Open Elective - M.Tech II Semester
ICT 586: Big Data Analytics and Technologies

Module-I

Big Data Overview

Girija V. Attigeri
Dept. of Information & Communication Technology, MIT, Manipal

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- Introduction to big data.
- Analysis of data at Rest- Hadoop analytics
- Limitations of existing distributing systems - Hadoop Approach
- Hadoop Architecture: Distributed file system: HDFS and GPFS
- MapReduce programming paradigm
- Internals of Hadoop MR engine
- Need for High level language- JAQL and PIG

Timeline | 70 Years of Big Data

1944

The acknowledgement of big data was identified by Fremont Rider, Wesleyan University Librarian, who estimated that libraries in American universities would expand to over 200,000,000 volumes by 2040. Today, Yale Library alone has approximately 12.5 million volumes across 20 buildings on campus.

1971

Arthur R. Miller, author of the book 'The Assault on Privacy,' identified that "too many information handlers seem to measure a man by the number of bits of storage capacity his dossier will occupy."

1975

The Ministry of Posts and Telecommunications in Japan began conducting the Information Flow Census, tracking the volume of information circulating in Japan. The census introduces "amount of words" as the unifying unit of measurement across all media.

1983

Author Ithiel de Sola Pool looked at the growth trends in 17 major communications media from 1960 to 1977, and concluded that the flow of information had exponentially grown by 2.9% throughout that period due to broadcasting and media.

1997

The term "big data" was used for the first time when researchers M. Cox and D. Ellsworth wrote an article identifying that the rise of data was becoming an issue for current computer systems. In other words, the "problem of big data."

2001

Doug Laney published a research note titled "3D Data Management: Controlling Data Volume, Velocity, and Variety." A decade later, these "3 V's" became the defining dimensions of big data.

2008

Economists Bret Swanson and writer George Gilder published "Estimating the Exaflood" which stated U.S. IP traffic could reach one zettabyte by 2015, and that the U.S. Internet of 2015 would be at least 50 times larger than it was in 2006.

2011

Martin Hilbert and Priscila Lopez, estimated that the world's information storage capacity grew at a compound annual growth rate of 25% per year between 1986 and 2007. They also estimated that in 1986, 99.2% of all storage capacity was analog, but by 2007, 94% of all storage capacity was digital.

1949

Claude Shannon, known as the "Father of Information," carried out research on big storage capacity on items such as punch cards and photographic data. One of the largest items on Shannon's list was the Library of Congress, measuring over 100 trillion bits of data.

1961

Derek Price's research on scientific knowledge concluded that scientific journals had doubled every 15 years. This is now better known as "law of exponential increase".

1981

The Hungarian Central Statistics Office carried out a research project that is still on-going today. This involved accounting for the country's information for industries via measuring data volume in bits.

1996

Digital storage became more cost-effective for storing data than paper.

2000

Peter Lyman and Hal R. Varian published the first study that quantified, in computer storage terms, the total amount of new and original information created in the world annually. The study concluded in 1999, a year in which the world had produced approximately 1.5 exabytes of unique information.

2005

"What is Web 2.0" was published by writer Tim O'Reilly, in which he stated that "data is the next Intel inside and SQL is the new HTML. Database management is a core competency of Web 2.0 companies, so much so that they have sometimes referred to these applications as 'infoware' rather than merely software."

2009

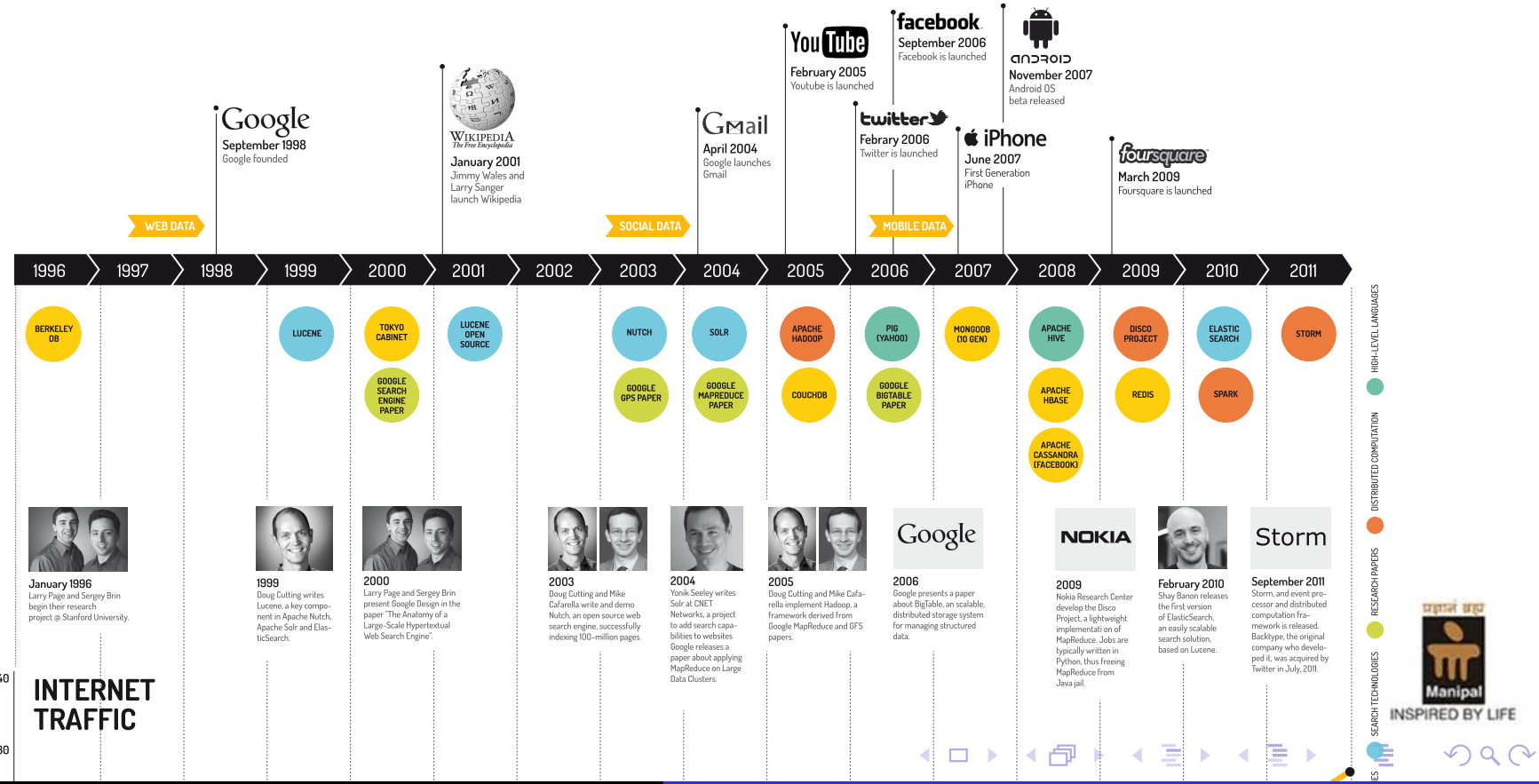
Researchers Roger E. Bohn and James E. Short found that modern Americans consumed information for an average of almost 12 hours per day. Consumption totalled 3.6 zettabytes and 10,845 trillion words, corresponding to 100,500 words and 34 gigabytes for an average person on an average day.

