

# Big Data



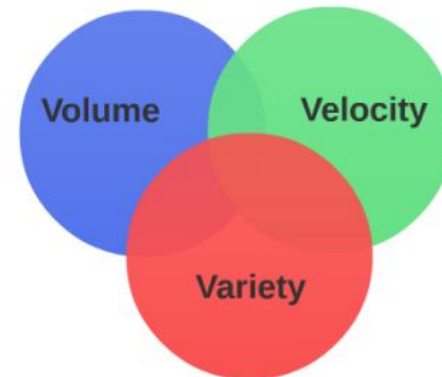
# WHAT IS BIG DATA?

# WHAT IS BIG DATA?

Many Terabytes, Petabytes, Exabytes...

Name	Abbr.	Size
Kilo	K	1,024
Mega	M	1,048,576
Giga	G	1,073,741,824
Tera	T	1,099,511,627,776
Peta	P	1,125,899,906,842,624
Exa	E	1,152,921,504,606,846,976
Zetta	Z	1,180,591,620,717,411,303,424
Yotta	Y	1,208,925,819,614,629,174,706,176

3Vs - Volume Velocity Variety



# IS THERE REALLY A USE CASE?



## Science

- Large Hadron Collider - 1 Petabyte every second
- NASA - 1.73 Gigabyte every hour



## Government

- NSA - Utah Data Center - Yottabyte Capacity
- Big Data Research and Development Initiative
- Barack Obama's successful 2012 re-election campaign

## Private

- eBay - 40PB Hadoop cluster for search, consumer recommendations, and merchandising
- Facebook - 30 PB Hadoop cluster. 50 billion photos. 130TB of logs every day.



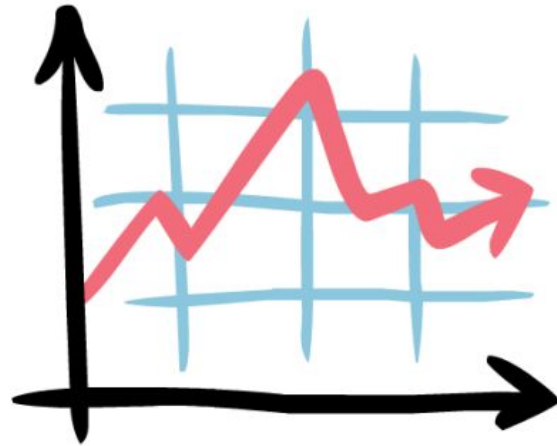
# BIG DATA - CHALLENGES

Storage

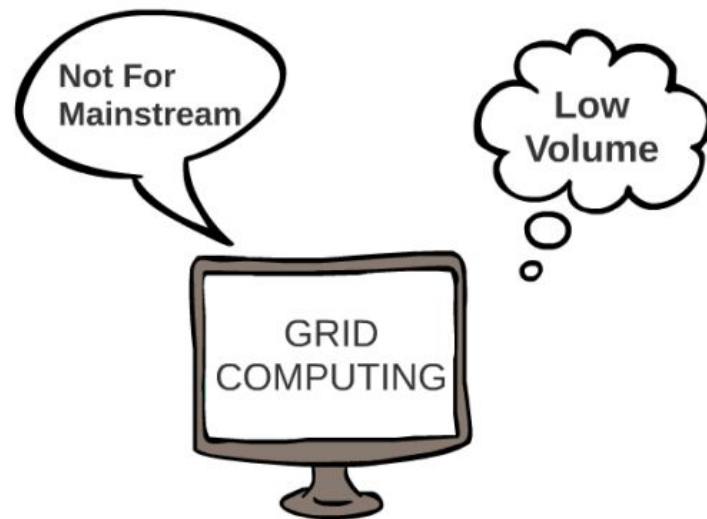
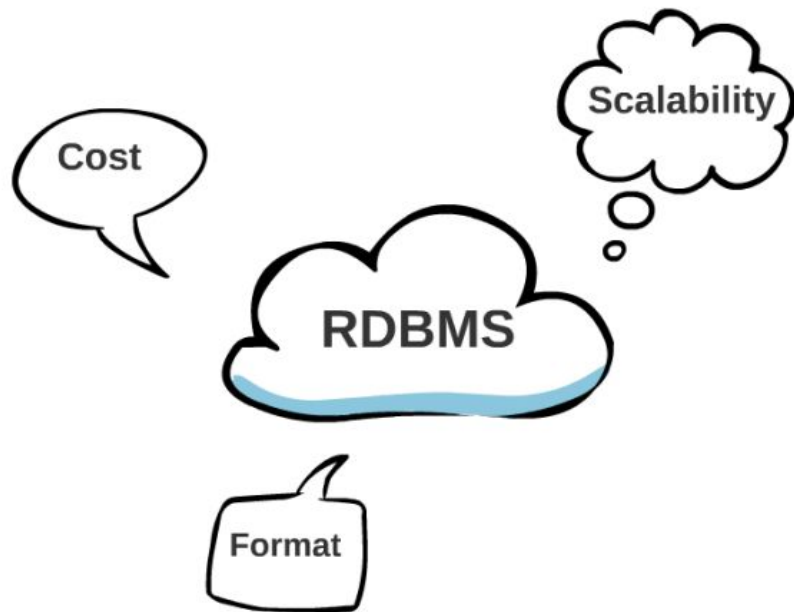
Computational Efficiency

