Big Data Analytics

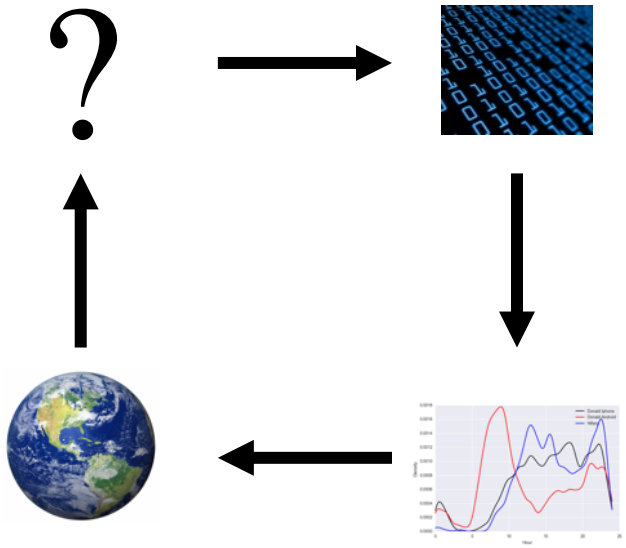
Map-Reduce and Spark

Review

Slides by:

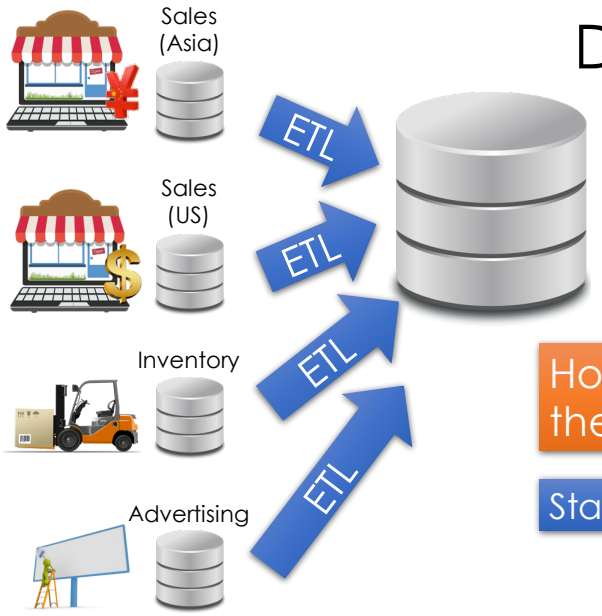
Joseph E. Gonzalez

jegonzal@cs.berkeley.edu



Previously … previously …

Data Warehouse



Collects and organizes historical data from multiple sources

How is data organized in the Data Warehouse?

Star Schemas

Data Lake*

Store a copy of all the data

- in one place
- in its original "natural" form

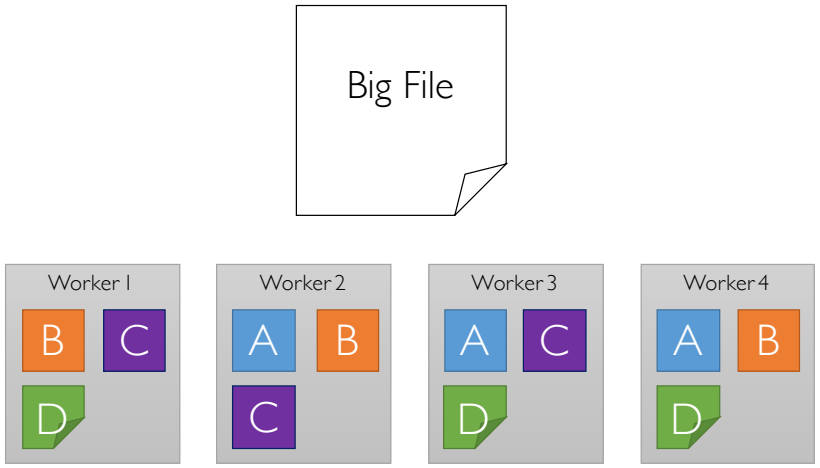
Enable data consumers to choose how to transform and use data.

