9311 ADVANCED TOPICS - INTRODUCTION TO BIG DATA MANAGEMENT

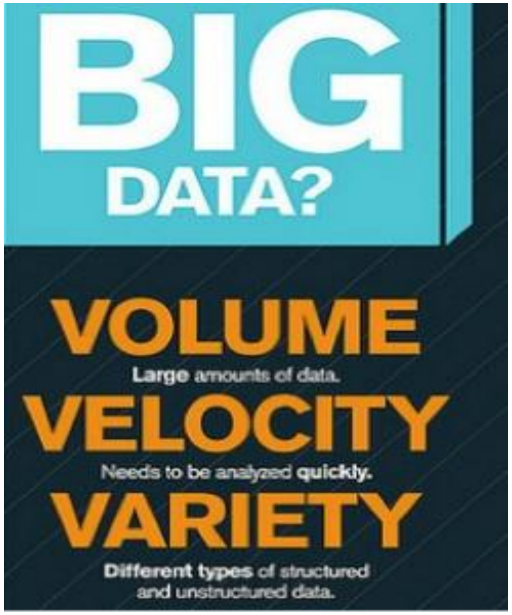
Outline

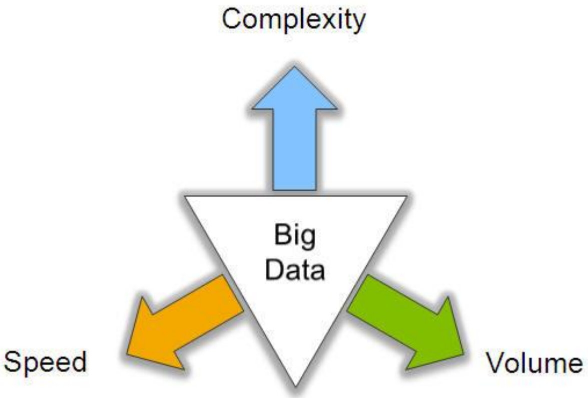
- Big Data
  - The 3V' characteristics
  - Cloud Computing

- MapReduce
  - Basic Idea
  - An example

BIG DATA

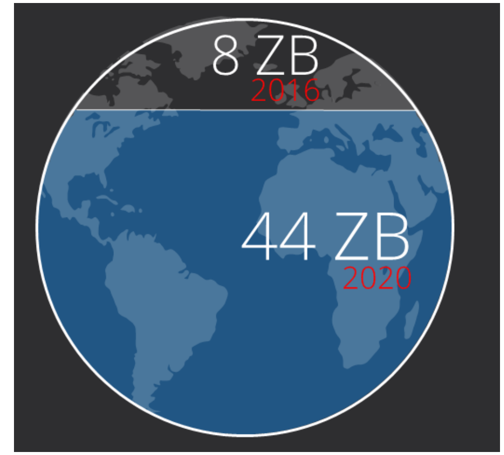
Big Data Characteristics: 3V

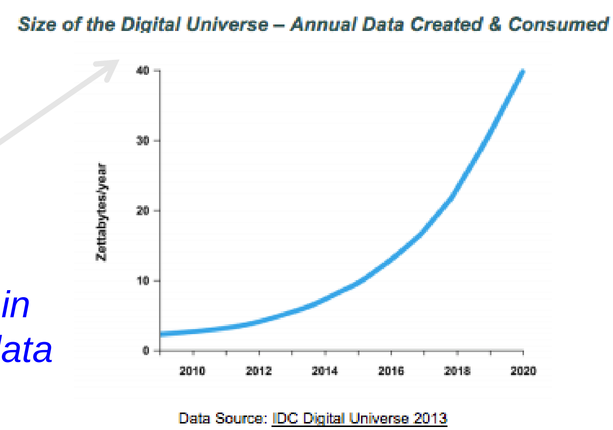




Volume (Scale)

- Data Volume
  - Growth 40% per year
  - From 8 zettabytes (2016) to 44zb (2020)
- Data volume is increasing exponentially





Exponential increase in collected/generated data

Volume (Scale)

Using SSD of 6G/s, a linear scan of a data set ***D*** would take

- 1.9 days when ***D*** is of 1PB (10^{15}B)
- 5.28 years when ***D*** is of 1EB (10^{18}B)

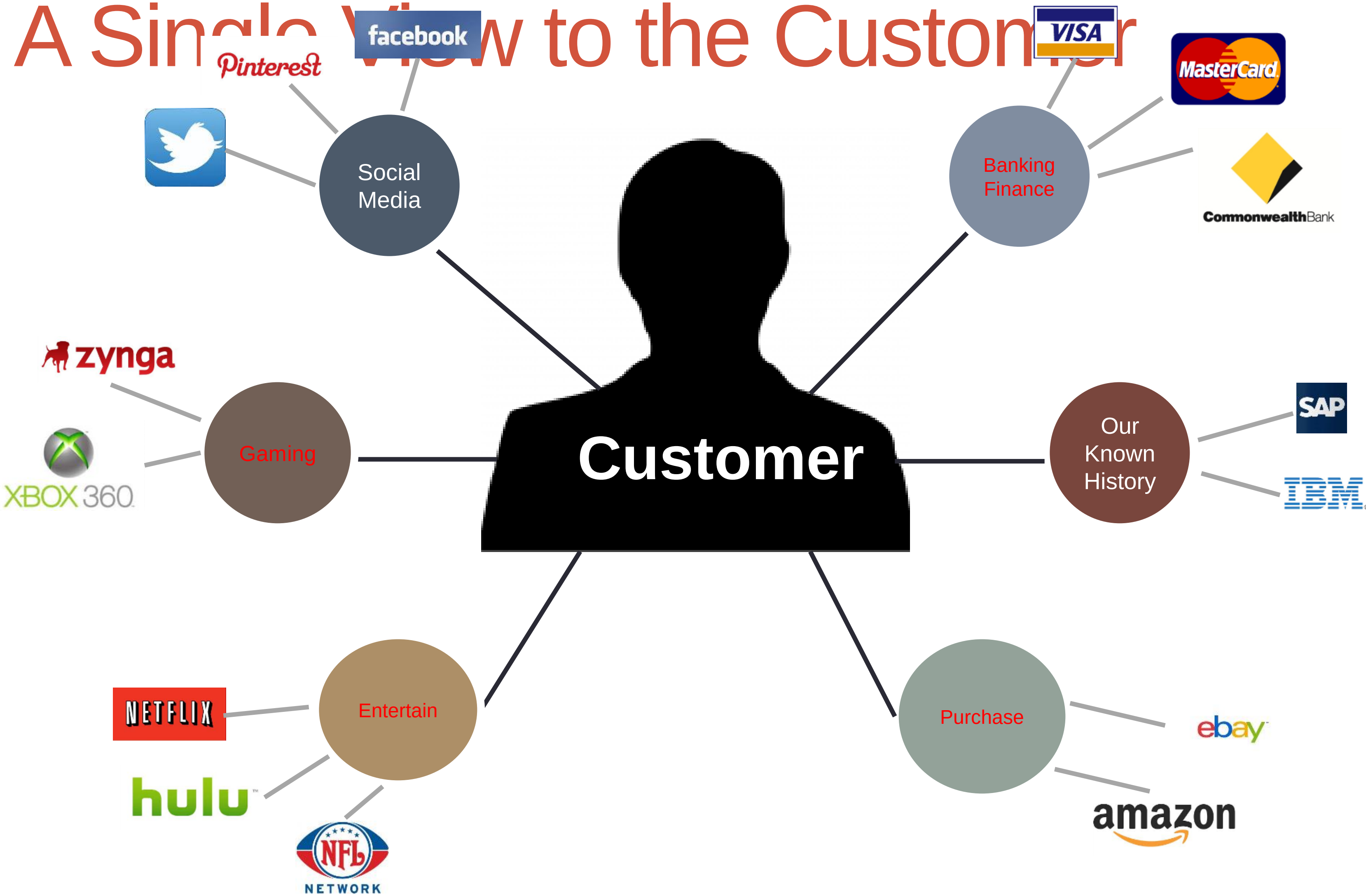
Volume (Scale)