Data Loss

Cost



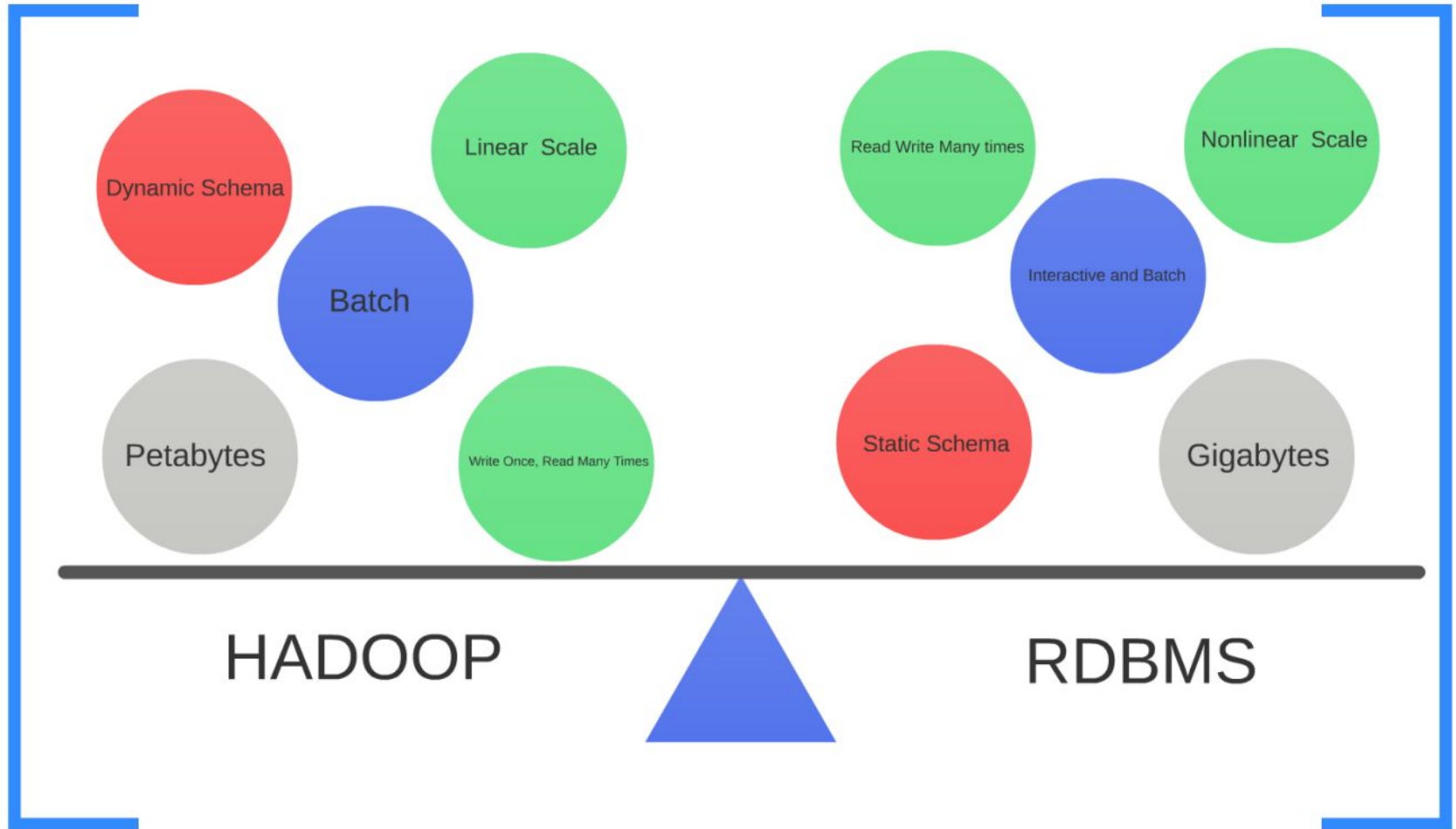
## TRADITIONAL SOLUTIONS



## HADOOP - A GOOD SOLUTION

- ✓ Support Huge Volume
- ✓ Storage Efficiency
- ✓ Good Data Recovery Solution
- ✓ Horizontal Scaling
- ✓ Cost Effective
- ✓ Easy For Programmers & Non Programmers