- *Schema on Read*

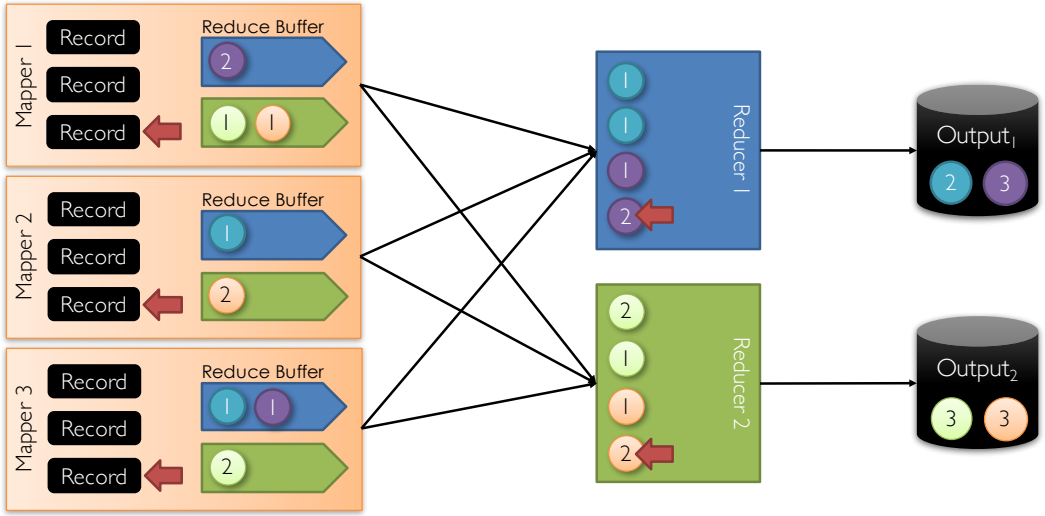
Enabled by new Tools:
Map-Reduce & Distributed Filesystems

What could go wrong?

Fault Tolerant Distributed File Systems (e.g., HDFS)