640K ought to be enough for anybody.

Variety (Complexity)

- Different Types:
  - Relational Data (Tables/Transaction/Legacy Data)
  - Text Data (Web)
  - Semi-structured Data (XML)
  - Graph Data
    - Social Network, Semantic Web (RDF), …
  - Streaming Data
    - You can only scan the data once
  - A single application can be generating/collecting many types of data
- Different Sources：
  - Movie reviews from IMDB and Rotten Tomatoes
  - Product reviews from different provider websites

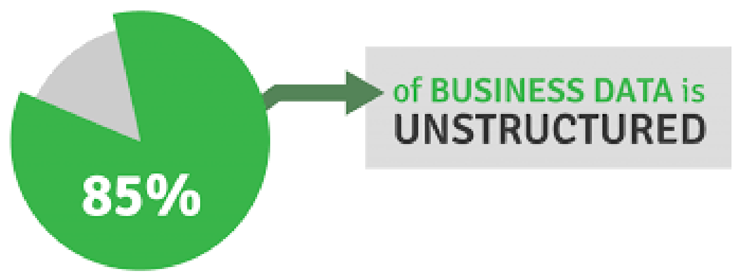
A Single View to the Customer



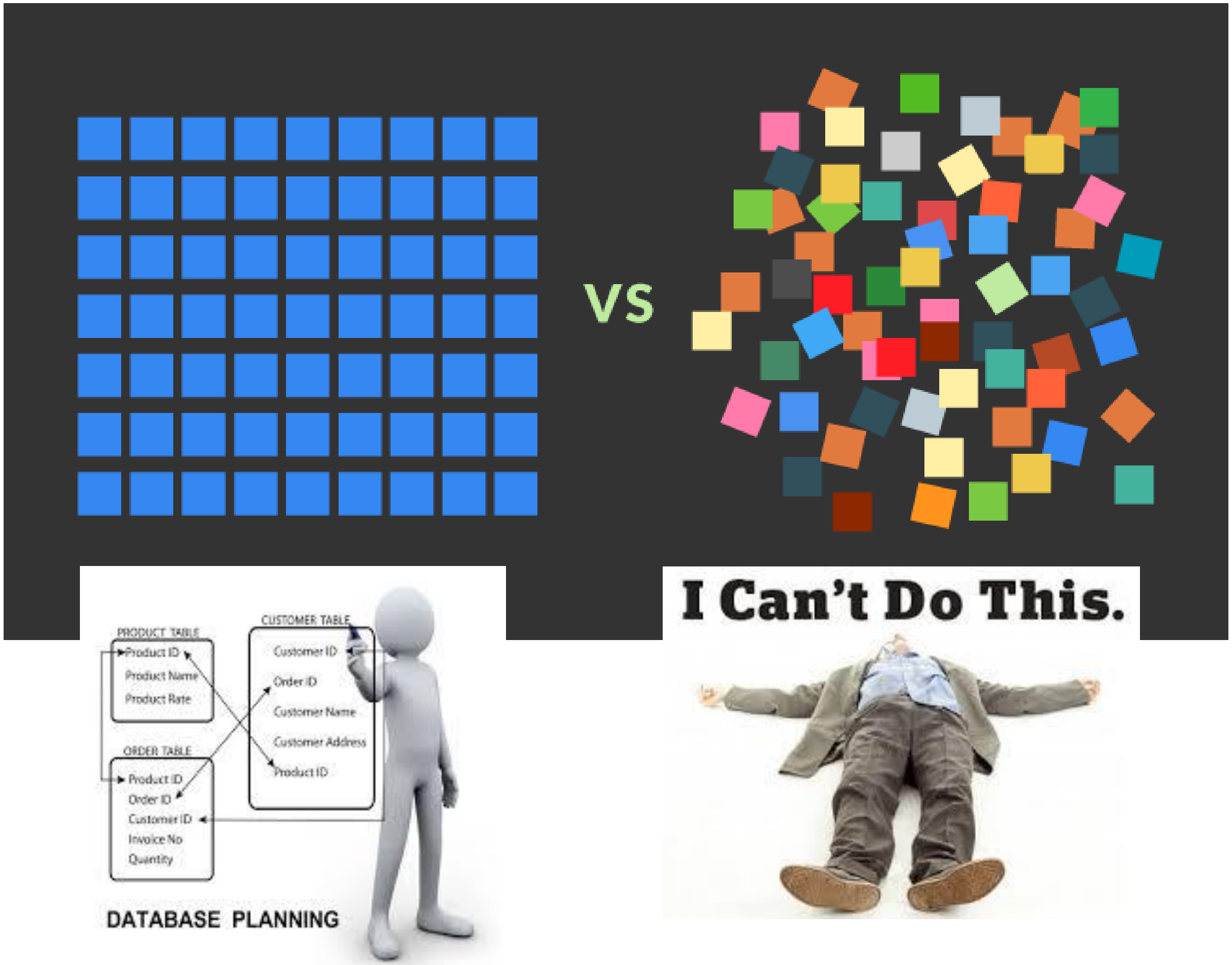
Variety --- Structured vs. Unstrucured

- Relational database (Structured data)
  - Relational table
  - Highly structured and formatted
  - Mathematical guaranteed

- **Unstructured data**



Big (Unstructured) Data



Velocity (Speed)