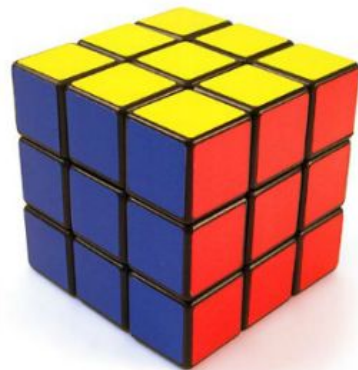
# UNDERSTANDING BIG DATA PROBLEM



**PROBLEM**



**ANALYZE**



**SOLUTION**

# SAMPLE BIG DATA PROBLEM

- Stocks Dataset - Day by day stock information for several symbols for several years
- Size - 1 TB
- Problem - Find out Maximum closing price for each stock symbol

```
ABCSE,B7J,2008-10-28,6.48,6.74,6.22,6.72,44300,5.79
ABCSE,B7J,2008-10-27,6.21,6.78,6.21,6.40,55200,5.51
ABCSE,B7J,2008-10-24,6.39,6.66,6.21,6.40,67400,5.51
ABCSE,B7J,2008-10-23,6.95,6.95,6.50,6.59,59400,5.68
ABCSE,B7J,2008-10-22,6.92,7.17,6.80,6.80,55300,5.86
ABCSE,B7J,2008-10-21,7.20,7.30,7.10,7.10,54400,6.11
ABCSE,B7J,2008-10-20,6.94,7.31,6.94,7.12,45700,6.13
ABCSE,B7J,2008-10-17,6.43,6.93,6.42,6.90,57700,5.94
ABCSE,B7J,2008-10-16,6.61,6.69,6.21,6.53,83200,5.62
ABCSE,B7J,2008-10-15,6.84,6.90,6.36,6.36,78900,5.48
ABCSE,B7J,2008-10-14,7.15,7.32,6.93,6.96,74700,5.99
ABCSE,B7J,2008-10-13,6.00,6.57,6.00,6.57,75700,5.66
ABCSE,B7J,2008-10-10,5.05,5.72,4.79,5.72,158400,4.93
ABCSE,B7J,2008-10-09,6.30,6.41,6.00,6.02,140500,5.18
ABCSE,B7J,2008-10-08,5.60,6.47,5.60,6.28,292000,5.41
ABCSE,B7J,2008-10-07,7.59,7.59,6.66,6.69,89900,5.76
ABCSE,B7J,2008-10-06,7.83,7.90,7.00,7.40,159600,6.37
```

# EXECUTION TIME

**Data access rate**

+


Program computation time (~60 mins)

+

Network Bandwidth.. etc..



> 3 hrs 🙄



Average Data Access Rate - 122 MB/sec

1 TB file will take 2 1/2 hours to read  
from disk

1 Sec - 122 MB  
x Secs - 1048576 MB (1 TB)

$x = 1048576 / 122 = 8595$  secs  
2 hr 22 mins

# EXECUTION TIME

**Data access rate**

+

Program computation time (~60 mins)

+

Network Bandwidth.. etc..



> 3 hrs



## HOW ABOUT THIS?

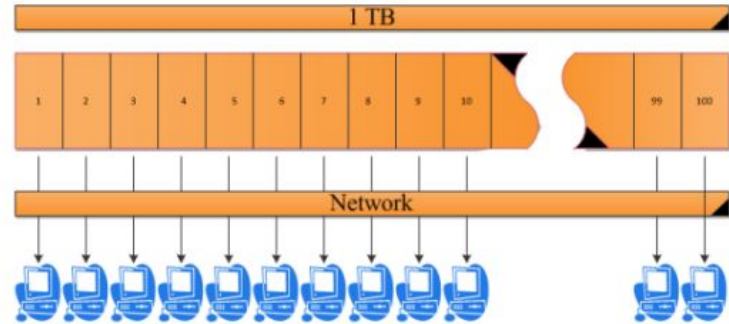
Split 1 TB file in to 100 equal sized blocks and read them parallely