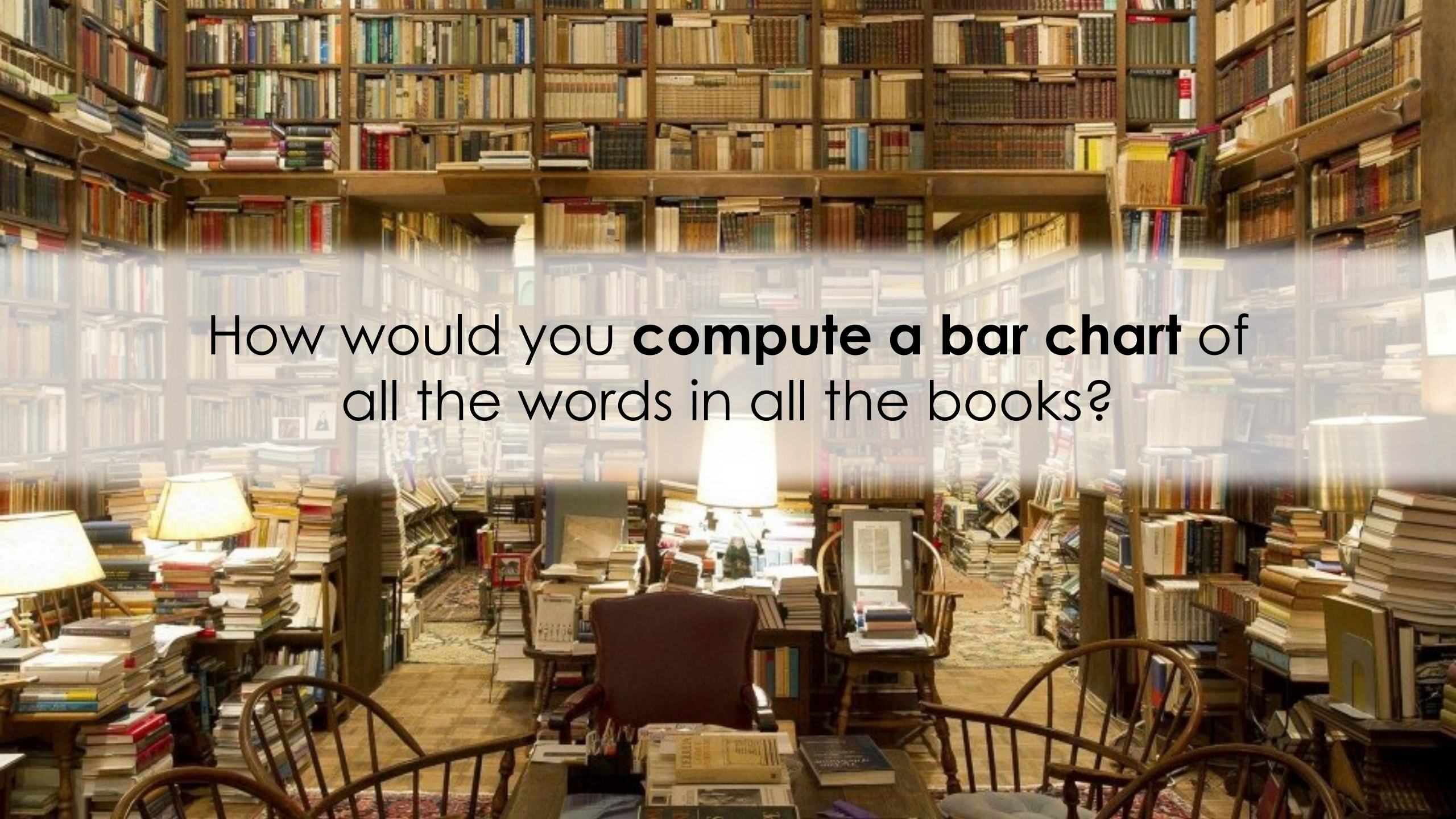


The Map Reduce System



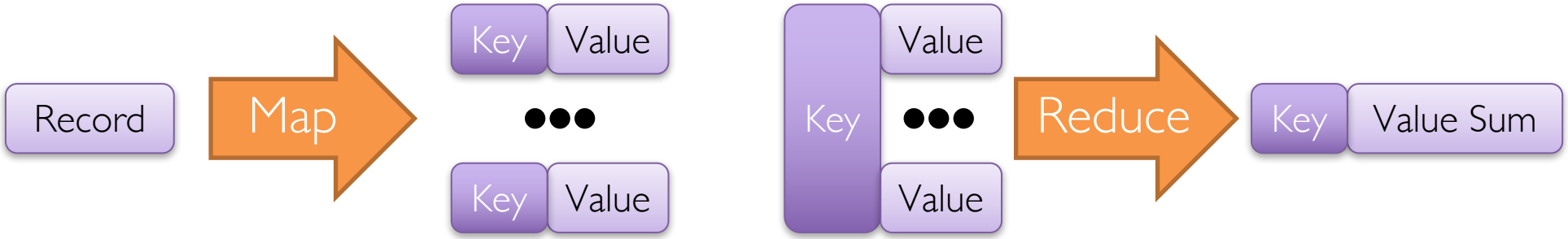
Map-Reduce Distributed Aggregation

Computing are very large files



How would you **compute a bar chart** of all the words in all the books?

The Map Reduce Abstraction



Example: *Word-Count*

```
Map(docRecord) {
  for (word in docRecord) {
    emit (word, 1)
  }
}
```

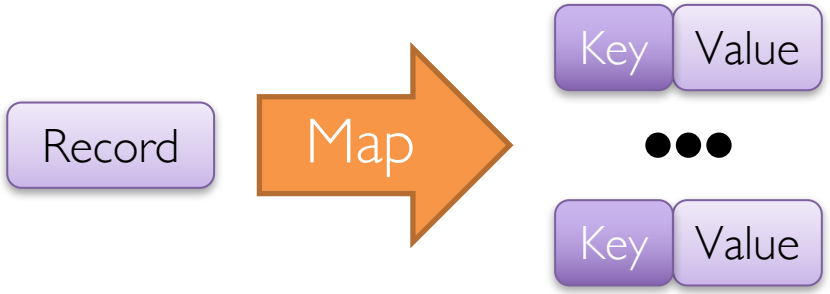
Key Value

```
Reduce(word, counts) {
  emit (word, SUM(counts))
}
```

