# BIG DATA ANALYTICS (DSE 3264)

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# Course Objectives

- To be familiar with overview of **Apache Hadoop Ecosystem**
- Understand the **storage mechanism**, architecture, features and execution modes of big data tools (**Pig, Hive, HBase, Spark**)
- To be proficient in data analysis and its implications on **structured, unstructured, and semi- structured data.**
- To be proficient with **Big Data framework and use cases**.

# Course Outcome

- Identify Big Data and its business inferences.
- Explore, Manage and **Analyze Job executions** in local & cluster-based Hadoop environment.
- Apply and Perform machine learning techniques using Scala & python.

# Syllabus

**Introduction to Big Data:** evolution, structuring elements, big data analytics, distributed and parallel computing for big data, Life cycle of Big data, Cloud computing and big data, in-memory computing technology for big data, Big Data Stack, Layer Structure, Big Data Layout.

**Hadoop:** ecosystem, Hadoop Distributed File System (HDFS),

**MapReduce:** MapReduce Framework, optimizing MapReduce jobs, MapReduce Applications, Understanding YARN architecture.

**Big Data Tools**: **"PIG":** History, Features, Architecture, Components, Data Models, Operators, Running & Executing Modes, Analysing data with Pig, Pig Libraries, Processing Structured Data using Pig.

# Syllabus

**Big Data Tools: "HBASE":** History, Characteristics, Features, Architecture, Storage Mechanism, HDFS Versus HBASE, HBase Query writing.

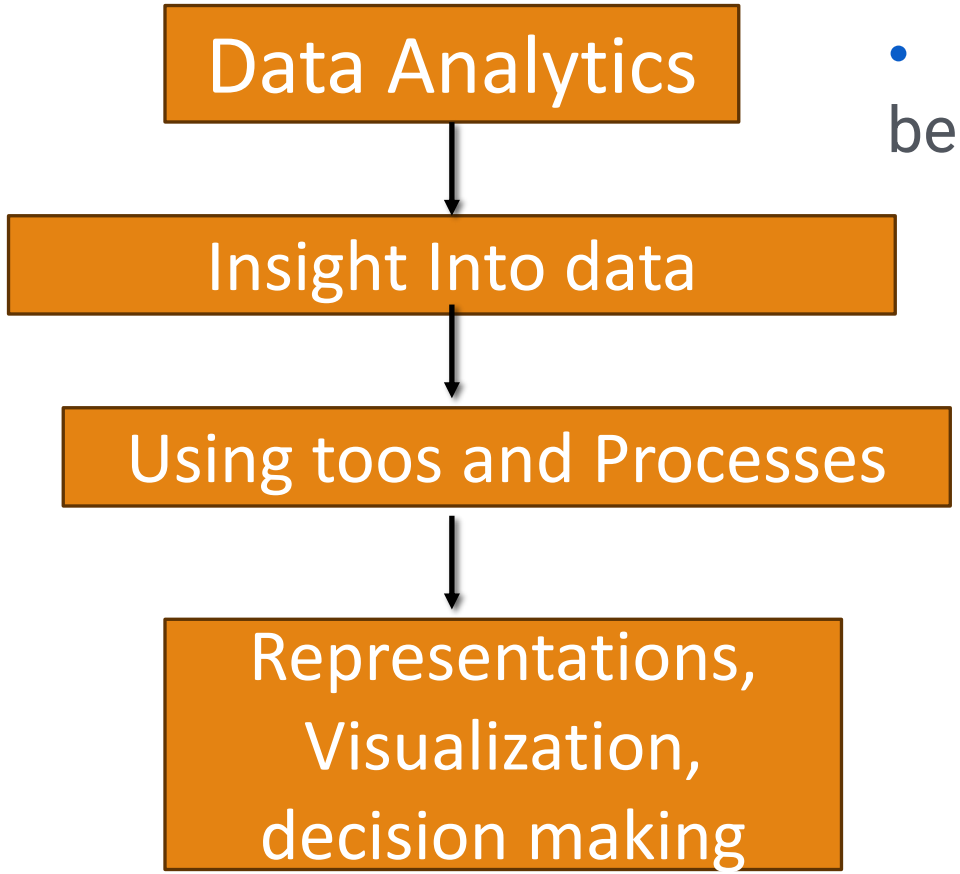
**Big Data Tools: "Hive":** Brief History of Hive, Data Types In Hive, Executing Modes, Writing & Executing Hive queries.