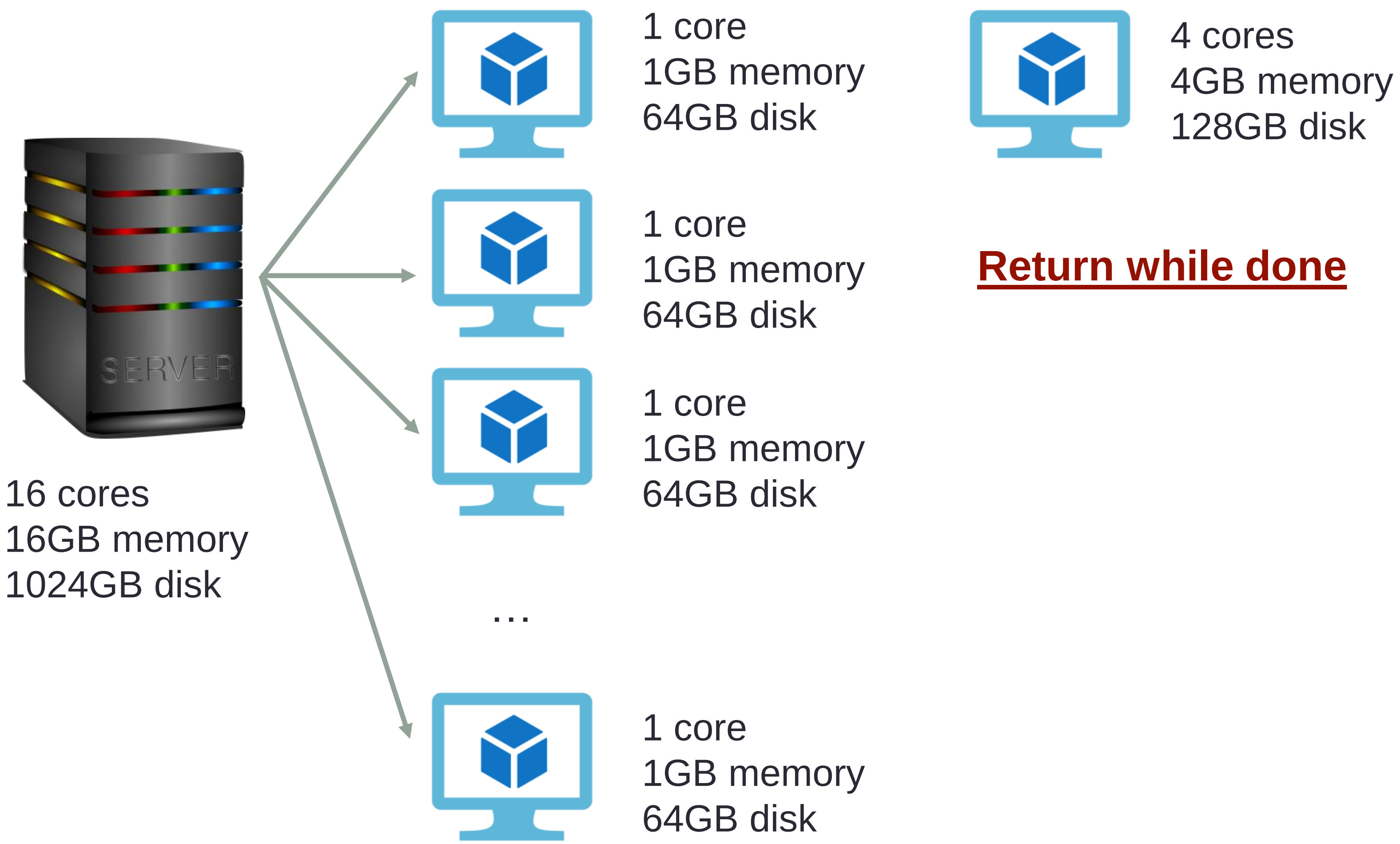
- Data is begin generated fast and need to be processed fast
- Online Data Analytics
- Late decisions ➔ missing opportunities
- Examples
  - **E-Promotions:** Based on your current location, your purchase history, what you like ➔ send promotions right now for store next to you
  - **Healthcare monitoring:** sensors monitoring your activities and body ➔ any abnormal measurements require immediate reaction
  - **Disaster management and response**

CLOUD COMPUTING

Cloud Computing

- Cloud Computing is a general term used to describe a new class of network based computing that takes place over the Internet
  - A collection/group of integrated and networked hardware, software and Internet infrastructure (called a platform).
  - Using the Internet for communication and transport provides hardware, software and networking services to clients
  - These platforms hide the complexity and details of the underlying infrastructure from users and applications by providing very simple graphical interface or API
- A technical point of view
  - Internet-based computing (i.e., computers attached to network)
- A business-model point of view
  - Pay-as-you-go (i.e., rental)

Virtualisation



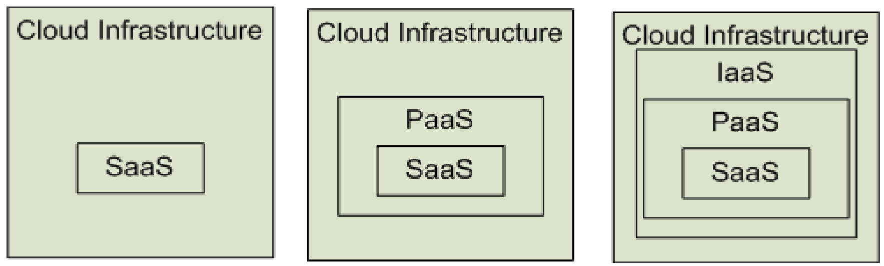
Cloud Computing

Pay-as-you-go !!!

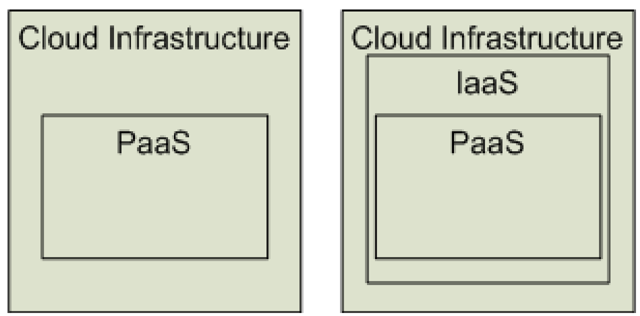
Cloud Computing Services

- Infrastructure as a service (IaaS)
  - Offering hardware related services using the principles of cloud computing. These could include storage services (database or disk storage) or virtual servers.
  - Amazon EC2, Amazon S3
- Platform as a Service (PaaS)
  - Offering a development platform on the cloud.
  - Google's Application Engine, Microsoft Azure
- Software as a service (SaaS)
  - Including a complete software offering on the cloud. Users can access a software application hosted by the cloud vendor on pay-per-use basis. This is a well-established sector.
  - Googles gmail and Microsoft hotmail, Google docs

Cloud Computing as Services

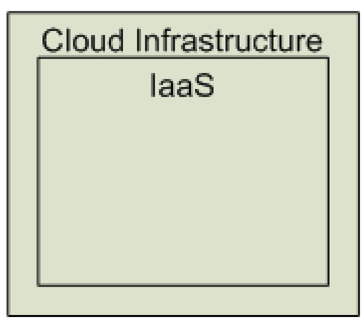


Software as a Service (SaaS) Providers Applications



Platform as a Service (PaaS)