2013/Present

Businesses are beginning to implement new in-memory technology such as SAP HANA to analyse and optimize mass quantities of data. Companies are becoming ever more reliant on utilizing data as a business asset to gain competitive advantage, with big data leading the charge as arguably the most important new technology to understand and make use of in order to remain relevant in today's rapidly changing market.

HCL TECHNOLOGIES:

BIG DATA
A BRIEF HISTORY

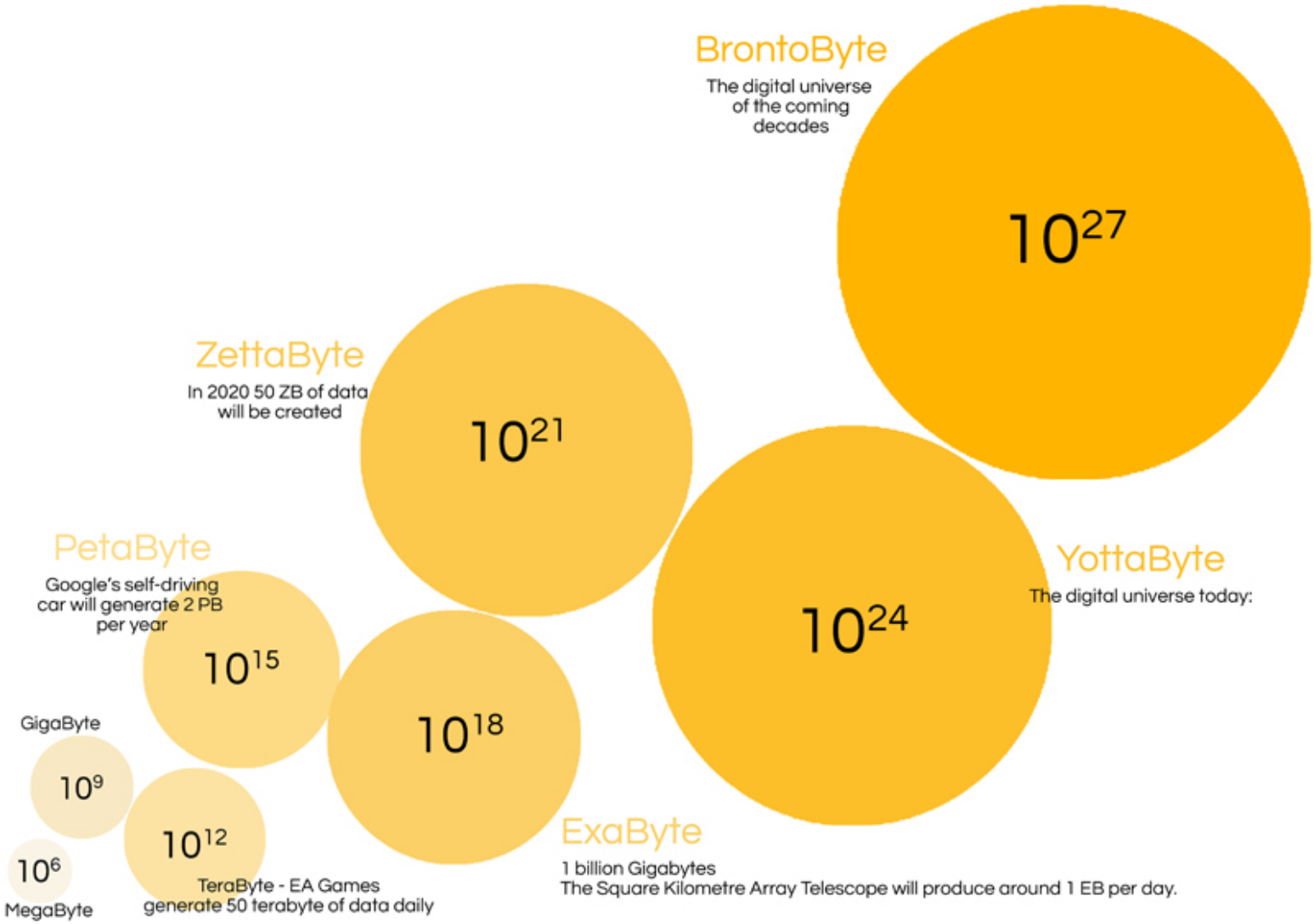


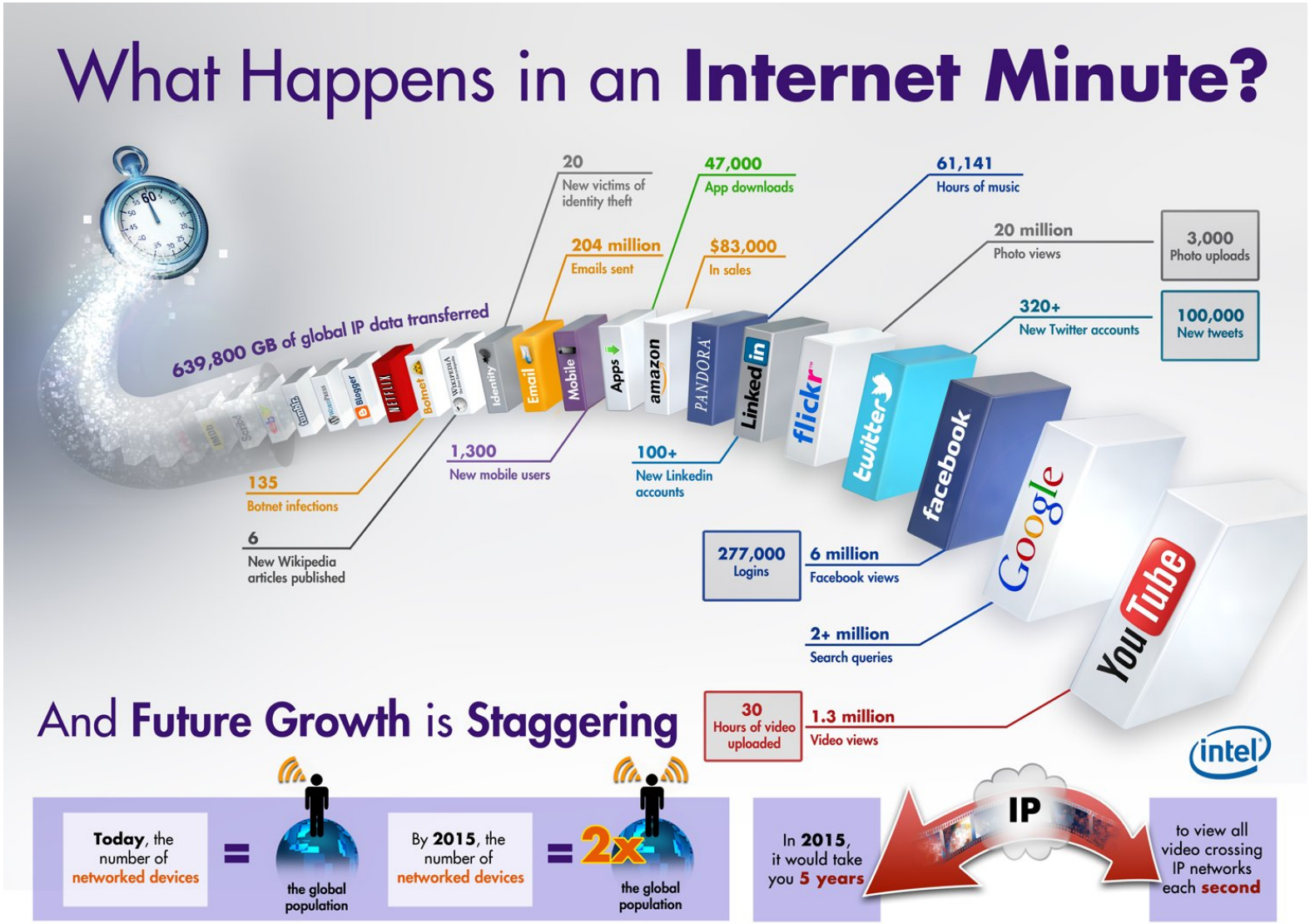
- Air Bus A380
  - 1 billion line of code
  - each engine generate 10 TB every 30 min
  - 640TB per Flight
- Twitter Generate approximately 12 TB of data per day
- New York Stock Exchange 1TB of data everyday

There are huge volumes of data in the world:

- From the beginning of recorded time until 2003, We created 5 billion gigabytes (exabytes) of data.
- In 2011, the same amount was created every two days
- In 2013, the same amount of data is created every 10 minutes.

- How big is the Big Data?
- What is big today maybe not big tomorrow
- Any data that can challenge our current technology in some manner can consider as Big Data
  - Volume
  - Communication
  - Speed of Generating
  - Meaningful Analysis


BrontoByte
The digital universe of the coming decades
10^{27}
ZettaByte
In 2020 50 ZB of data will be created
10^{21}
YottaByte
The digital universe today:
10^{24}
PetaByte
Google's self-driving car will generate 2 PB per year
10^{15}
10^{18}
GigaByte
10^{9}
10^{12}
TeraByte - EA Games generate 50 terabyte of data daily
10^{6}
MegaByte
ExaByte
1 billion Gigabytes
The Square Kilometre Array Telescope will produce around 1 EB per day.


What Happens in an Internet Minute?
639,800 GB of global IP data transferred
20
New victims of identity theft
47,000
App downloads
61,141
Hours of music
204 million
Emails sent
$83,000
In sales
20 million
Photo views
3,000
Photo uploads
320+
New Twitter accounts
100,000
New tweets
135
Botnet infections
1,300