**Big Data tools: "Apache Spark":** Spark Architecture, Components, Features, Spark vs Hadoop, RDD, Need for RDD, Spark memory management & Fault tolerance, Spark's Python and Scala shells, Programming with RDD: RDD Operations, Passing Functions to Spark, Common Transformations and Actions,

# Contents

- Introduction to Big Data
- Types of Big Data
- Big Data characteristics
- Challenges
- Data Generators (Fields of Big Data)
- Traditional Vs Big Data approach
- Life Cycle
- Case Study.

# Big Data Analytics

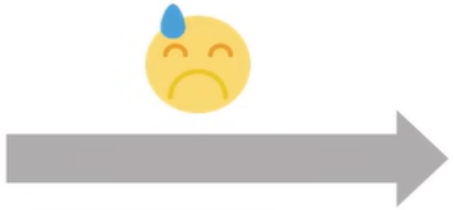



- Big Data is a massive amount of datasets that **cannot** be **stored, processed, or analyzed using traditional tools**.
  - The term *big data* was first used to refer to increasing data volumes in the mid-1990s.
  - In 2001, Doug Laney, then an analyst at consultancy Meta Group Inc., expanded the definition of big data.
    - ***Volume*** of data being stored and used by organizations.
    - ***Variety*** of data being generated by organizations.
    - ***Velocity***, or speed, in which that data was being created and updated.

# Why Big Data Analytics

Massive amount of data which cannot be stored, processed and analyzed using traditional tools is known as big data


Big data



Storing

Processing

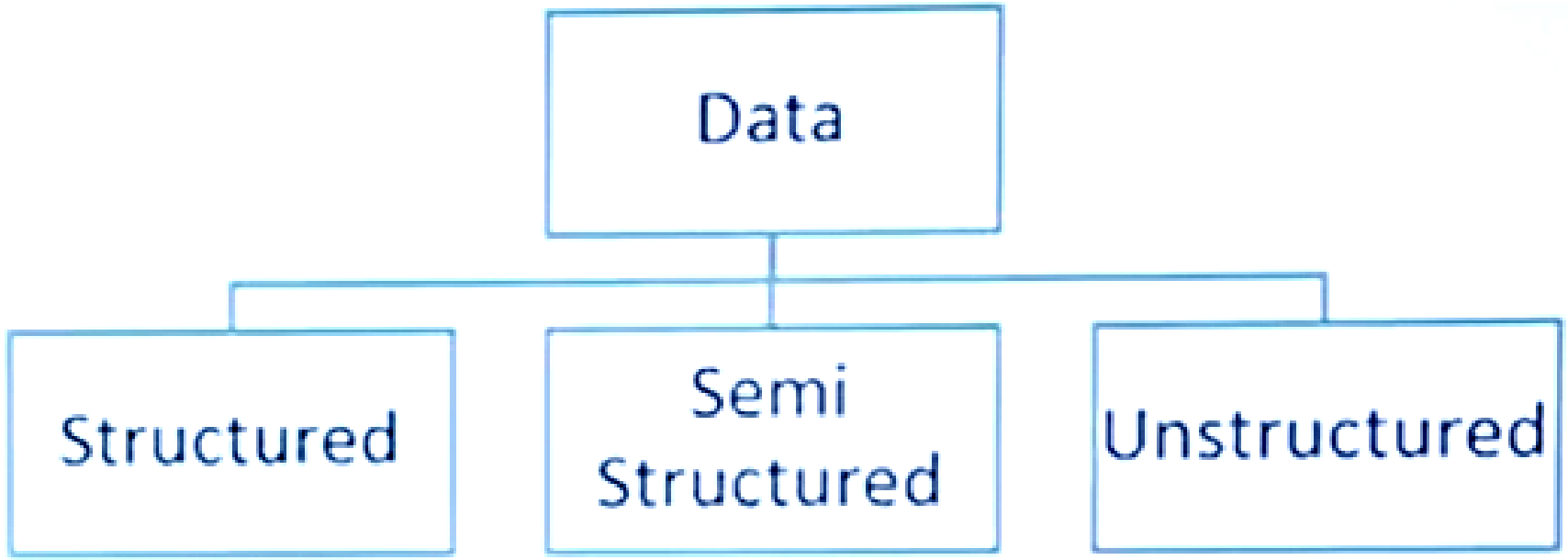
Analyzing

Storing, processing and analyzing big data became difficult using traditional methods