Map: Idempotent
Reduce: Commutative and Associative

[Dean & Ghemawat, OSDI'04]

Parallel Computation



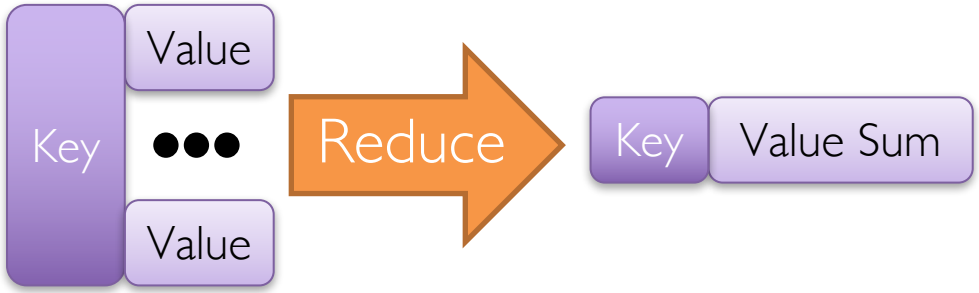
Example: *Word-Count*

```
Map(docRecord) {
  for (word in docRecord) {
    emit (word, 1)
  }
}
```

Key Value

Group By Key

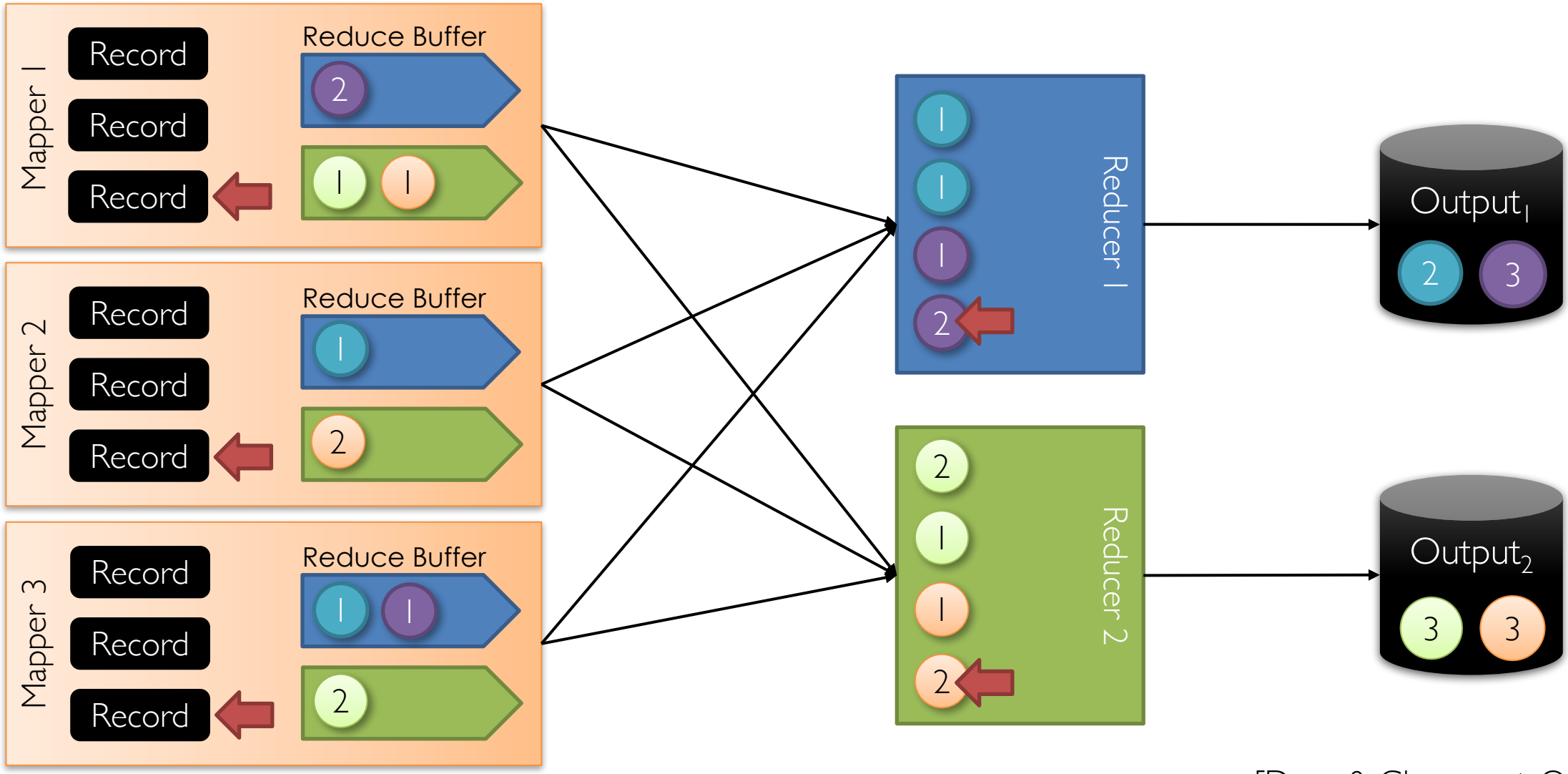
Parallel Computation




```
Reduce(word, counts) {
  emit (word, SUM(counts))
}
```