New mobile users
100+
New Linkedin accounts
6
New Wikipedia articles published
277,000
Logins
6 million
Facebook views
2+ million
Search queries
30
Hours of video uploaded
1.3 million
Video views
And Future Growth is Staggering
Today, the number of networked devices
=
the global population
By 2015, the number of networked devices
= 2x
the global population
In 2015, it would take you 5 years
IP
to view all video crossing IP networks each second


Google
Spotify
YouTube
DOMAINS
facebook
skype
flickr
twitter
snapchat
amazon.com
Linked in
Pinterest
Instagram
EMAIL
tumblr.
Walmart
WordPress
WEBSITES
2 MILLION Searches
14 New Songs Added
70 New Registered
15 THOUSAND Tracks downloaded from iTunes
347 New Blog Posts
571 New Created
17 THOUSAND Transactions
20 THOUSAND New Tumblr Photos
204 MILLION emails sent
3,600 photos every second
11 THOUSAND Active Users
11 THOUSAND Professional searches
$83,000 Amazon Sales
104 THOUSAND Photos Shared
278 THOUSAND Tweets
20 MILLION Photo Views
1.4 MILLION Minutes Connecting with Each other
350GB of data
1.8 MILLION likes
41 THOUSAND posts every second
72 HOURS of Video uploaded

Big Data Vectors (3Vs):
Big Data are high-volume, high-velocity, and/or high-variety information assets that require new forms of processing to enable enhanced decision making, insight discovery and process optimization

- Volume: Enterprises are flooded with ever-growing data of all types, easily gathering terabytes even petabytes of information.
- Turingn 12 terabytes of Tweets created each day into improved product sentiment analysis
- Converting 350 billion annual meter readings to better predict power consumption

- Velocity: Sometimes 2 minutes is too late. For time-sensitive processes such as catching fraud, big data must be used as it streams into your enterprise in order to maximize its value.
- Scrutinizing 5 million trade events created each day to identify potential fraud
- Analyzing 500 million daily call detail records in real-time to predict customer churn faster