Time to read = 150 mins /100

< 2 minutes 😊

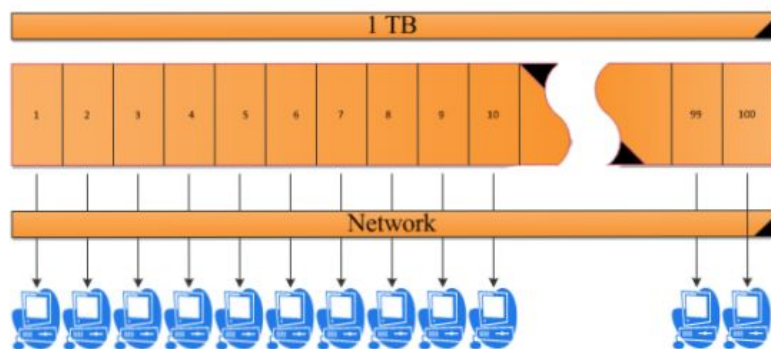
Computation Time = 60 mins /100

< 1 minute 😊





# STORAGE CLOSER TO COMPUTATION



Node 1



Node 2



Node 3



**REPLICATION**



**AGGREGATE  
COMPUTATION**



Node 1

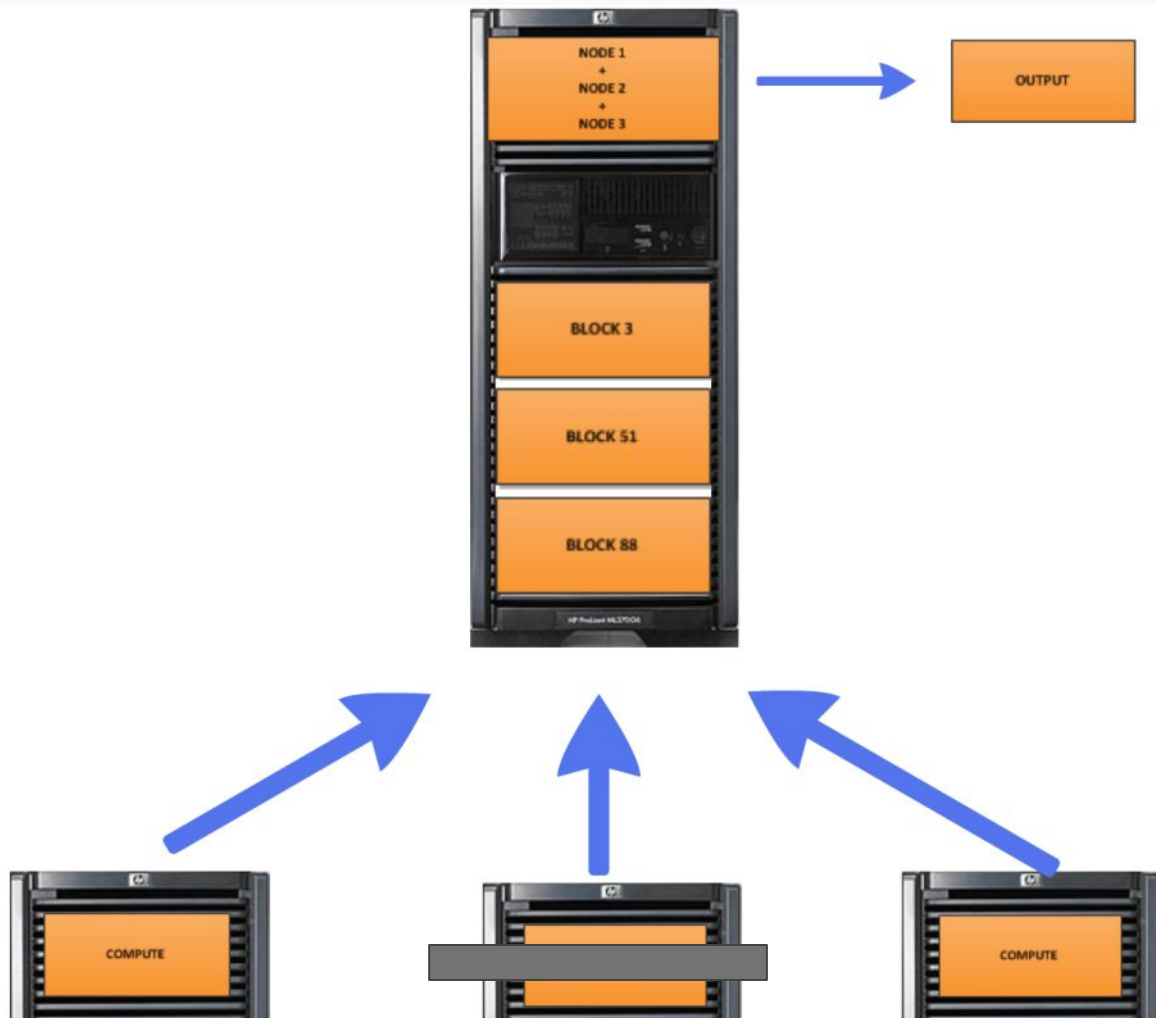


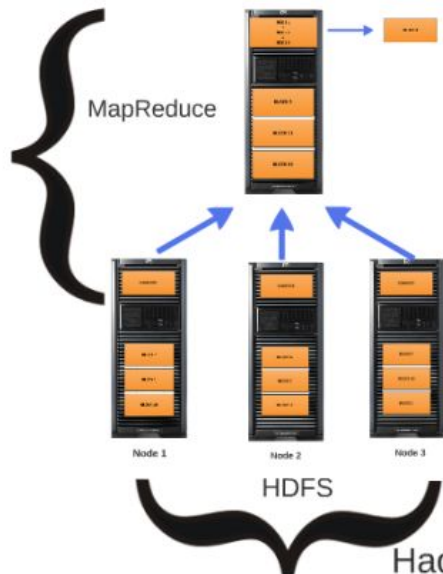
Node 2



Node 3







**HDFS - Reliable Shared Storage**

**+**

**MapReduce - Distributed Computation**

**=**



Hadoop is a framework for distributed processing of large data sets across clusters of commodity computers



Doug Cutting & Mike Cafarella  
started working on Nutch



Doug Cutting adds DFS &  
MapReduce support to Nutch



Google publishes GFS &  
MapReduce papers



NY Times converts 4TB of  
image archives over 100 EC2s

**YAHOO!**  
Fastest sort of a TB, 3.5mins  
over 910 nodes

Fastest sort of a TB,  
62secs over 1,460 nodes  
Sorted a PB in 16.25hours  
over 3,658 nodes