Map: Idempotent
Reduce: Commutative and Associative

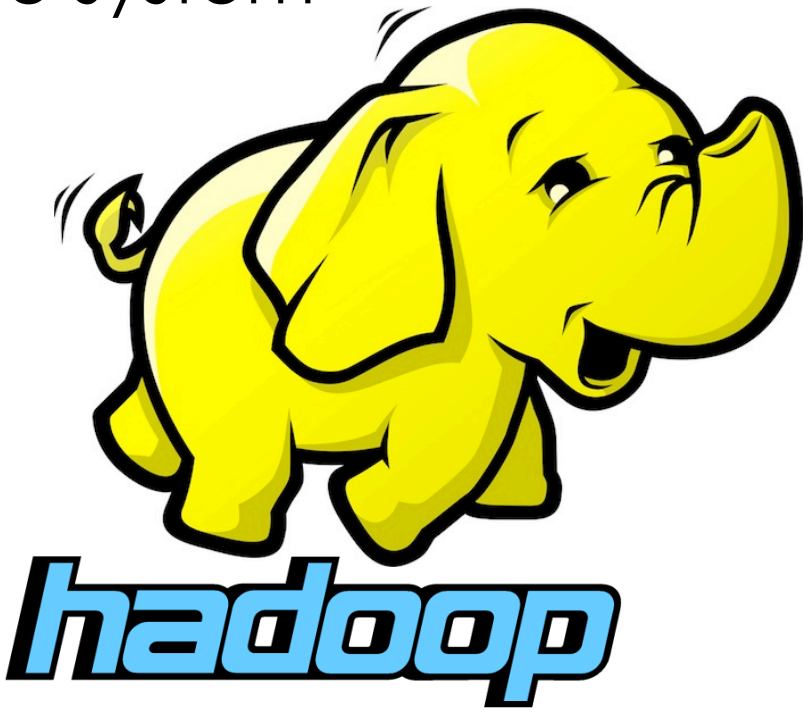
The Map Reduce System



[Dean & Ghemawat, OSDI'04]

Hadoop

- First open-source map-reducesoftware system
  - Managed by Apache foundation
- Based on Google's
  - Map-Reduce
  - Google File System
- Several key technologies
  - **HDFS:** Hadoop File System
  - **Yarn:** Yet another resource negotiator
  - **MapReduce:** map-reduce compute framework
    - Difficult to use → increasingly less used