- Variety: Big data is any type of data - structured and unstructured data such as text, sensor data, audio, video, click streams, log files and more. New insights are found when analyzing these data types together.
- Monitoring 100s of live video feeds from surveillance cameras to target points of interest
- Exploit the 80% data growth in images, video and documents to improve customer satisfaction

- high-volume: Amount of data
- high-velocity: Speed rate in collecting or acquiring or generating or processing of data
- high-variety: Different data type such as audio, video, image data (mostly unstructured data)

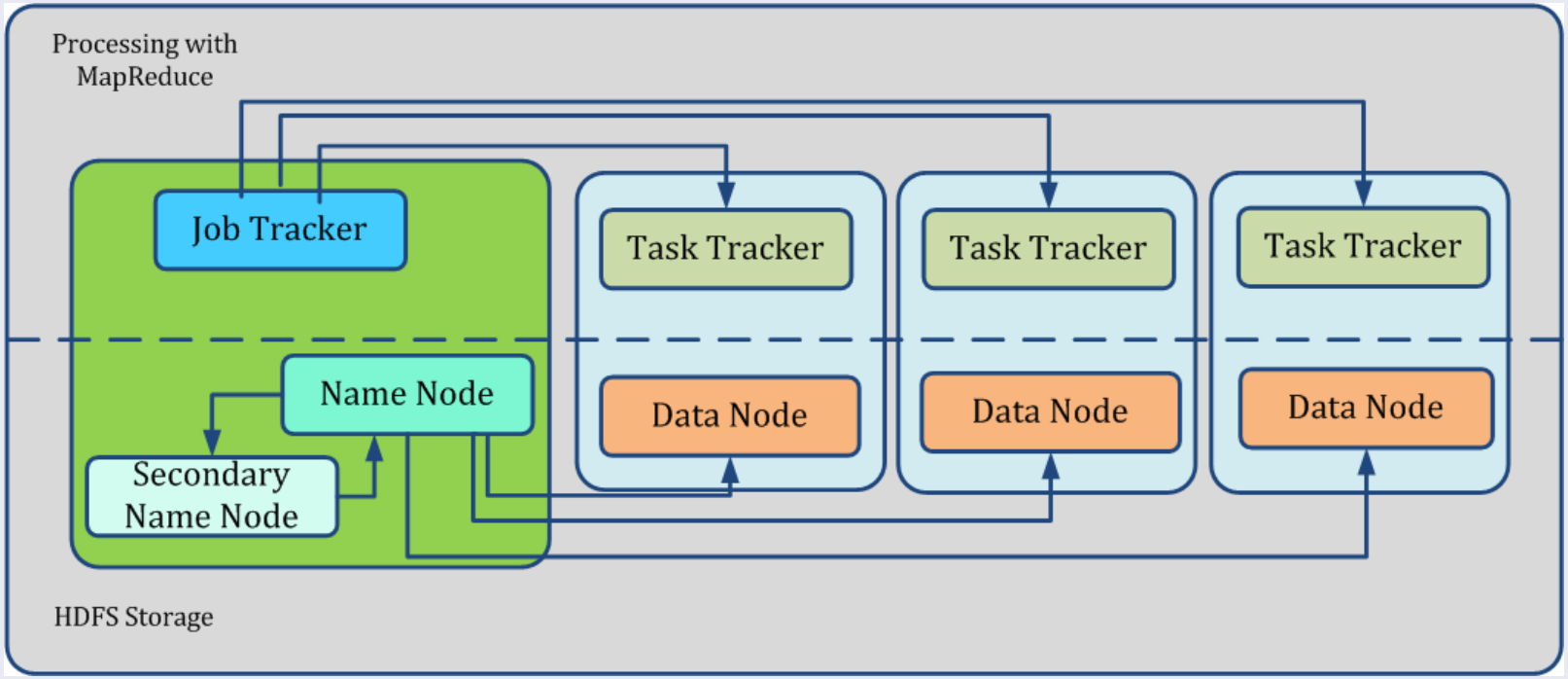
Big-Data is similar to Small-data but bigger.. But having data bigger it requires different approaches: Techniques, tools, architecture with an aim to solve new problems Or old problems in a better way

Analysis of data at Rest Hadoop analytics

The Apache Hadoop software library is a framework that allows for the distributed processing of large data sets across clusters of computers using simple programming models It is designed to scale up from single servers to thousands of machines, each offering local computation and storage.

Core components of Hadoop

Hadoop Logical Architecture



Distributed File System

- Distributed File System is a special case of distributed system.
- In the Distributed file system, storage resources and clients are dispersed in the network.
- The main goal of Distributed File System is to provide common view of centralized file system, even though it has a distributed implementation.

