suppose we have user data in one file, website data in another file.
- We need to find the top 5 most visited pages by users aged 18-25



In Pig Latin

```
Users = load 'users' as (name, age);
Fltrd = filter Users by
        age >= 18 and age <= 25;
Pages = load 'pages' as (user, url);
Jnd = joinFltrdby name, Pages by user;
Grpd = groupJndbyurl;
Smmd = foreachGrpdgenerate group,
COUNT(Jnd) as clicks;
Srtd = orderSmmdby clicks desc;
Top5 = limitSrtd 5;
store Top5 into 'top5sites';
```

Pig runs over Hadoop

Job executes on cluster

Pig resides on user machine

User machine

No need to install anything extra on your Hadoop cluster.

How Pig is used in Industry

- At Yahoo!, 70% MapReduce jobs are written in Pig
- Used to
  - Process web log
  - Build user behavior models
  - Process images
  - Data mining
- Also used by Twitter, LinkedIn, Ebay, AOL, etc.

Hive - SQL on top of Hadoop

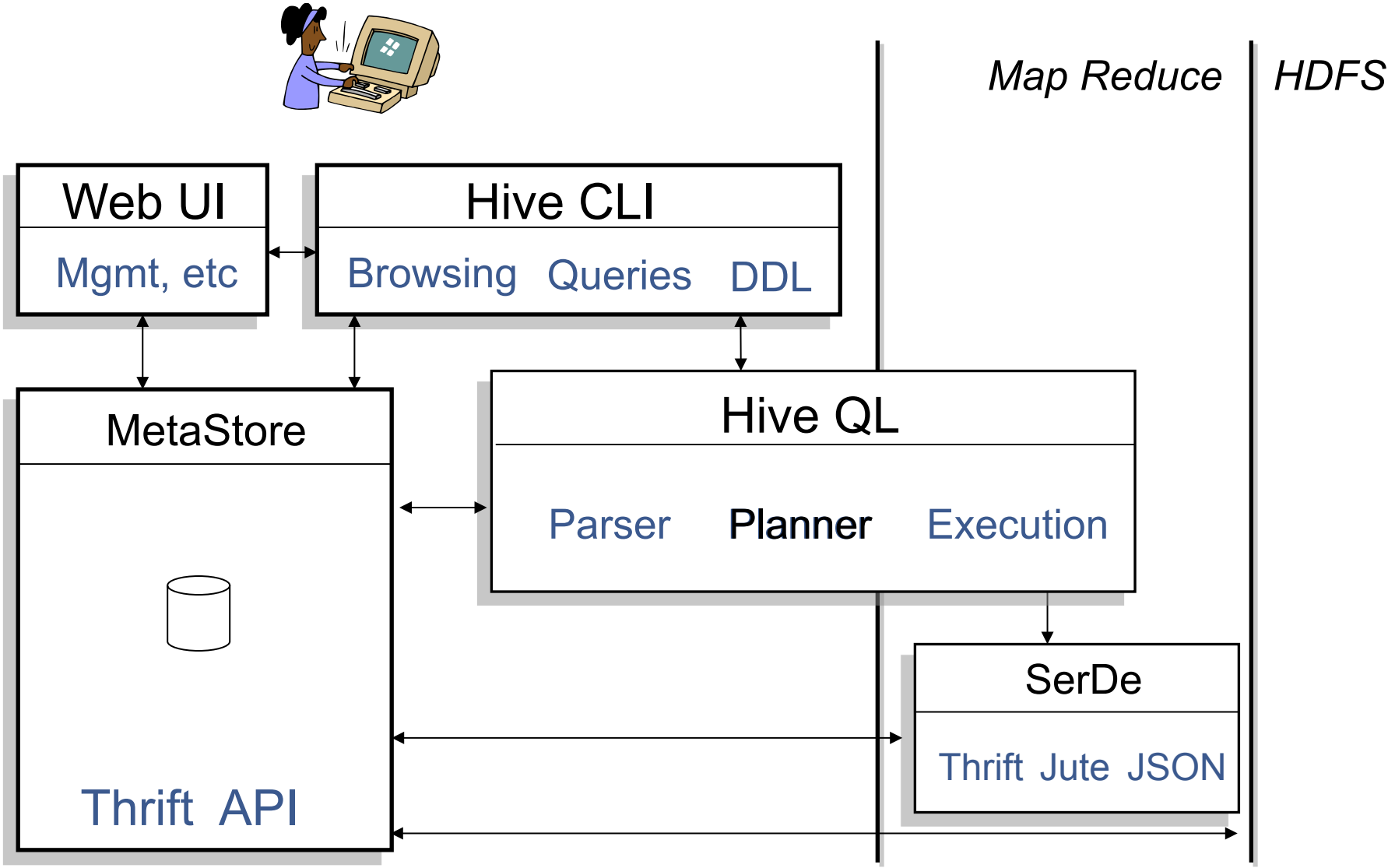
Map-Reduce and SQL

- **Map-Reduce is scalable**
  - SQL has a huge user base
  - SQL is easy to code
- **Solution: Combine SQL and Map-Reduce**
  - Hive on top of Hadoop (open source)
  - Aster Data (proprietary)
  - Green Plum (proprietary)

Hive

- **A database/data warehouse on top of Hadoop**