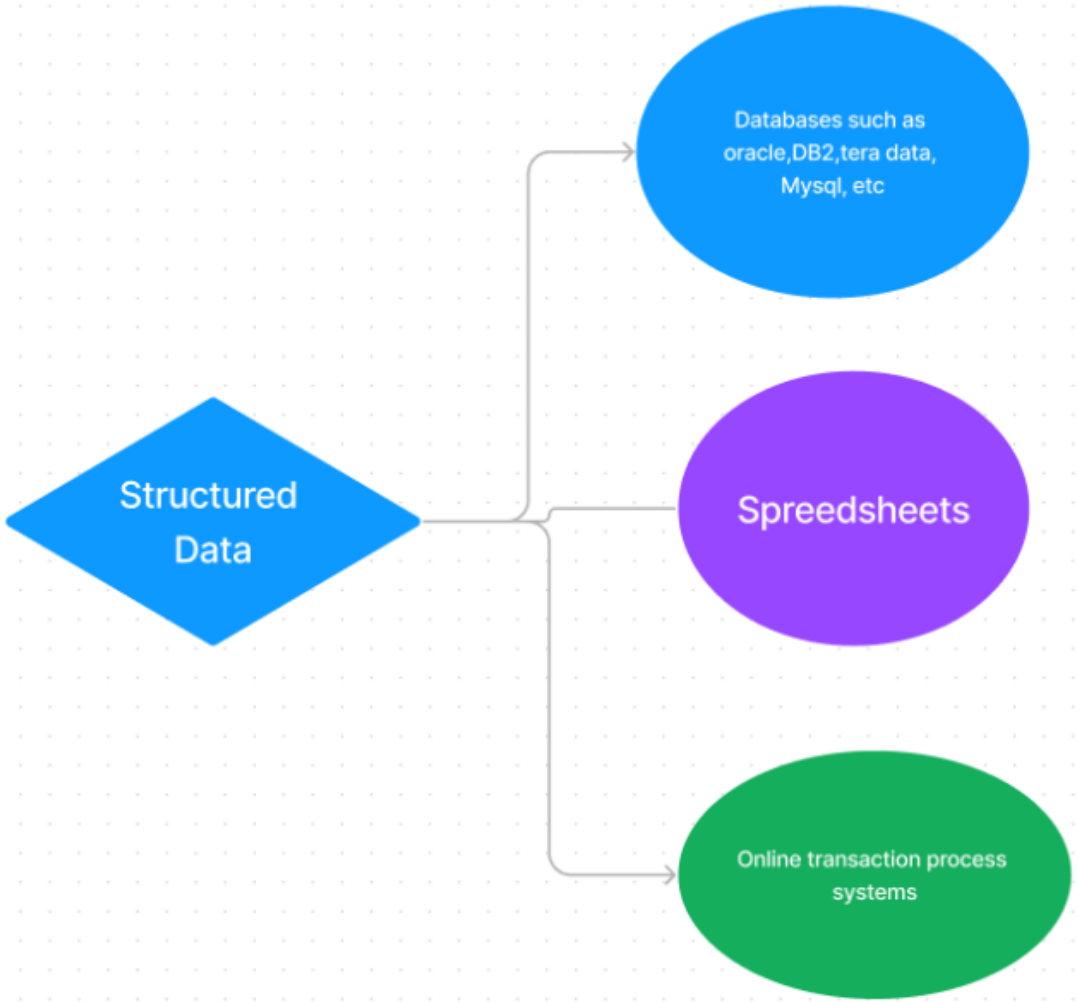
# Small Data VS Big Data

| SL.NO | Small Data | Big Data |
|---|---|---|
| 1 | Structured | Structured /Unstructured/ semistructured/ |
| 2 | **Megabyte (MB)**: 1 MB is equivalent to 1,024 kilobytes or approximately 1 million bytes.<br>**Gigabyte (GB)**: 1 GB equals 1,024 megabytes or approximately 1 billion bytes.<br>**Terabyte (TB)**: 1 TB is equal to 1,024 gigabytes or approximately 1 trillion bytes. | **Petabyte (PB)**: 1 PB is equivalent to 1,024 terabytes or 1 million gigabytes.<br>**Exabyte (EB)**: 1 EB equals 1,024 petabytes or 1 billion gigabytes.<br>**Zettabyte (ZB)**: 1 ZB is equal to 1,024 exabytes or 1 trillion gigabytes.<br>**Yottabyte (YB)**: 1 YB represents 1,024 zettabytes or 1 quadrillion gigabytes. |
| 3 | Gradually Increases (Slow) | Exponentially/ Rapidly Increases |
| 4 | Locally Present | Globally Present |
| 5 | Centralized | Distributed |
| 6 | Frameworks:Oracle, SQL Server | Hadoop, Spark, Cassandra |
| 7 | Single Node | Multiple Node |

# TYPES OF DATA



# Structured




•Data that resides in a fixed field within a record.