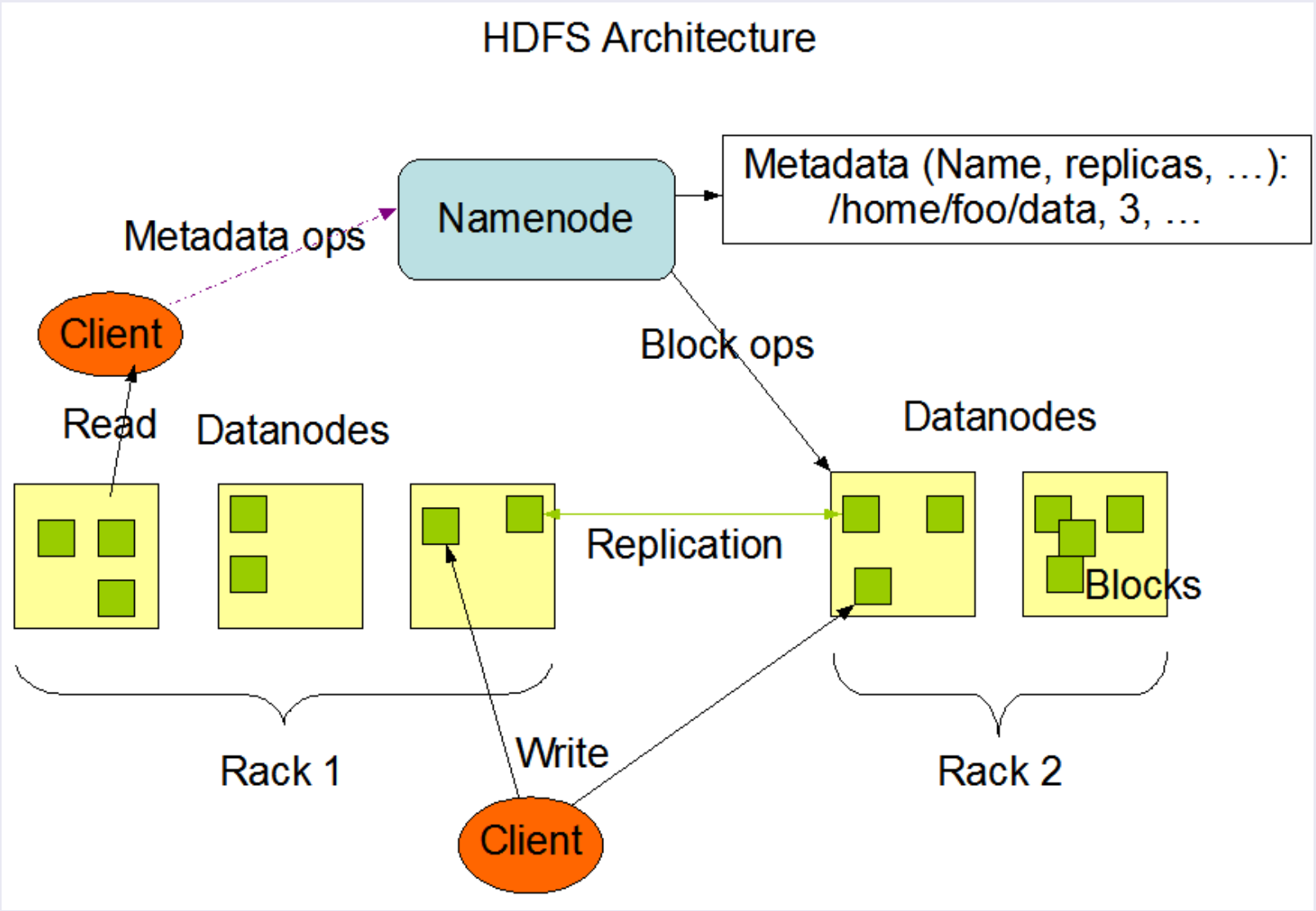
- HDFS is a Java-based file system that provides scalable and reliable data storage, and it was designed to span large clusters of commodity servers.
- HDFS has demonstrated production scalability of up to 200 PB of storage and a single cluster of 4500 servers, supporting close to a billion files and blocks.

- Goal:
  - Batch Processing
  - High aggregate data bandwidth
  - support millions of files in single instance
  - Detection of faults and fast recovery
- Architecture : Master/Salve architecture
- Processes : Stateful
- Communication: TCP/IP
  - Client to name node through configurable TCP port
  - Name Node to Data nodes Data node protocol
  - RPC wraps both Client and Data node protocols
- Naming
- Synchronization: Write Once and read many access
- Caching and Replication:
  - Block size and Replication factor is configurable
  - Rack aware replica policy
- Fault Tolerance

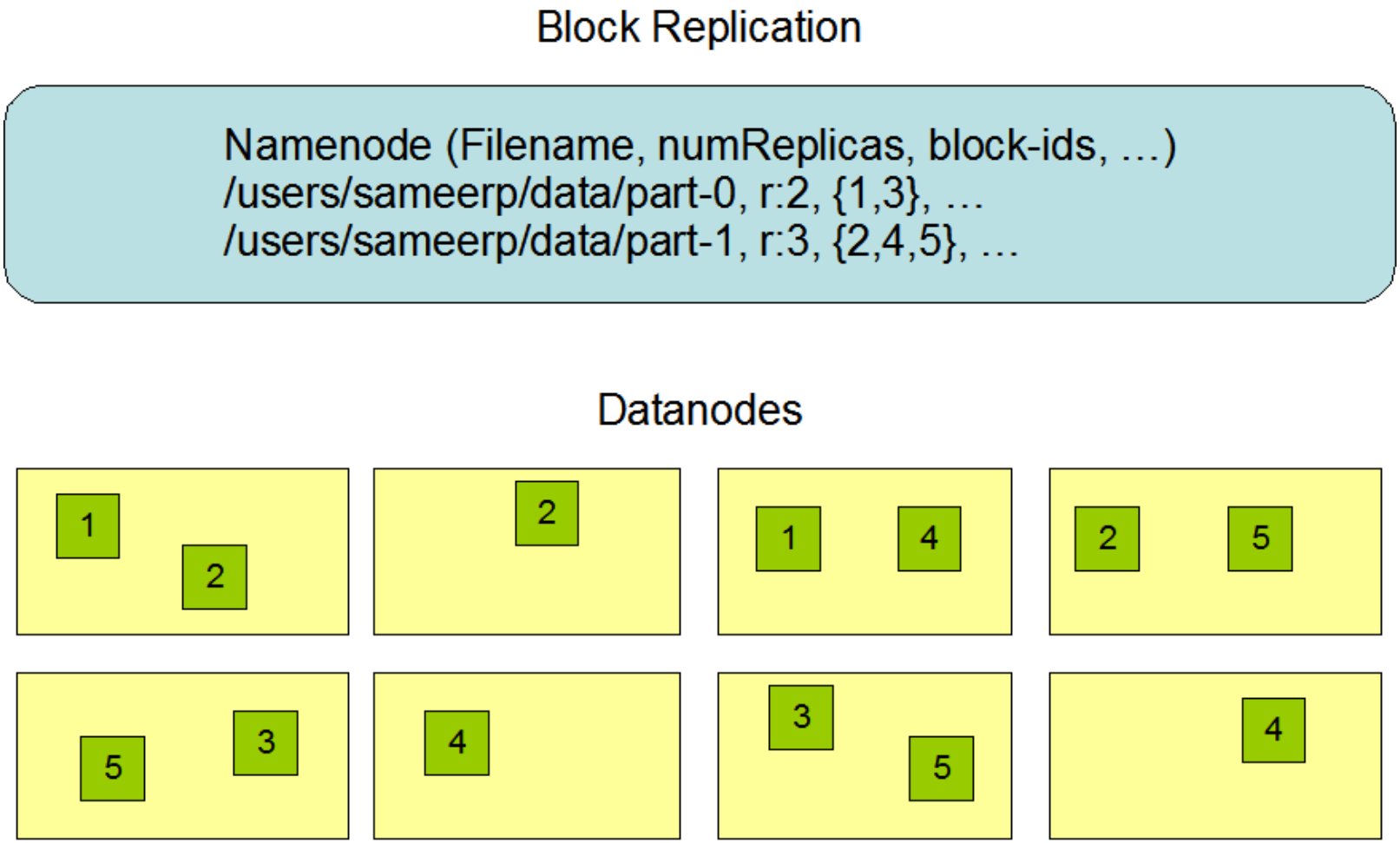
Assumptions and Goals

- Hardware Failure : detection of faults and quick, automatic recovery from them is a core architectural goal of HDFS
- Streaming Data Access
- Large Data Sets
- Simple Coherency Model
- Moving Computation is Cheaper than Moving Data
- Portability Across Heterogeneous Hardware and Software Platforms