  - Rich data types (structs, lists and maps)
  - Efficient implementations of SQL filters, joins and group-by's on top of mapreduce
- **Allow users to access Hadoop data without using Hadoop**
- **Link:**
  - **http://svn.apache.org/repos/asf/hadoop/hive/trunk/**

Hive Architecture



Hive QL – Join

- SQL:

INSERT INTO TABLE pv_users

SELECT pv.pageid, u.age

FROM page_view pv JOIN user u ON (pv.userid = u.userid);

page_view

pageid	**userid**	time
1	**111**	9:08:01
2	**111**	9:08:13
1	**222**	9:08:14

X

user

userid	age	gender
111	25	female
222	32	male

=

pv_users

pageid	age
1	25
2	25
1	32

Hive QL – Join in Map Reduce

page_view

pageid	**userid**	time
1	**111**	9:08:01
2	**111**	9:08:13
1	**222**	9:08:14

user

userid	age	gender
111	25	female
222	32	male

Map

key	value
111	<**1**,1>
111	<**1**,2>
222	<**1**,1>

key	value
111	<**2**,25>
222	<**2**,32>

Shuffle Sort

Reduce

key	value
111	<**1**,1>
111	<**1**,2>
111	<**2**,25>

pv_users

pageid	age
1	25
2	25

key	value
222	<**1**,1>
222	<**2**,32>

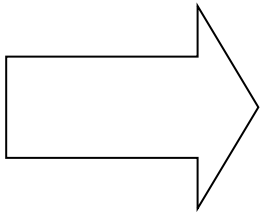
pageid	age
1	32

Hive QL – Group By

- SQL:
  - **INSERT INTO TABLE pageid_age_sum**
    SELECT pageid, age, count(1)
    FROM pv_users
    GROUP BY pageid, age;