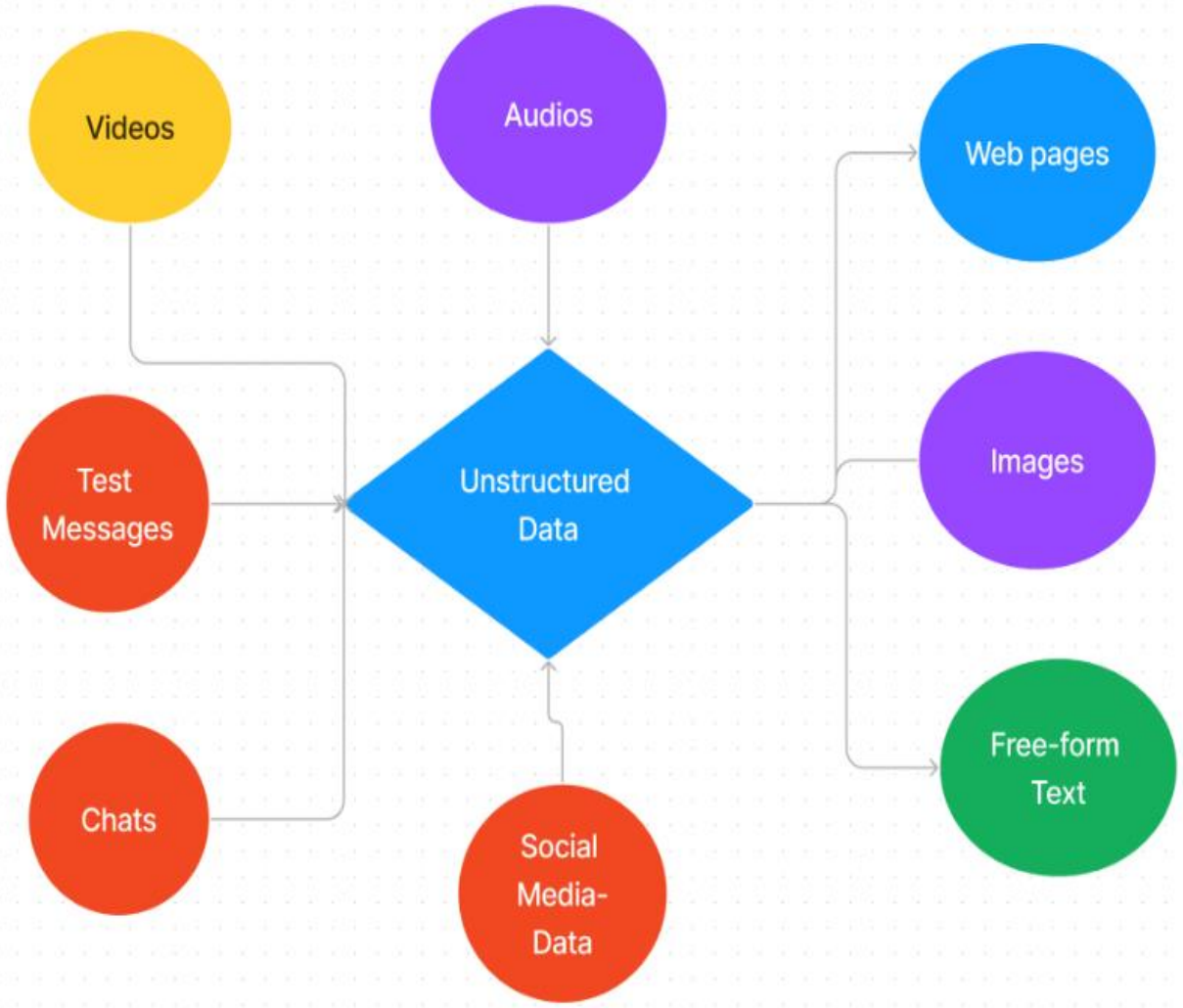
•It is type of data most familiar to our everyday lives. Ex: birthday, address

• A certain schema binds it, so all the data has the same set of properties. Structured data is also called relational data.