In-Memory Dataflow System

Developed at the UC Berkeley AMP Lab

M. Zaharia, M. Chowdhury, M. J. Franklin, S. Shenker, and I. Stoica. *Spark: cluster computing with working sets*. HotCloud'10

M. Zaharia, M. Chowdhury, T. Das, A. Dave, J. Ma, M. McCauley, M.J. Franklin, S. Shenker, I. Stoica. *Resilient Distributed Datasets: A Fault-Tolerant Abstraction for In-Memory Cluster Computing*, NSDI 2012

Functional Programming API

- Python, R, Java, and Scala APIs
- Data is represented as **distributed collections:**
  - *Resilient Distributed Dataset (RDD):* A collection of **objects**
    - Objects could be text, images, python dictionaries …
  - *DataFrame:* A collection of **rows** which all have the same schema (preferred way to use Spark today)
- Computation
  - **Transformations:** users apply functions to the distributed collections which return new distributed collections
    - E.g., map, filter, reduceByKey
  - **Actions**: users apply functions which return values:
    - E.g., count, sum, collect

Multiple Demos!!

Interacting with Data @ Scale

Map-Reduce

Interacting With the Data

Good for smaller datasets

- Faster more natural interaction
- Lots of tools!

Request Data Sample

Sample of Data

$\Sigma = \bigoplus_{r \in \text{Data}} f_\theta(r)$

Compute Locally

Analysis Algorithm

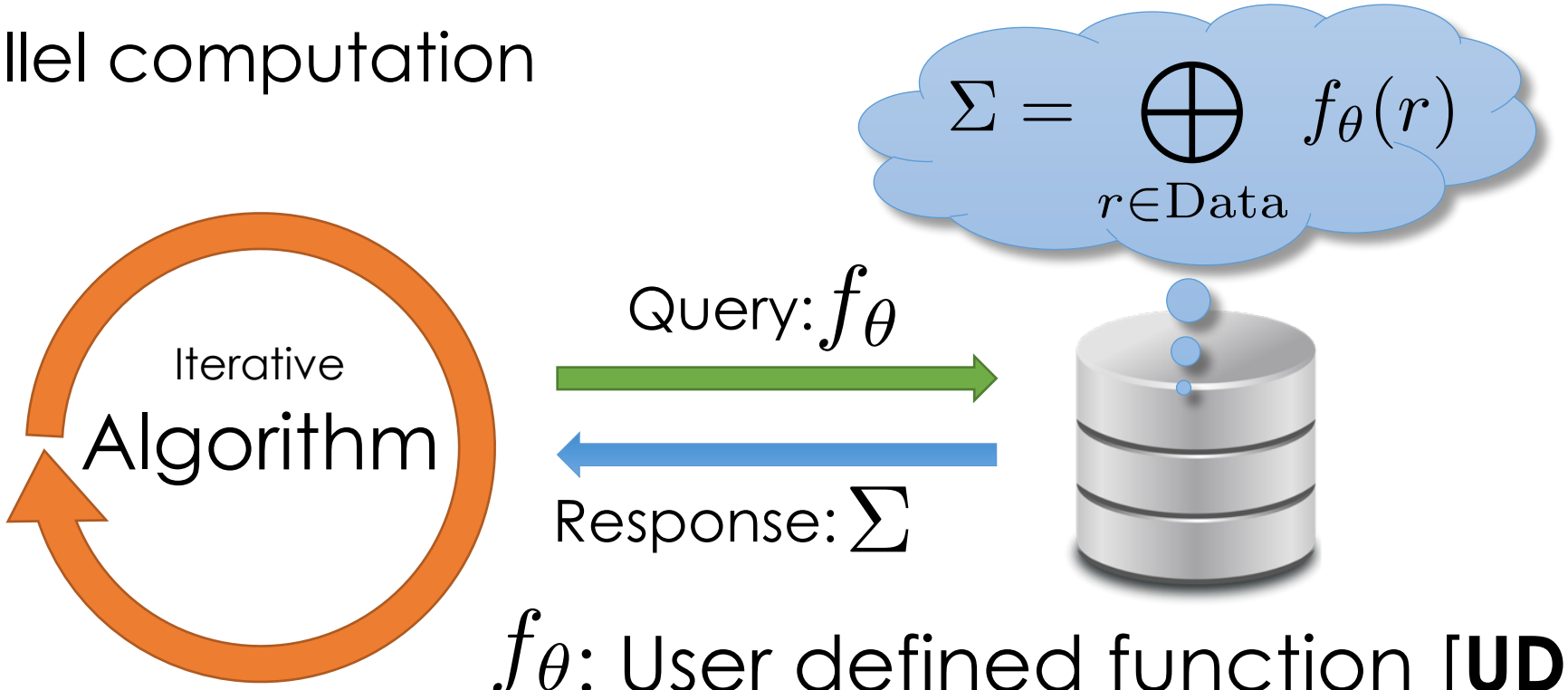
Computation

Can we send the computation to the data?

Yes!

Statistical Query Pattern
Common Machine Learning Pattern

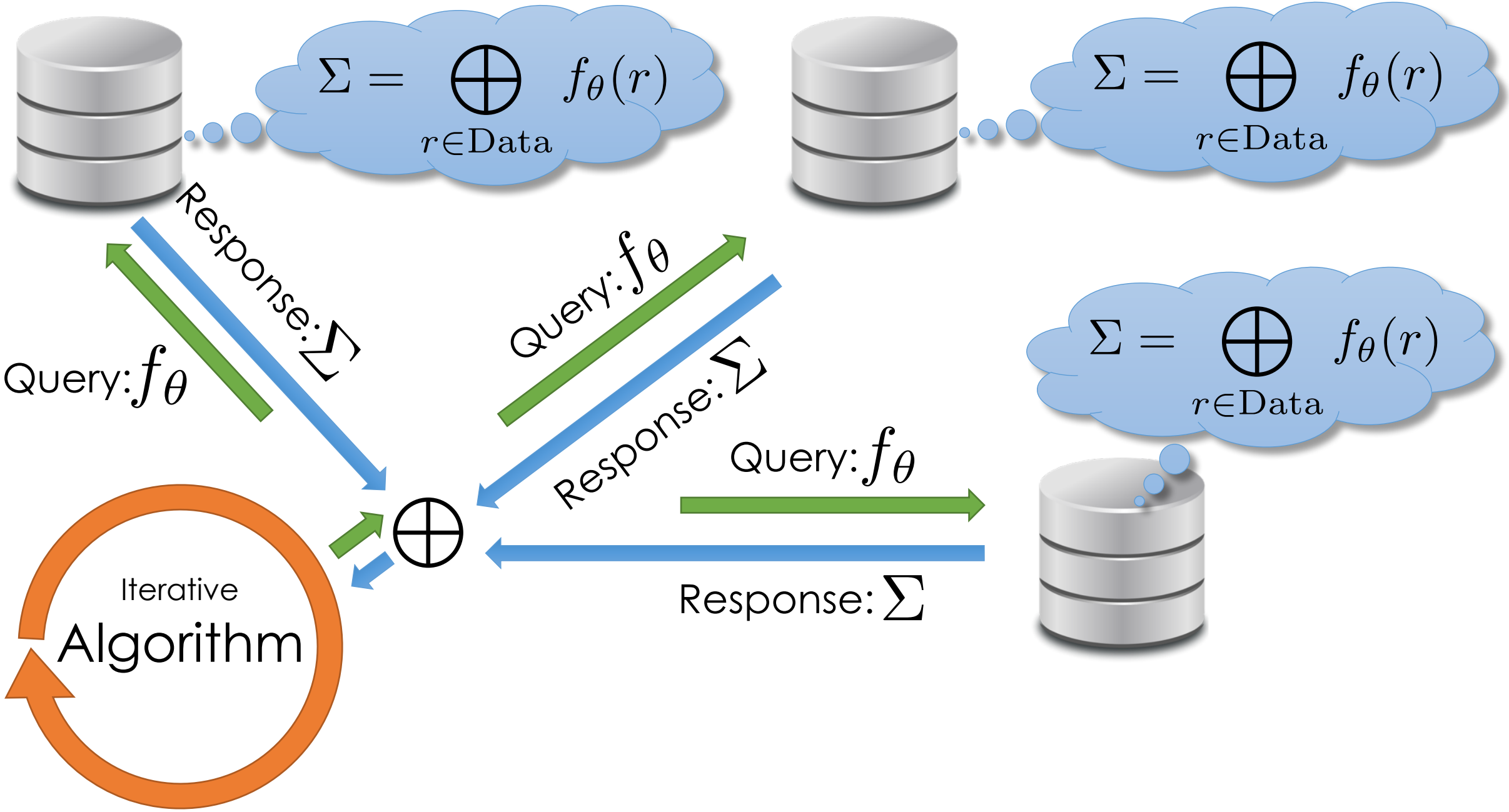
- Computing aggregates of user defined functions
- Data-Parallel computation