HDFS Logical Architecture



Data Replication



- Replica Placement
  - The placement of replicas is critical to HDFS reliability and performance.
  - The purpose of a rack-aware replica placement policy is to improve data reliability, availability, and network bandwidth utilization
  - When the replication factor is three HDFSs placement policy is
    - put one replica on one node in the local rack
    - another on a node in a different (remote) rack,
    - the last on a different node in the same remote rack
  - This policy cuts the inter-rack write traffic which generally improves write performance. The chance of rack failure is far less than that of node failure;
- Replica Selection
- Safemode

The Communication Protocols

- Robustness : The primary objective of HDFS is to store data reliably even in the presence of failures. The three common types of failures are NameNode failures, DataNode failures and network partitions.
  - Data Disk Failure, Heartbeats and Re-Replication
  - Cluster Rebalancing
  - Data Integrity
  - Metadata Disk Failure
  - Snapshots

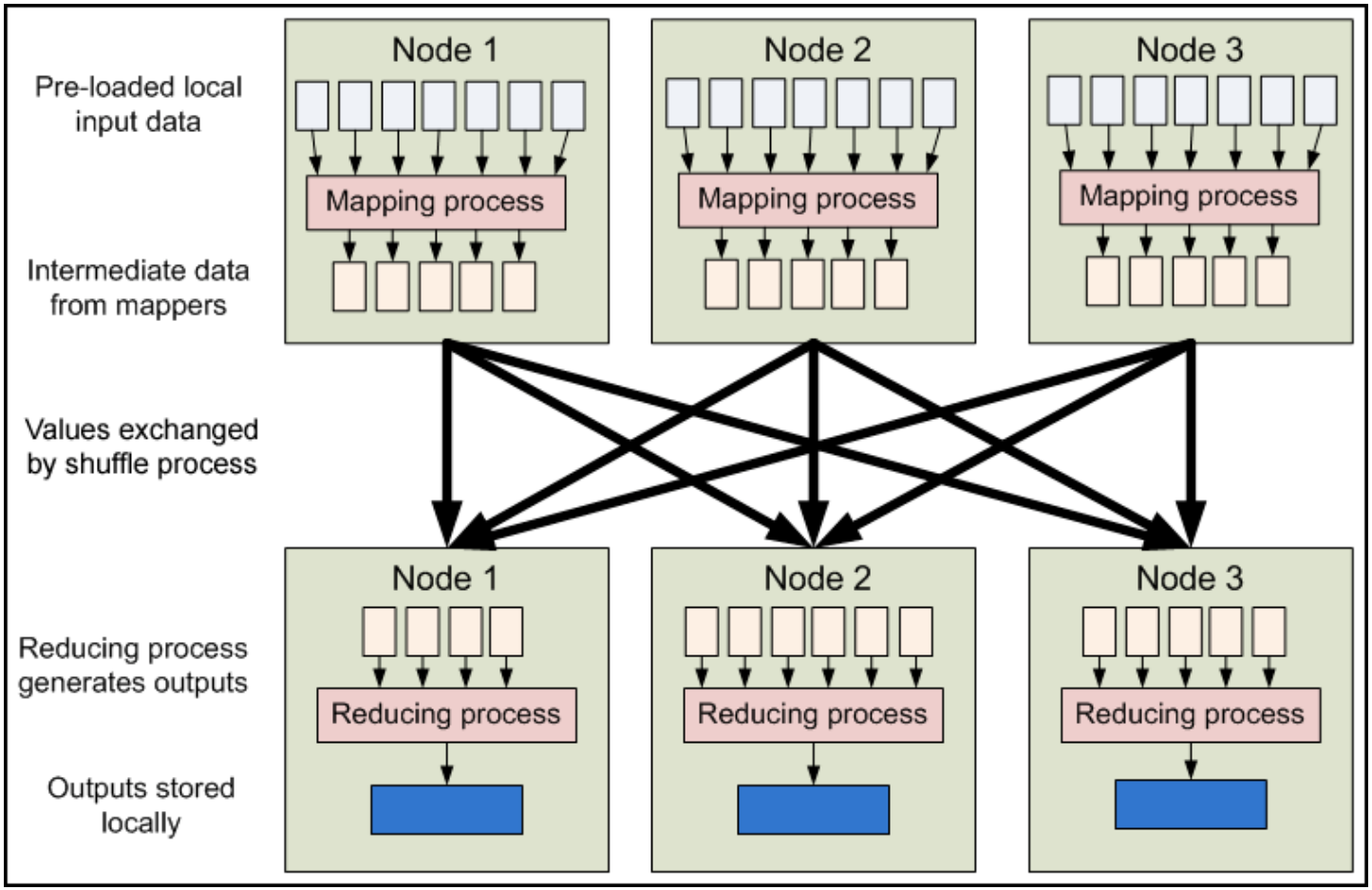
Data Organization

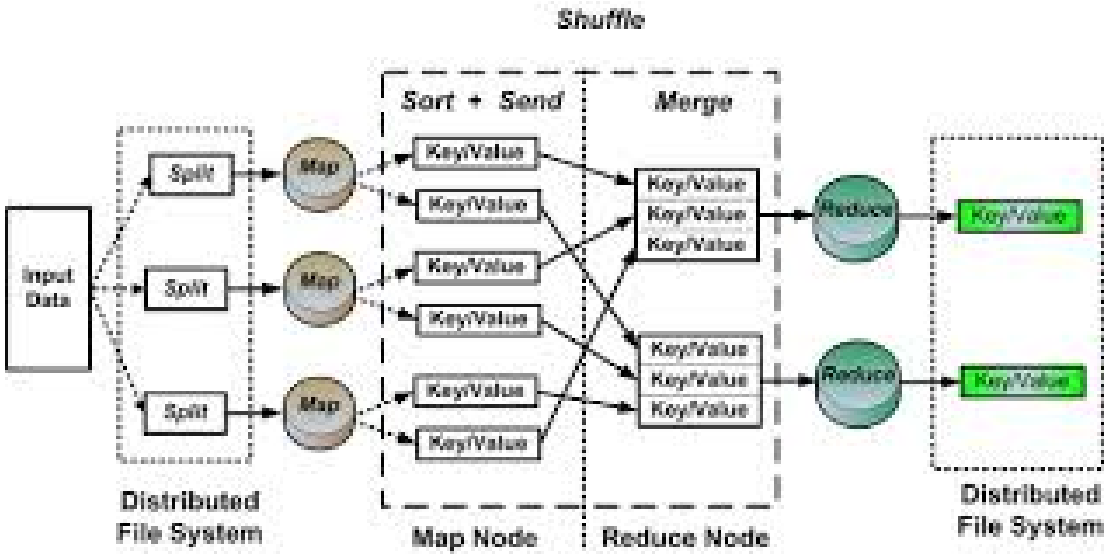
- Data Blocks
- Staging
- Replication Pipelining