Deploy customer created Applications



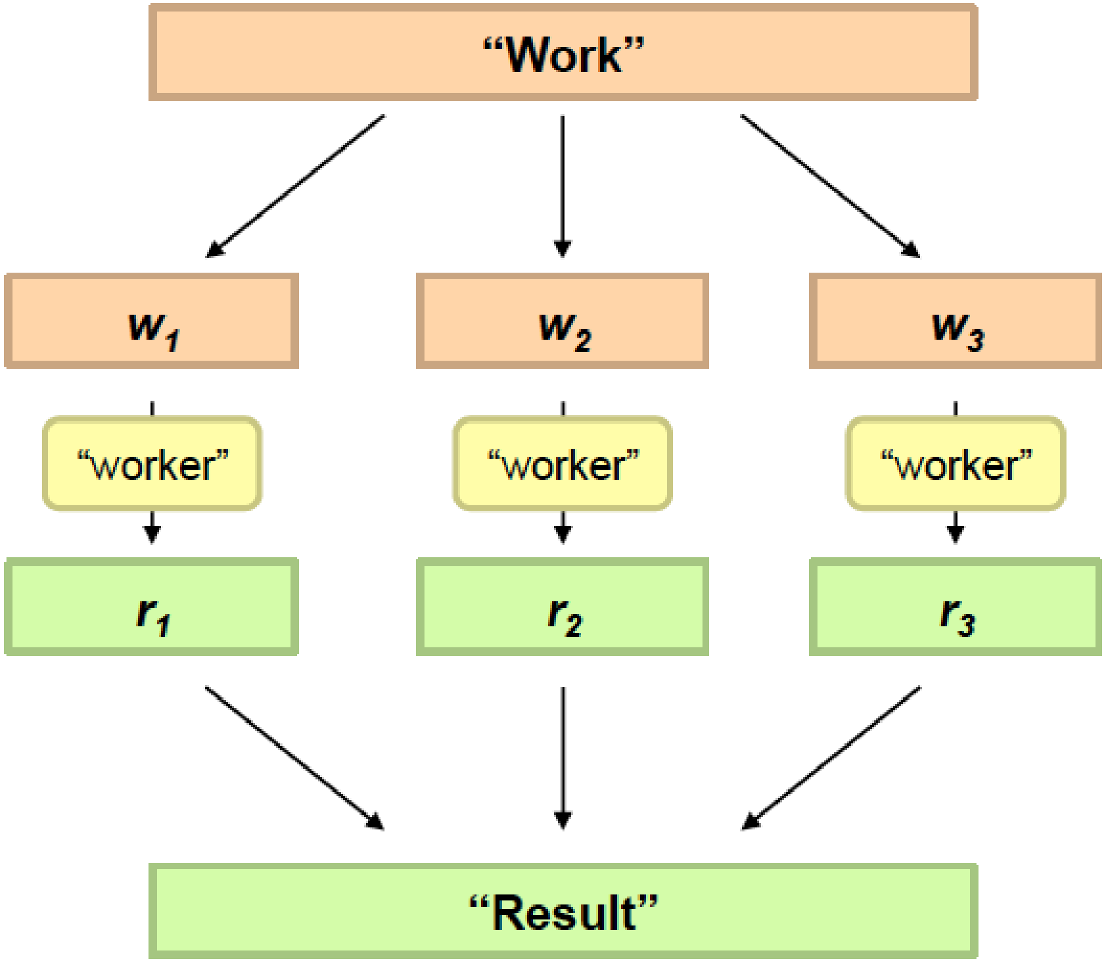
Infrastructure as a Service (IaaS)

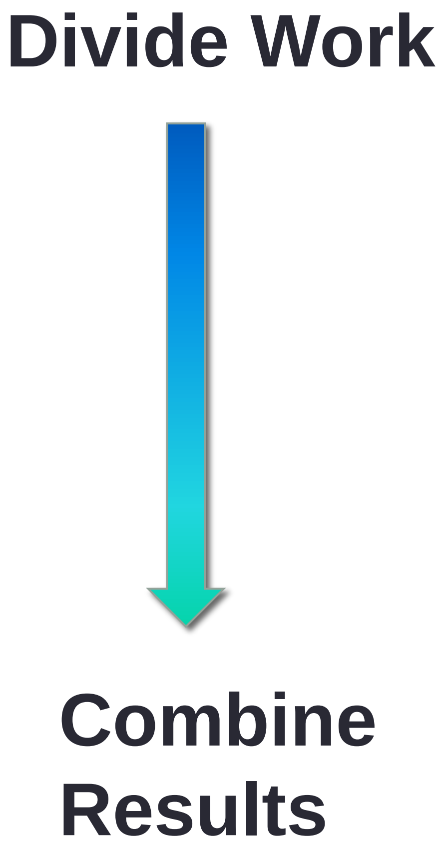
Rent Processing, storage, N/W capacity & computing resources

HADOOP

THE OPEN-SOURCE BIG DATA ENGINE

Philosophy to Scale for Big Data Processing





Distributed processing is non-trivial

- How to assign tasks to different workers in an efficient way?
- What happens if tasks fail?
- How do workers exchange results?
- How to synchronize distributed tasks allocated to different workers?

Challenge : Failure is the Norm

# of Machines	Probability of Failure
	
	1 - (1 - 1%)^1000 = **99.996%**

What is Hadoop

- Open-source data storage and processing platform
- Before the advent of Hadoop, storage and processing of big data was a big challenge
- Massively scalable, automatically parallelizable
  - Based on work from Google
    - Google: GFS + MapReduce + BigTable (Not open)
    - Hadoop: HDFS + Hadoop MapReduce + HBase（opensource)
- Named by Doug Cutting in 2006 (worked at Yahoo! at that time), after his son's toy elephant.

Hadoop offers

- Redundant, Fault-tolerant data storage
- Parallel computation framework
- Job coordination

Programmers

No longer need to worry about

Q: Where file is located?

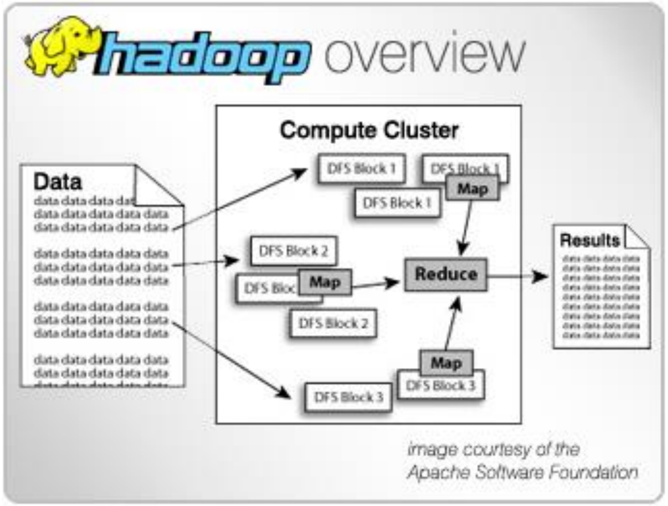
Q: How to handle failures & data lost?

Q: How to divide computation?

Q: How to program for scaling?

Why Use Hadoop?