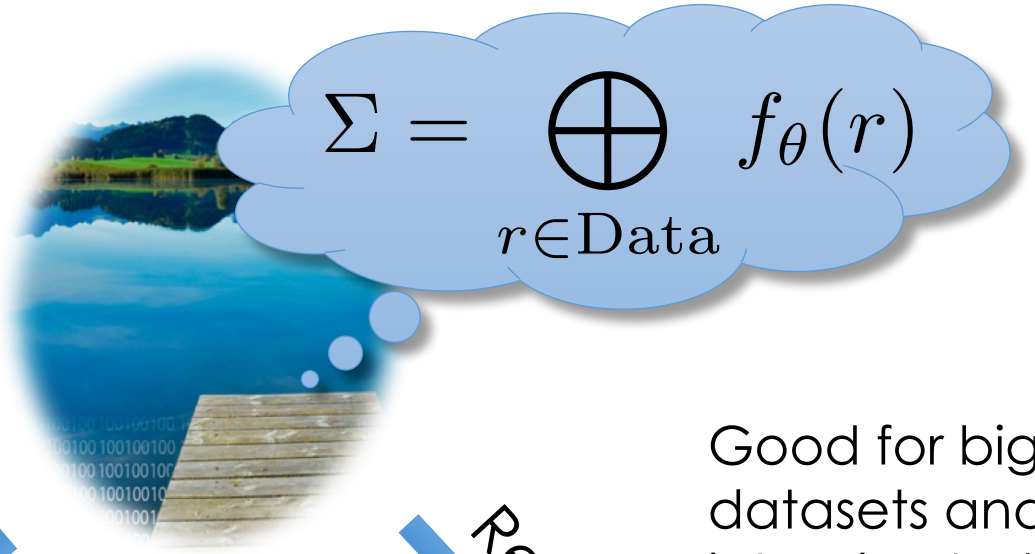
f_θ: User defined function [**UDF**]

$\bigoplus$: User defined aggregate [**UDA**]

D. Caragea et al., *A Framework for Learning from Distributed Data Using Sufficient Statistics and Its Application to Learning Decision Trees*. Int. J. Hybrid Intell. Syst. 2004


$\Sigma = \bigoplus_{r \in \text{Data}} f_\theta(r)$
$\Sigma = \bigoplus_{r \in \text{Data}} f_\theta(r)$
$\Sigma = \bigoplus_{r \in \text{Data}} f_\theta(r)$
Query: f_θ
Response: Σ
Query: f_θ
Response: Σ
Query: f_θ
Response: Σ
$\bigoplus$
Iterative
Algorithm

Interacting With the Data



Good for smaller datasets

- Faster more natural interaction
- Lots of tools!

Request Data Sample

Sample of Data

$\Sigma = \bigoplus_{r \in \mathrm{Data}} f_\theta(r)$

Compute Locally

Algorithm

Good for bigger datasets and compute intensive tasks

Query: f_θ

Response: Σ

Algorithm

Cluster Compute