Yahoo! hires Cutting,  
Hadoop spins out of Nutch



**cloudera**  
Founded

Doug Cutting  
joins Cloudera

Facebook launches Hive:  
SQL Support for Hadoop



Hadoop Summit 2009,  
750 attendees

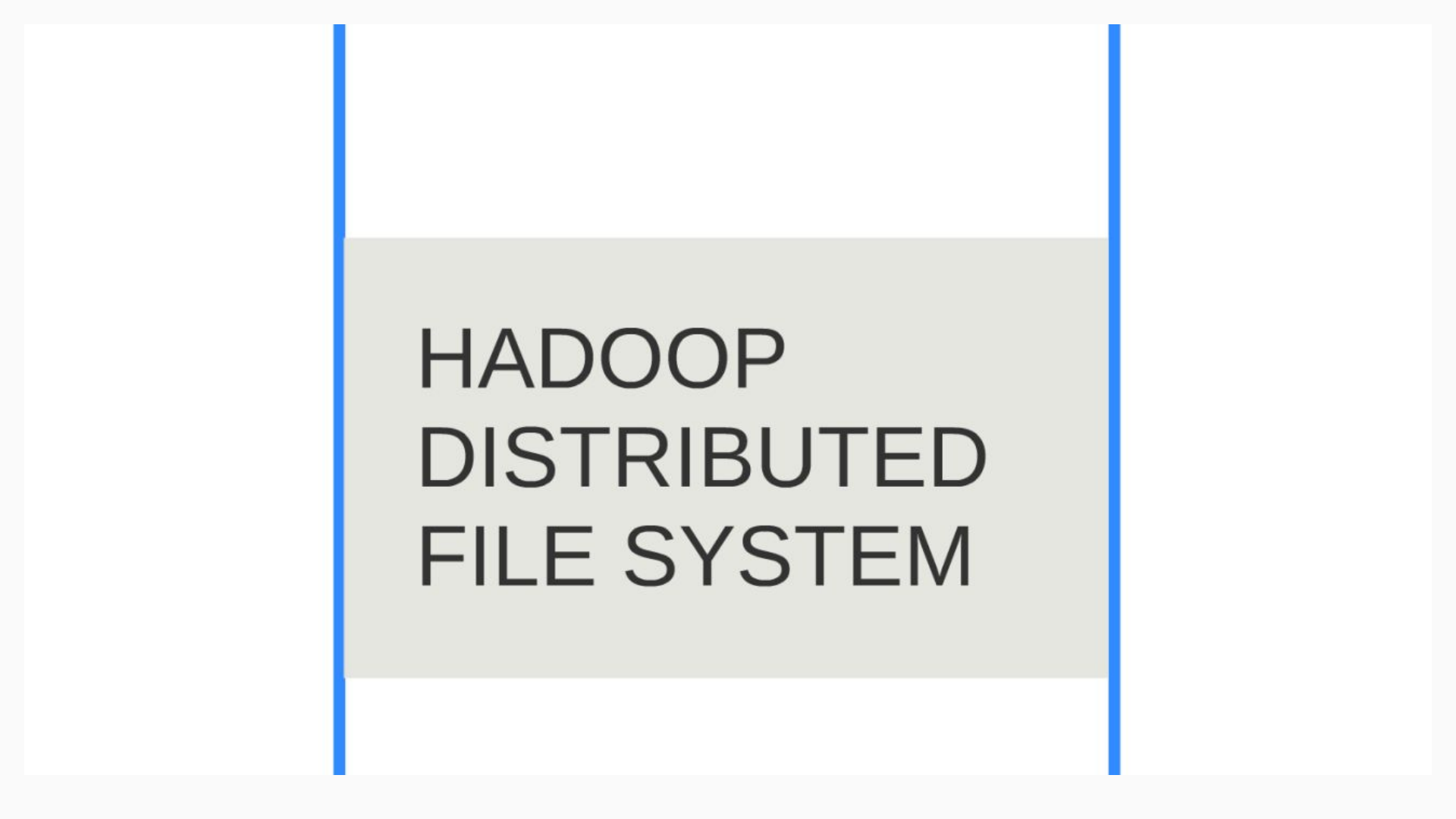


Michael j. cafarella



Doug cutting



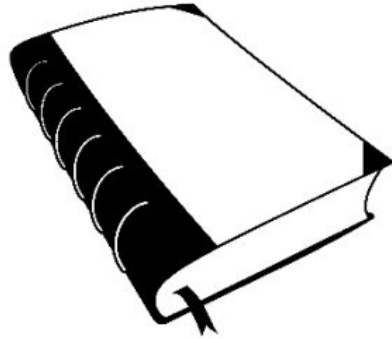
The image features a light gray rectangular background centered on a white page. This gray area is flanked by two vertical blue lines, one on the left and one on the right. The text 'HADOOP DISTRIBUTED FILE SYSTEM' is written in a dark gray, sans-serif font, centered within the gray rectangle.

# HADOOP DISTRIBUTED FILE SYSTEM

## PILE OF PAPERS VS. BOOK



**VS**



Go to Chapter 34 - Act 2

Without a file system, information placed in a storage area would be one large body of data with no way to tell where one piece of information stops and the next begins.

# FUNCTIONS OF FILE SYSTEM

- Control how data is stored and retrieved
- Metadata about the files and folders
- Permissions and security
- Manage storage space efficiently