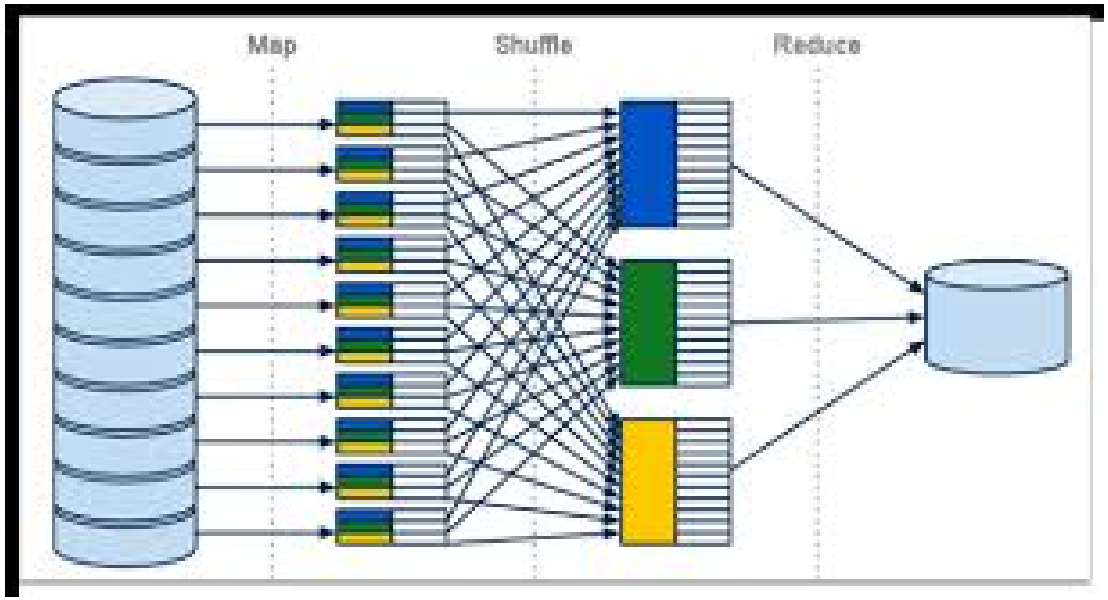
Map Reduce

MapReduce is the heart of Hadoop. It is this programming paradigm that allows for massive scalability across hundreds or thousands of servers in a Hadoop cluster.
The MapReduce concept is fairly simple to understand for those who are familiar with clustered scale-out data processing solutions.

- Users specify the computation in terms of a map and a reduce function,
- the underlying runtime system automatically parallelizes the computation across large-scale clusters of machines, handles machine failures, and schedules inter-machine communication to make efficient use of the network and disks


Pre-loaded local input data
Intermediate data from mappers
Values exchanged by shuffle process
Reducing process generates outputs
Outputs stored locally
Node 1
Node 2
Node 3
Mapping process
Mapping process
Mapping process
Node 1
Node 2
Node 3
Reducing process
Reducing process
Reducing process


Shuffle
Sort + Send
Merge
Input Data
Split
Split
Split
Map
Map
Map
Key/Value
Key/Value
Key/Value
Key/Value
Key/Value
Key/Value
Key/Value
Key/Value
Key/Value
Reduce
Reduce
Key/Value
Key/Value
Distributed File System
Map Node
Reduce Node
Distributed File System