pv_users

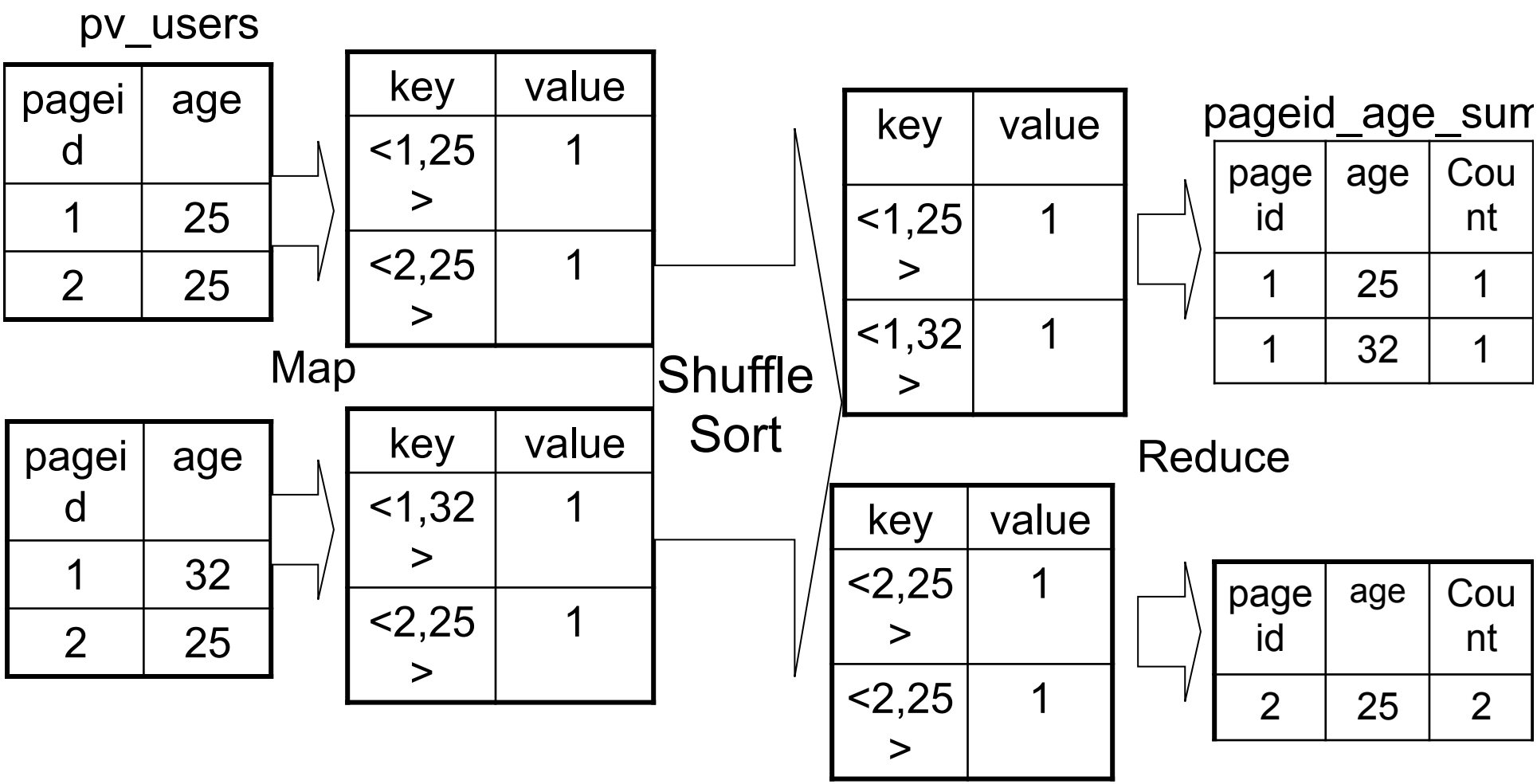
pageid	age
1	25
2	25
1	32
2	25



pageid_age_sum

pageid	age	Count
1	25	1
2	25	2
1	32	1

Hive QL – Group By in Map Reduce



Beyond Hadoop – Spark

Spark

- One problem with Hadoop/MapReduce is that it is fundamental batch oriented, and everything goes through a read/write on HDFS for every step in a dataflow
- Spark was developed to leverage the main memory of distributed clusters and to, whenever possible, use only memory-to-memory data movement (with other optimizations
- Can give up to 100fold speedup over MR

Spark

- Developed at the AMP lab here at Berkeley
- Open source version available from Apache
- DataBrick was founded to commercialize Spark
- Related software includes a very-high-speed Database – SparkDB
- Next time we will hear a talk (recorded) from Michael Franklin about BDAS & Spark