- Cheaper
  - Scales to Petabytes or more easily
- Faster
  - Parallel data processing
- Better
  - Suited for particular types of big data problems

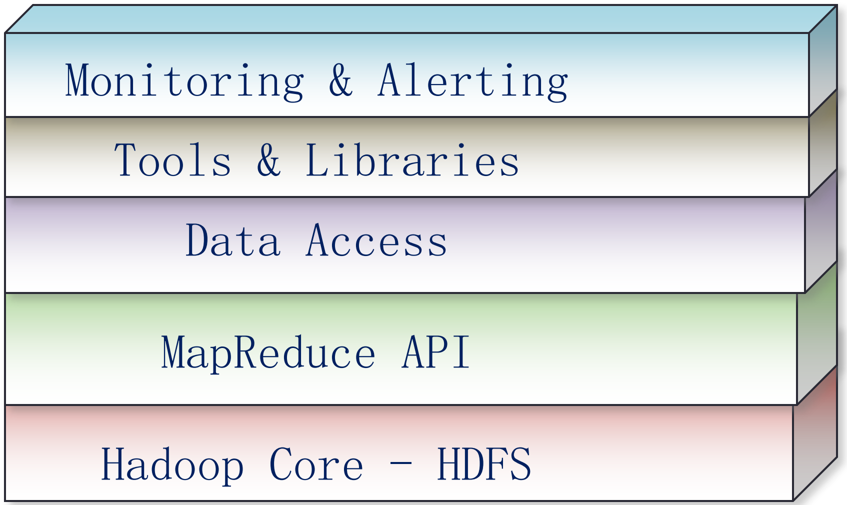


Companies Using Hadoop

facebook
The New York Times
ebY
hp
IBM
JPMorganChase
eHarmony
twitter
intel
NETFLIX
rackspace HOSTING
amazon.com
VISA
NING
SAMSUNG
YAHOO!

Hadoop is a set of Apache Frameworks and more…

- Data storage (HDFS)
  - Runs on commodity hardware (usually Linux)
  - Horizontally scalable
- Processing (MapReduce)
  - Parallelized (scalable) processing
  - Fault Tolerant
- Other Tools / Frameworks
  - Data Access
    - HBase, Hive, Pig, Mahout
  - Tools
    - Hue, Sqoop
  - Monitoring
    - Greenplum, Cloudera



MAPREDUCE

A big-data programming model

What is MapReduce

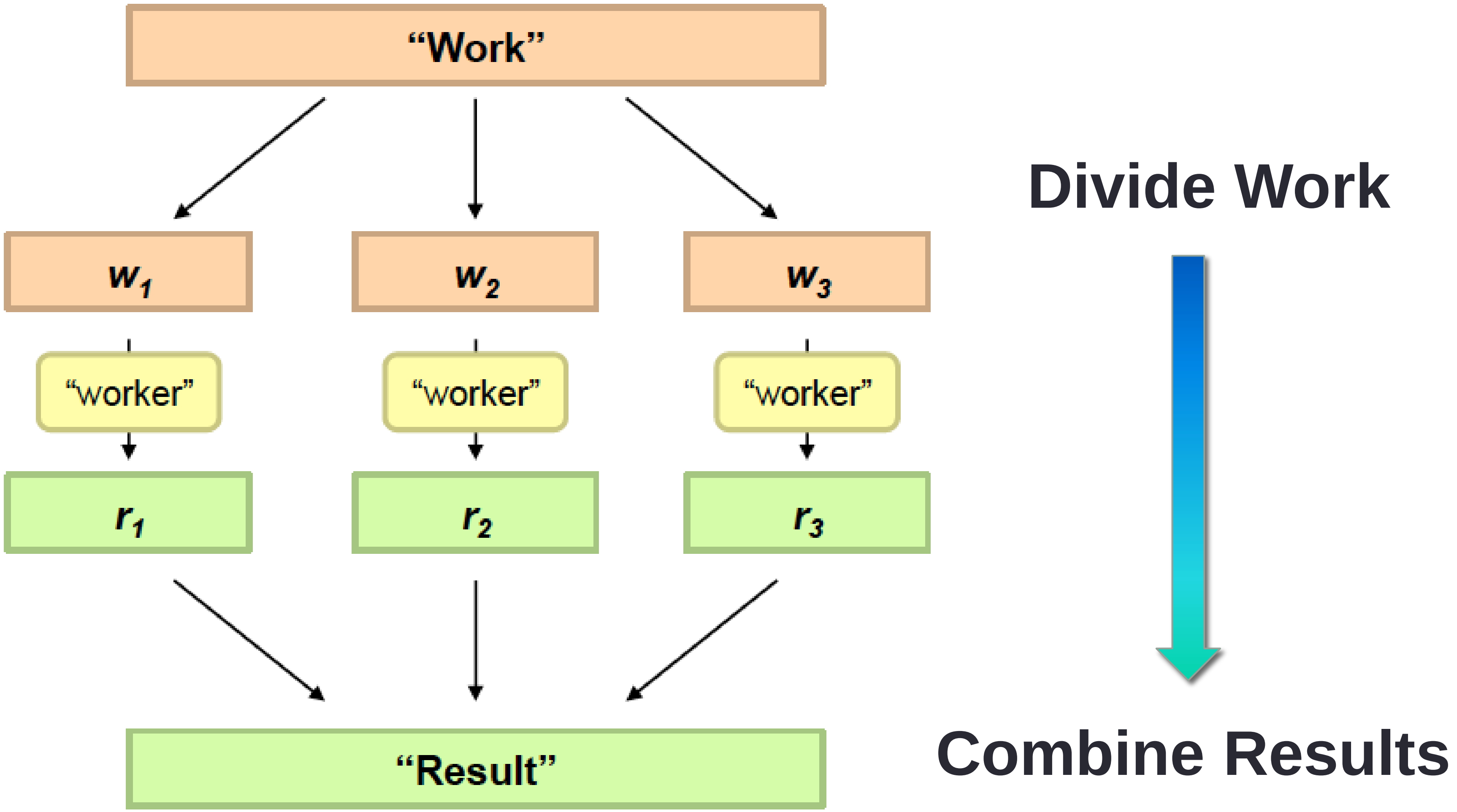
- Origin from Google, [OSDI'04]