•It is split into multiple tables to enhance the integrity of the data by creating a single record to depict an entity.

•Relationships are enforced by the application of table constraints.

# Unstructured




•Unstructured data is the kind of data that doesn't adhere to any definite schema or set of rules.

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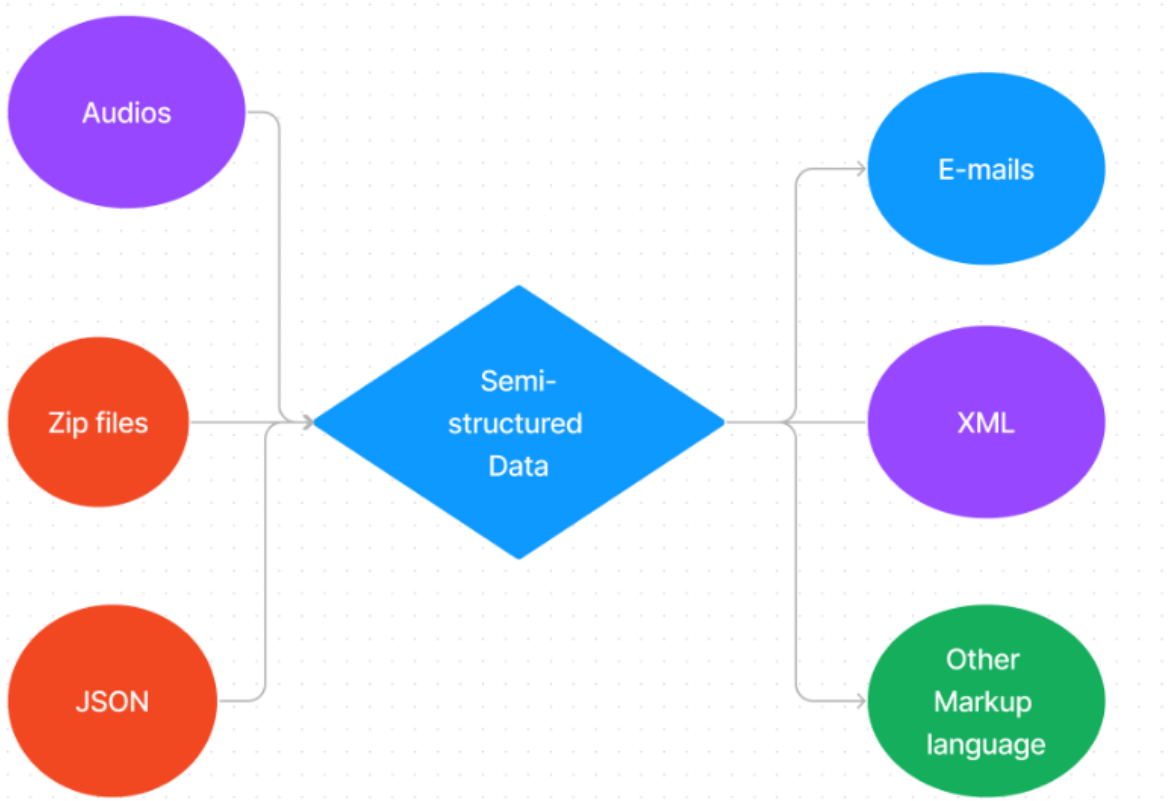
• Its arrangement is unplanned and haphazard.

•Photos, videos, text documents, and log files can be generally considered unstructured data.

•Even though the metadata accompanying an image or a video may be semi-structured, the actual data being dealt with is unstructured.

•Additionally, Unstructured data is also known as "dark data" because it cannot be analyzed without the proper software tools.

# Semi- Structured




•Semi-structured data is not bound by any rigid schema for data storage and handling.

•The data is not in the relational format and is not neatly organized into rows and columns like that in a spreadsheet.

•However, there are some features like key-value pairs that help in discerning the different entities from each other.

•Since semi-structured data doesn't need a structured query language, it is commonly called *NoSQL data*.

•This type of information typically comes from external sources such as social media platforms or other web-based data feeds.

# Data Generated On internet – Per minute

"2.1Million"

"3.8Million"

"1.0Million"

"4.5Million"

"188Million"

# Examples of Big Data

- Big data is a clustered management of different forms of data
- Generated by various devices (Android, iOS, etc.),
- Applications (music apps, web apps, game apps, etc.),
- Actions (searching through SE, navigating through similar types of web pages, etc.).