## DIFFERENT FILE SYSTEMS



Microsoft

FAT32 - 4 GB File limit 32 GB Volume limit

NTFS - 16 EB File limit 16 EB Volume limit

HFS - 2 GB File limit 2 TB Volume limit

HFS+ - 8 EB File limit 8 EB Volume limit



ext3 - 2 TB File limit 32 TB Volume limit

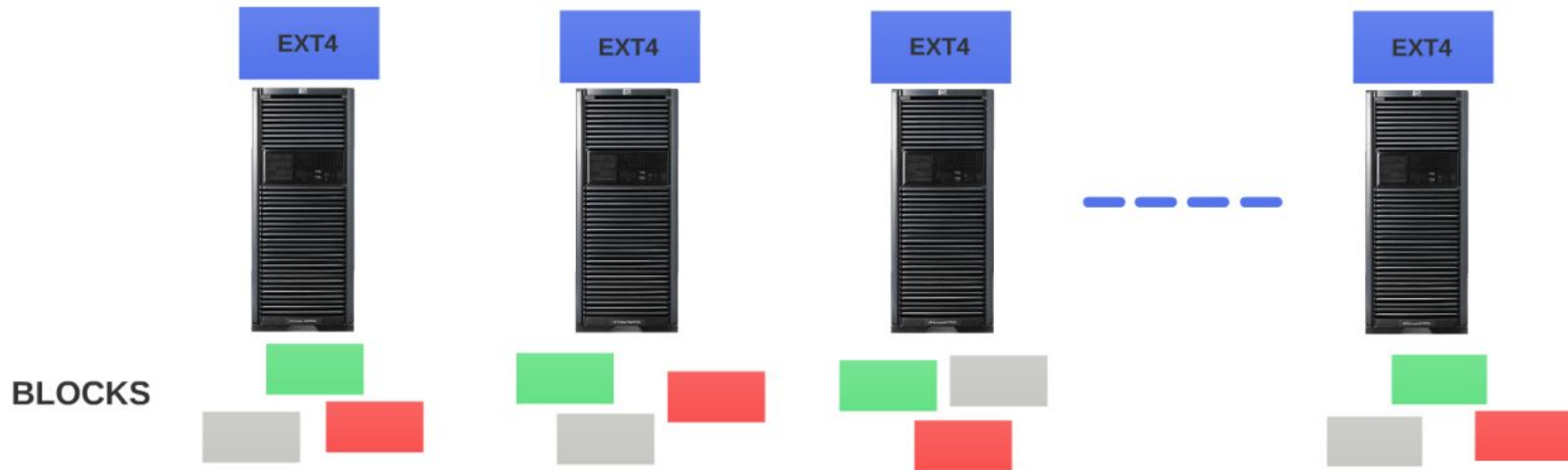
ext4 - 16 TB File limit 1 EB Volume limit

XFS - 8 EB File limit 8 EB Volume limit

Why another file system ?

## LOCAL FILE SYSTEM vs. HDFS

### HADOOP DISTRIBUTED FILE SYSTEM



## BENEFITS OF HDFS

- Support distributed processing
  - Blocks (not as whole files)
- Handle failures
  - Replicate blocks
- Scalability
  - Able to support future expansion
- Cost effective
  - Commodity hardware



## Acer (C:) Properties



Security

Previous Versions

Quota

General

Tools

Hardware

Sharing



Acer

Type: Local Disk

File system: NTFS

 Used space:	2,10,70,42,44,736 bytes	196 GB
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 Free space:	44,04,62,41,792 bytes	41.0 GB
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Capacity:	2,54,75,04,86,528 bytes	237 GB
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Drive C:

[Details](#)☐ Compress this drive to save disk space☒ Allow files on this drive to have contents indexed in addition to file properties