  MapReduce: Simplified Data Processing on Large Clusters

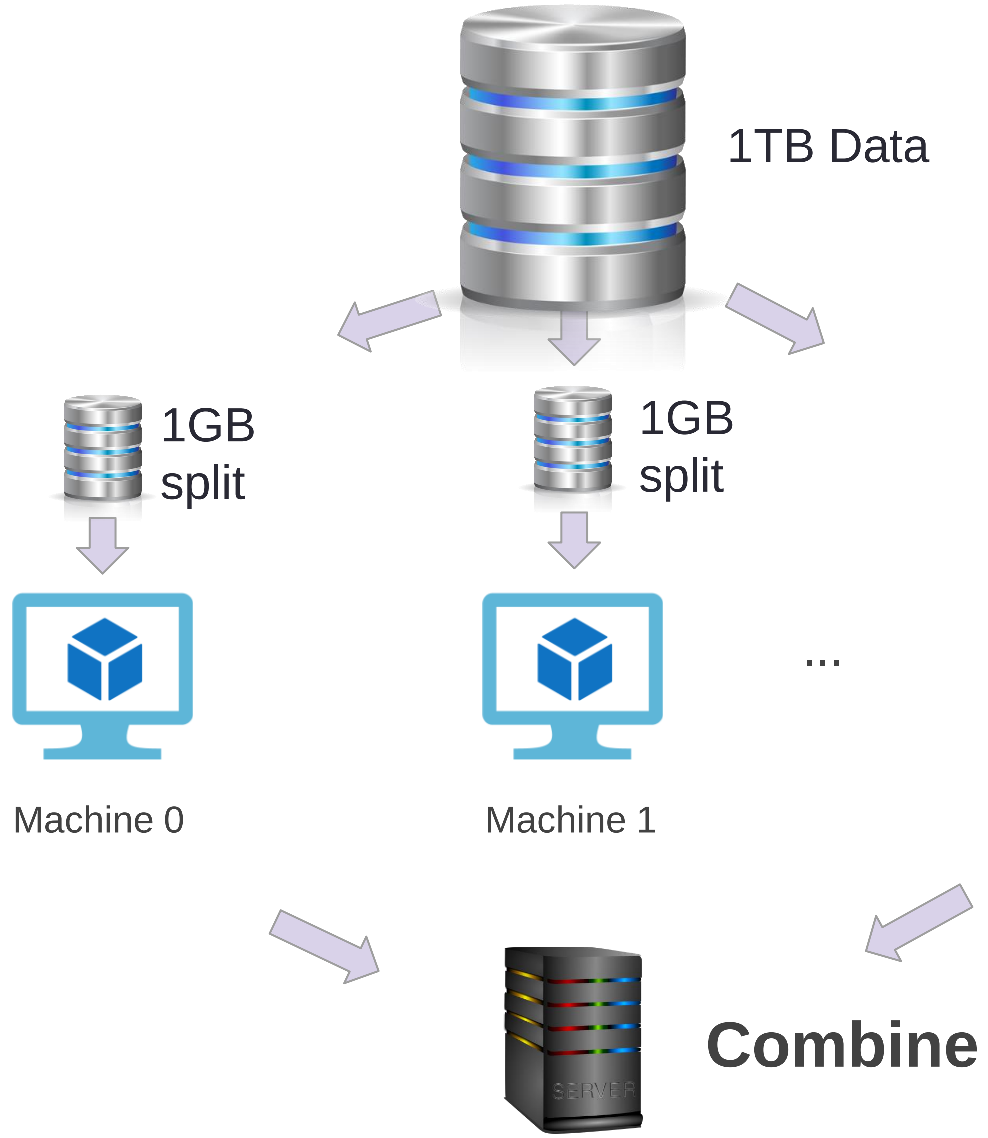
  Jeffrey Dean and Sanjay Ghemawat
- A programming model for parallel data processing
- Hadoop can run MapReduce programs written in various languages:
  e.g. Java, Ruby, Python, C++

- We introduce basic principles for MapReduce only in this course. *If interested: COMP9313 – Big Data Management*

Philosophy Revisit



Divide and Combine



Typical Big Data Problem

- Iterate over a large number of records
- Extract something of interest
- Shuffle and sort intermediate results
- Aggregate intermediate results
- Generate final output

Map

Reduce

Key idea: provide a functional abstraction for these two operations

Map and Reduce Functions

- Programmers specify two functions:
  - **map** $(k_1, v_1) \rightarrow$ list $[<k_2, v_2>]$
    - Map transforms the input into key-value pairs to process
  - **reduce** $(k_2, \text{list } [v_2]) \rightarrow [<k_3, v_3>]$
    - Reduce aggregates the list of values for each key
    - All values with the same key are sent to the same reducer
  - list $[<k_2, v_2>]$ will be grouped according to key k_2 as $(k_2, \text{list } [v_2])$