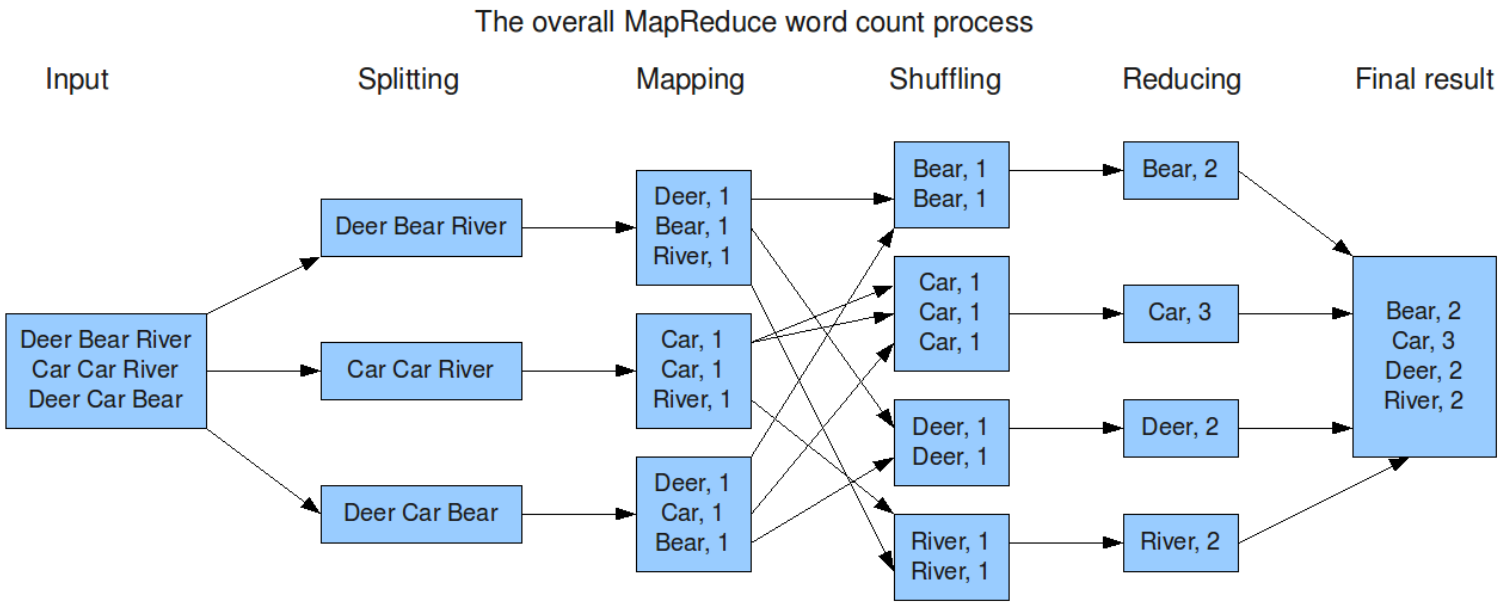

Map
Shuffle
Reduce

Mapper

- Mapper maps input key,value pairs to a set of intermediate key,value pairs.
- Maps are the individual tasks that transform input records into intermediate records
- The transformed intermediate records do not need to be of the same type as the input records. A given input pair may map to zero or many output pairs
- The Hadoop MapReduce framework spawns one map task for each InputSplit generated by the InputFormat for the job
- Mapper implementations are passed the JobConf for the job via the JobConfigurable.configure(JobConf)
- Output pairs do not need to be of the same types as input pairs. A given input pair may map to zero or many output pairs. Output pairs are collected with calls to OutputCollector.collect(WritableComparable,Writable).
- Reporter to report progress
- The Mapper outputs are sorted and then partitioned per Reducer. The total number of partitions is the same as the number of reduce tasks for the job.

Reducer

- reduces a set of intermediate values which share a key to a smaller set of values.
- Reducer has 3 primary phases: shuffle, sort and reduce.
  - Shuffle :Input to the Reducer is the sorted output of the mappers. In this phase the framework fetches the relevant partition of the output of all the mappers, via HTTP.
  - Sort:The framework groups Reducer inputs by keys (since different mappers may have output the same key) in this stage. The shuffle and sort phases occur simultaneously; while map-outputs are being fetched they are merged.
  - Reduce :In this phase the reduce(WritableComparable, Iterator, OutputCollector, Reporter) method is called for each key, (list of values) pair in the grouped inputs.


The overall MapReduce word count process
Input
Splitting
Mapping
Shuffling
Reducing
Final result
Deer Bear River
Car Car River
Deer Car Bear
Deer Bear River
Car Car River
Deer Car Bear
Deer, 1
Bear, 1
River, 1
Car, 1
Car, 1
River, 1
Deer, 1
Car, 1
Bear, 1
Bear, 1
Bear, 1
Car, 1
Car, 1
Car, 1
Deer, 1
Deer, 1
River, 1
River, 1
Bear, 2
Car, 3
Deer, 2
River, 2
Bear, 2
Car, 3
Deer, 2
River, 2

Hadoop Ecosystem

Hadoop Ecosystem is a group of numerous self-standing software projects that are built around Hadoop, each addressing a variety of problem spaces and meeting different needs

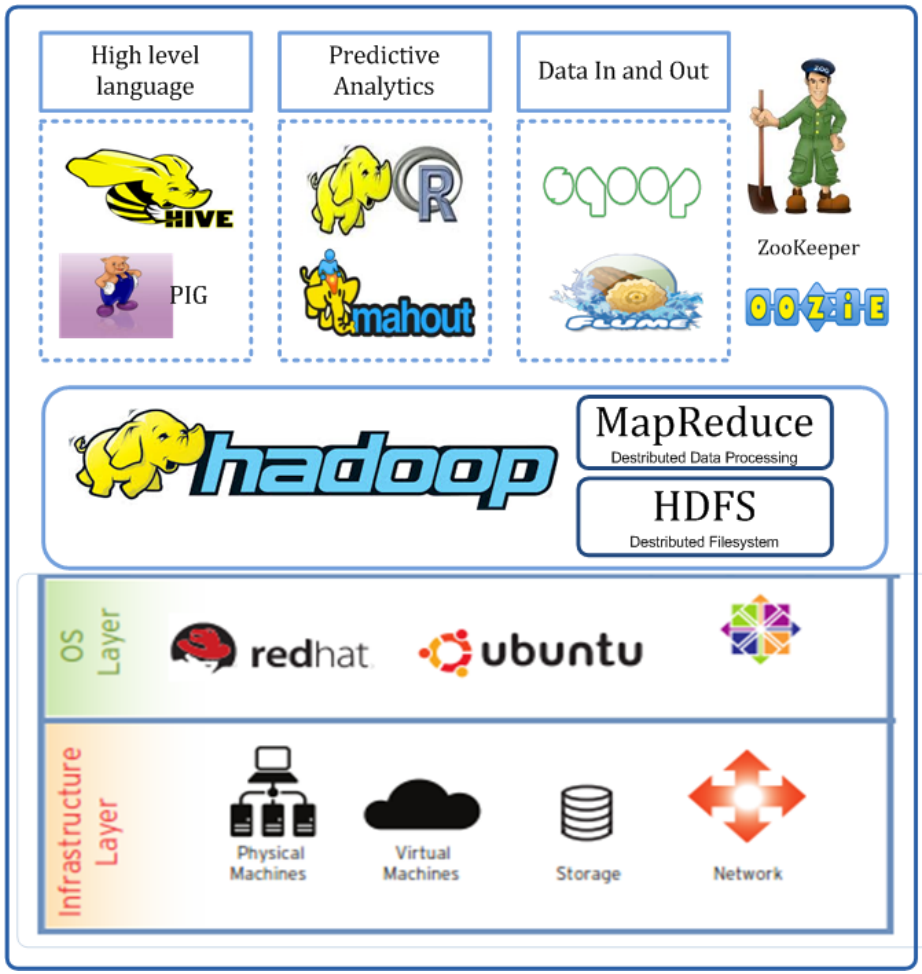


Figure: Hadoop Eco System

Thank You