OK

Cancel

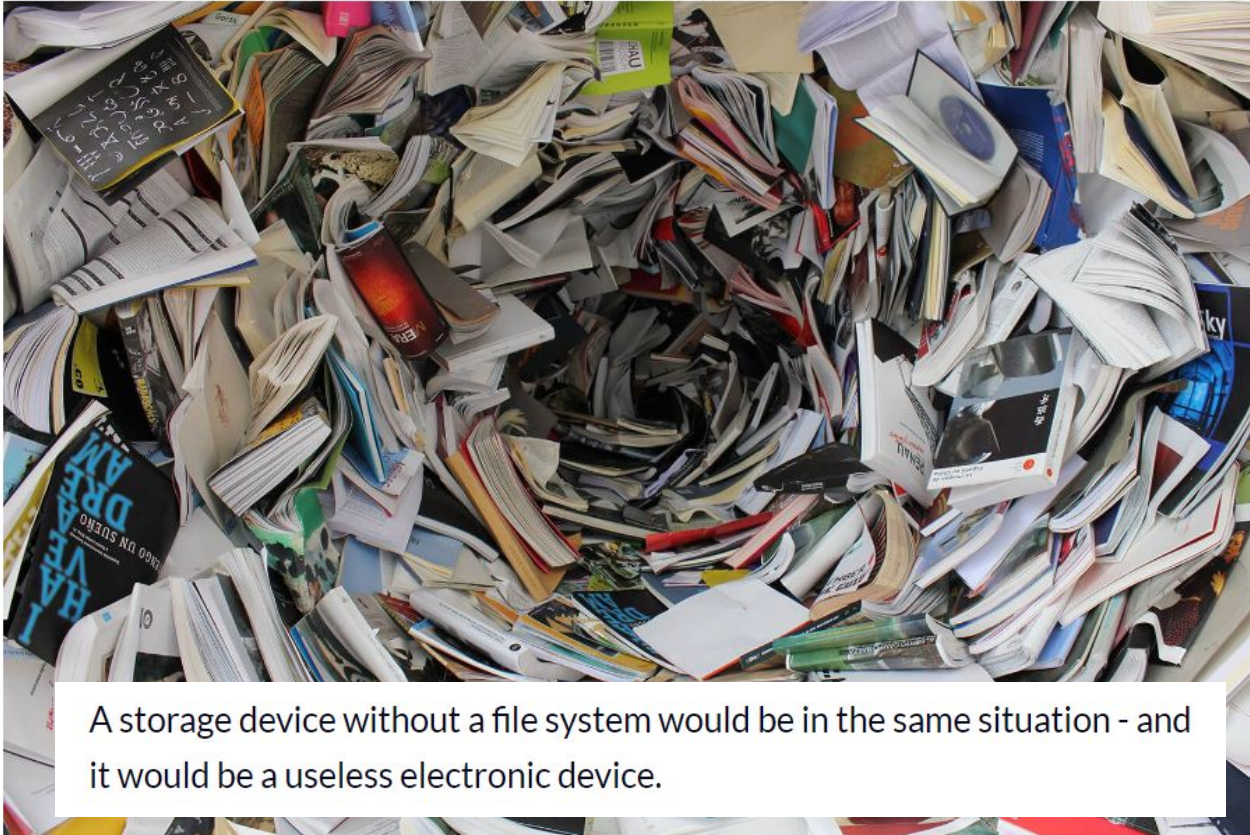
Apply

## **Why do we need a file system in the first place, you may ask?**

Well, without a file system, the storage device would contain a big chunk of data stored back to back, and the operating system wouldn't be able to tell them apart.

The term file system takes its name from the old paper-based data management systems, where we kept documents as files and put them into directories.

Imagine a room with piles of papers scattered all over the place.



A storage device without a file system would be in the same situation - and it would be a useless electronic device.

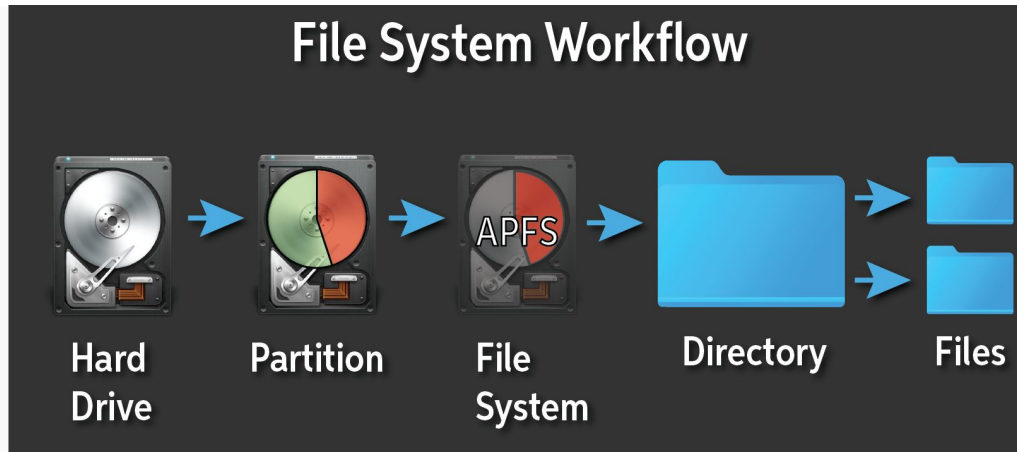


However, a file system changes everything:



A file system isn't just a bookkeeping feature, though.

Space management, metadata, data encryption, file access control, and data integrity are the responsibilities of the file system too.





# Everything begins with partitioning

Storage devices must be **partitioned** and **formatted** before the first use.

But what is partitioning?

Partitioning is splitting a storage device into several *logical regions*, so they can be managed separately as if they are separate storage devices.



Storage Device

We usually do partitioning by a disk management tool provided by operating systems, or as a command-line tool provided by the system's firmware.

A storage device should have at least one partition or more if needed.

### **Why should we split the storage devices into multiple partitions anyways?**

The reason is that we don't want to manage the whole storage space as a single unit and for a single purpose. It's just like how we partition our workspace, to separate (and isolate) meeting rooms, conference rooms, and various teams.



What do you mean by firmware?

### Firmware Definition

Firmware provides instructions to help hardware start up, communicate with other devices, and perform basic input/output tasks. Software, on the other hand, is installed onto a device and used for interaction, such as browsing the internet, word processing, listening to music, and videoconferencing.

## NTFS

4 KB BLOCK SIZE

FILE SIZE

UNUSED SPACE

2 KB

2 KB

8 KB

0 KB

13 KB

3 KB

# HDFS

256 MB BLOCK SIZE

FILE SIZE

UNUSED SPACE

1 MB

?