- The MapReduce environment takes in charge of everything else

A WordCount Example

- Given a file, count the occurrence of each word

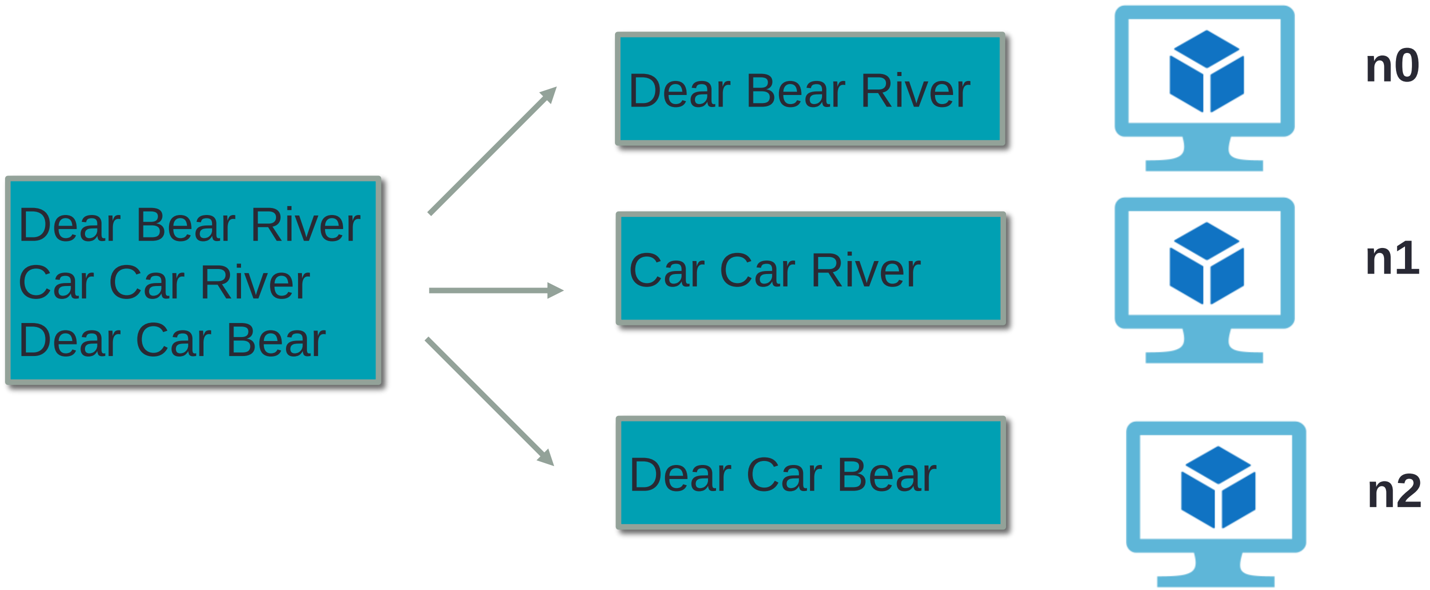
Data File

Dear Bear River
Car Car River
Dear Car Bear

- *E.g., Car* occurs three times
- Imagine we have a file of 1TB

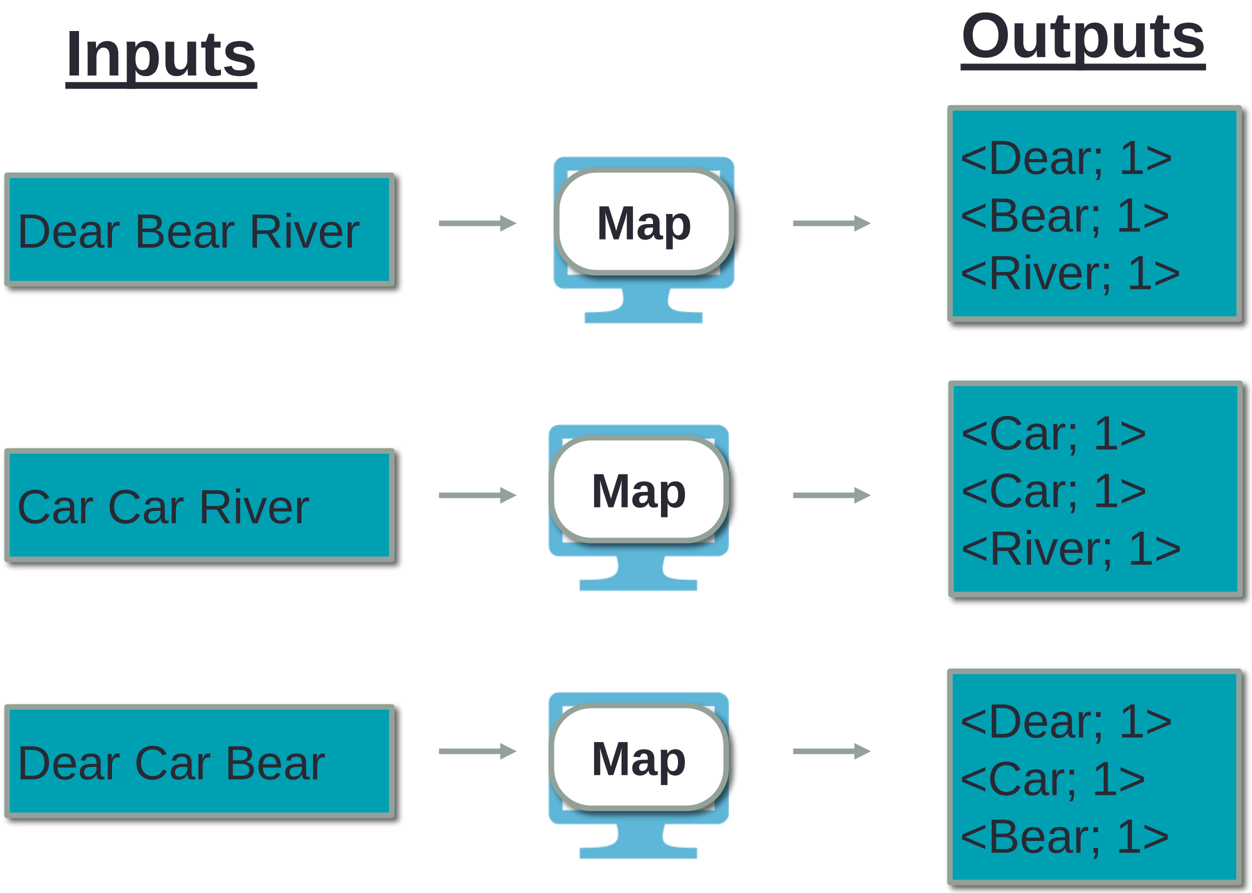
Step 1: Splitting

- Original file is split into smaller pieces



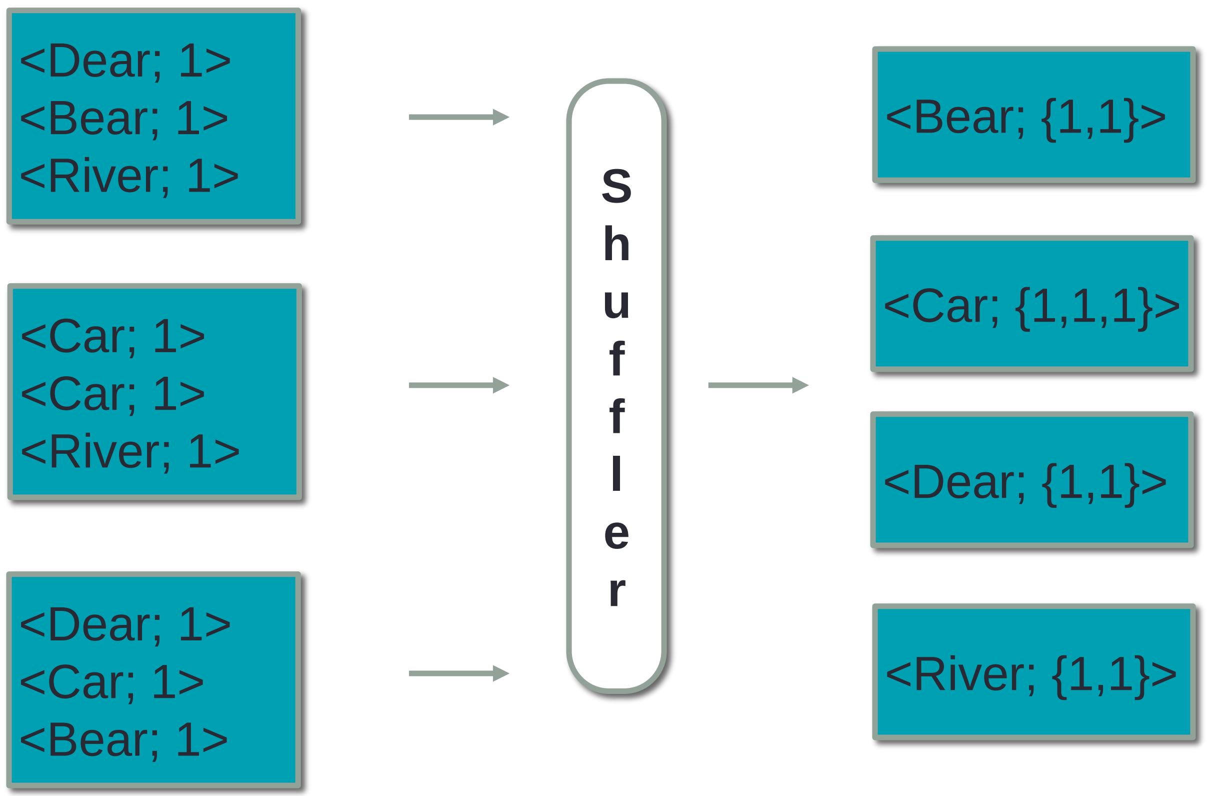
Step 2: Mapping

- Read the file piece, and generate <key; value> pairs by extracting words from lines. Here value is 1 since each word read means it occurs once



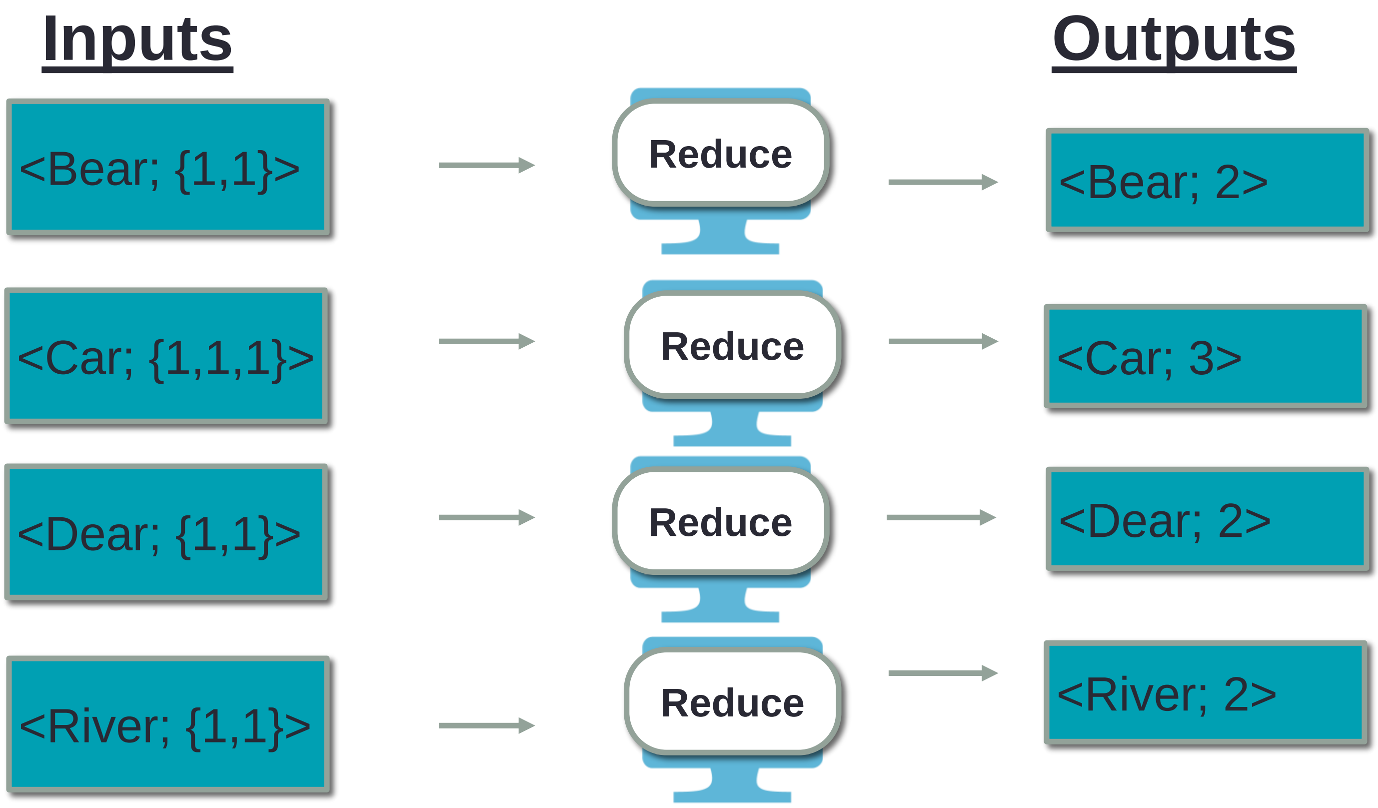
Step 3: Shuffling

- *Hadoop framework handles this step*. Sort the key value pairs and group based on the key value

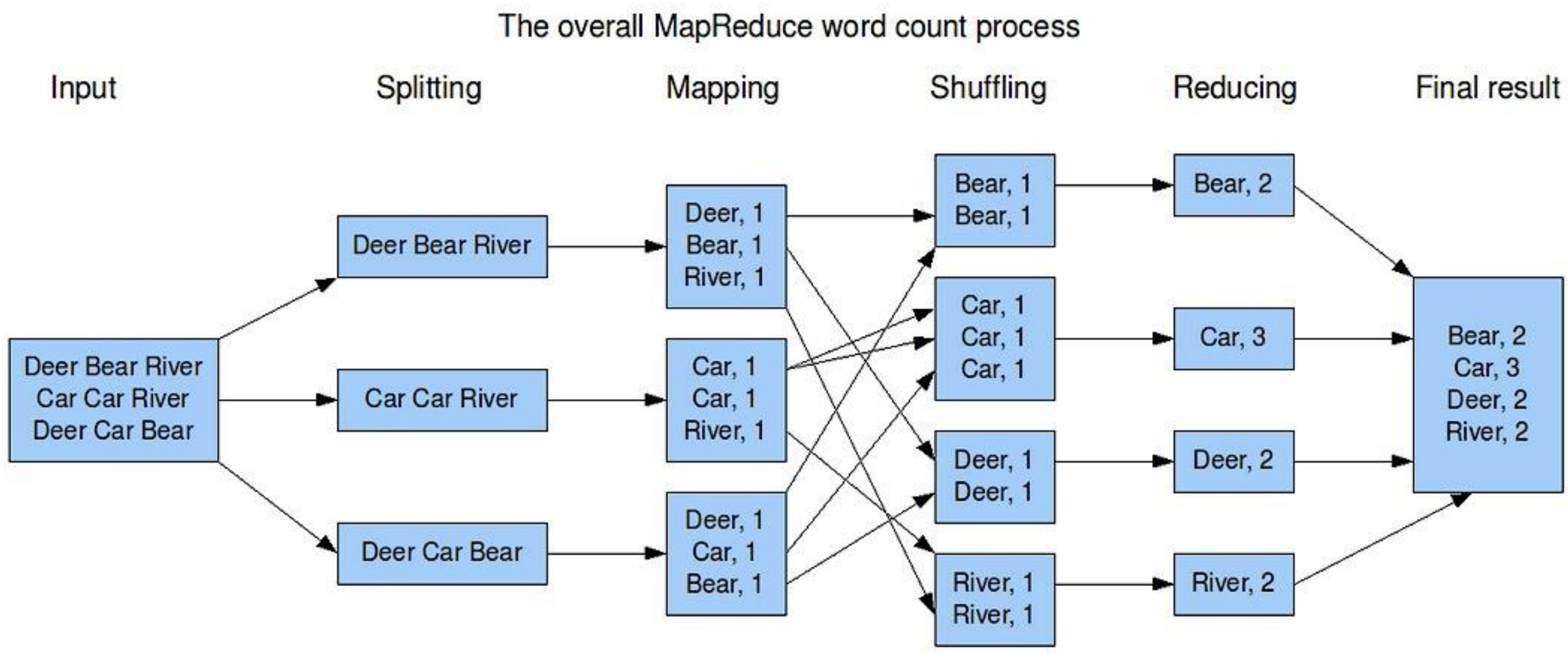


Step 4: Reducing

- Reducer aggregate the list of values of each key and output the result



MapReduce Example - WordCount



“Word Count” in MapReduce

Mapper and Reducer function

```
class Mapper
    method Map(docid a, doc d)
        for all term t ∈ doc d do
            Emit(term t, count 1)
```

```
class Reducer
    method Reduce(term t, counts [c1, c2, . . .])
        sum ← 0
        for all count c ∈ counts [c1, c2, . . .] do
            sum ← sum + c
        Emit(term t, count s)
```

MapReduce

- WordCount example counts the occurrence of each word.
- We can also get other aggregate values, such as sum and maximum.