HDFS  
READ  
WRITE



## **Namenode**

HDFS - Metadata  
Block locations



## **Datanode**

Stores actual blocks

## Read Operation



Name Node

Give me block locations for  
MyFirstFileInHDFS.log

BLK_0045732	R8 DN20	R1 DN2	R1 DN10
BLK_9610590	R8 DN20	R3 DN4	R3 DN13
BLK_8851209	R2 DN7	R1 DN2	R1 DN10



Client

Data  
Nodes



R8 DN20



R3 DN4



R2 DN7

Send me BLK\_0045732

Here you go

Send me BLK\_9610590

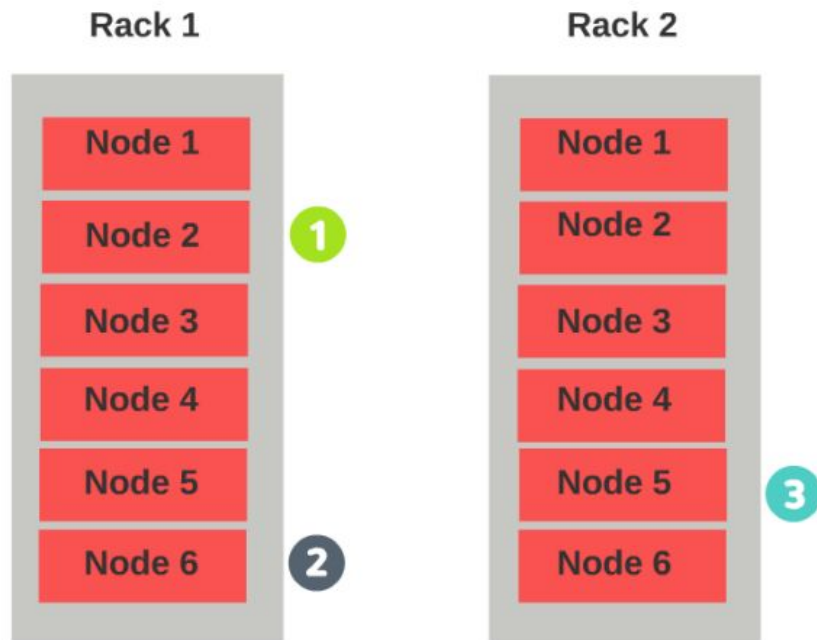
Here you go

Send me BLK\_8851209

Here you go



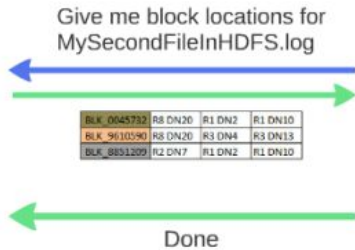
# NODE PROXIMITY



## Write Operation



Name Node



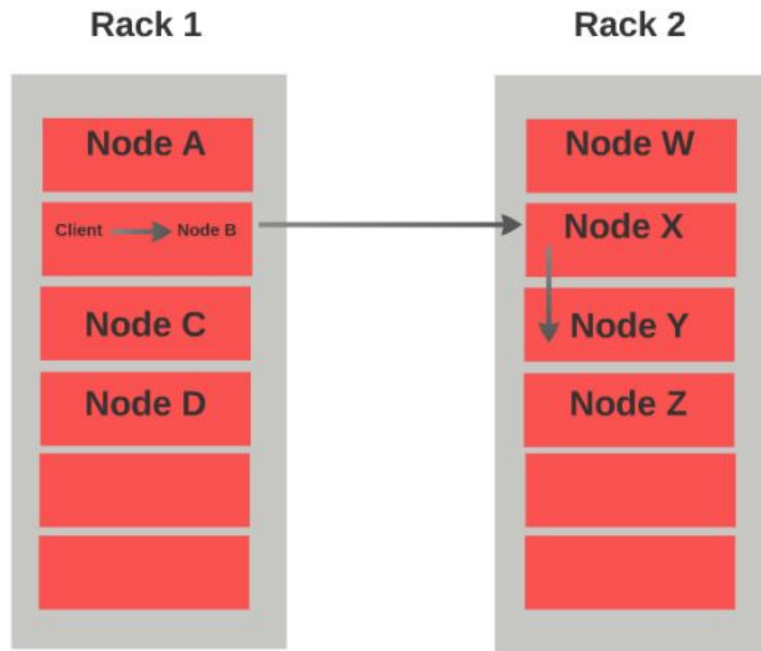
Client



Data Nodes Pipeline

# Replica Placement

1. Same Node as Client
2. Node in another Rack
3. Node in same Rack as 2



# Write Operation - Failure



Name Node

Give me block locations for  
MySecondFileInHDFS.log



BLK_0045732	R8 DN20	R1 DN2	R1 DN10
BLK_9610590	R8 DN20	R3 DN4	R3 DN13
BLK_8851209	R2 DN7	R1 DN2	R1 DN10

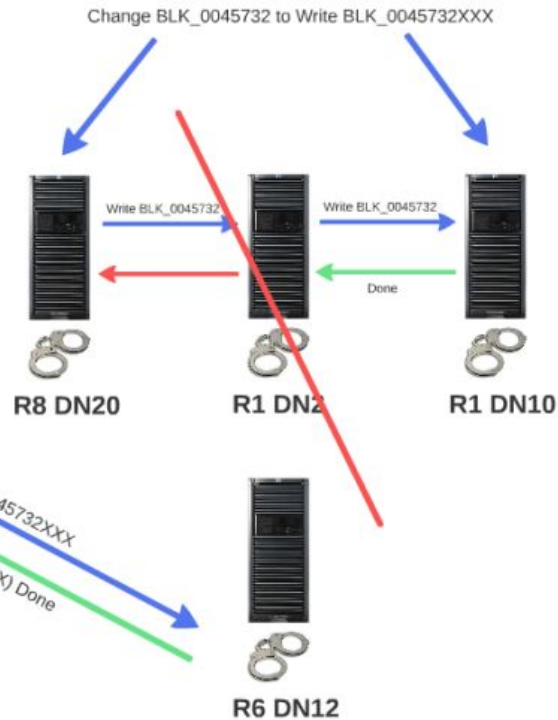


Client

Write BLK\_0045732



(BLK\_0045732XXX) Done



Data Nodes Pipeline