# Challenges of Big Data

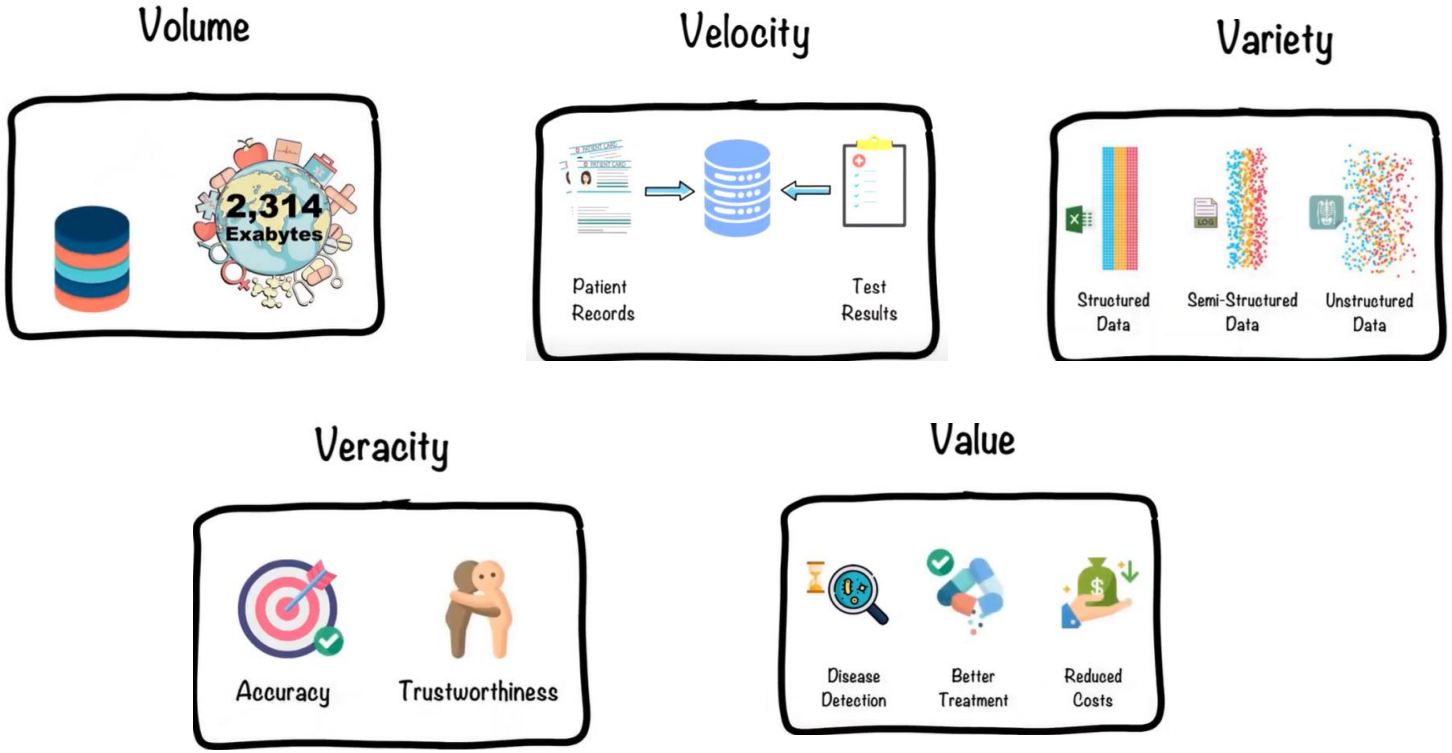
- **Rapid Data Growth:** The growth velocity at such a high rate creates a problem to look for insights using it. **There is no 100% efficient way to filter out relevant data.**
- **Storage:** The generation of such a massive amount of data needs space for storage, and organizations face challenges to **handle such extensive data without suitable tools and technologies.**
- **Unreliable Data:** It cannot be guaranteed that the big data collected and analyzed are totally (100%) accurate. **Redundant data, contradicting data, or incomplete** data are challenges that remain within it.
- **Data Security:** Firms and organizations storing such massive data (of users) can be a target of cybercriminals, and there is a risk of data getting stolen. Hence, encrypting such colossal data is also a challenge for firms and organizations.

# Fields of data that come under the umbrella of Big Data: (Generators of Data)

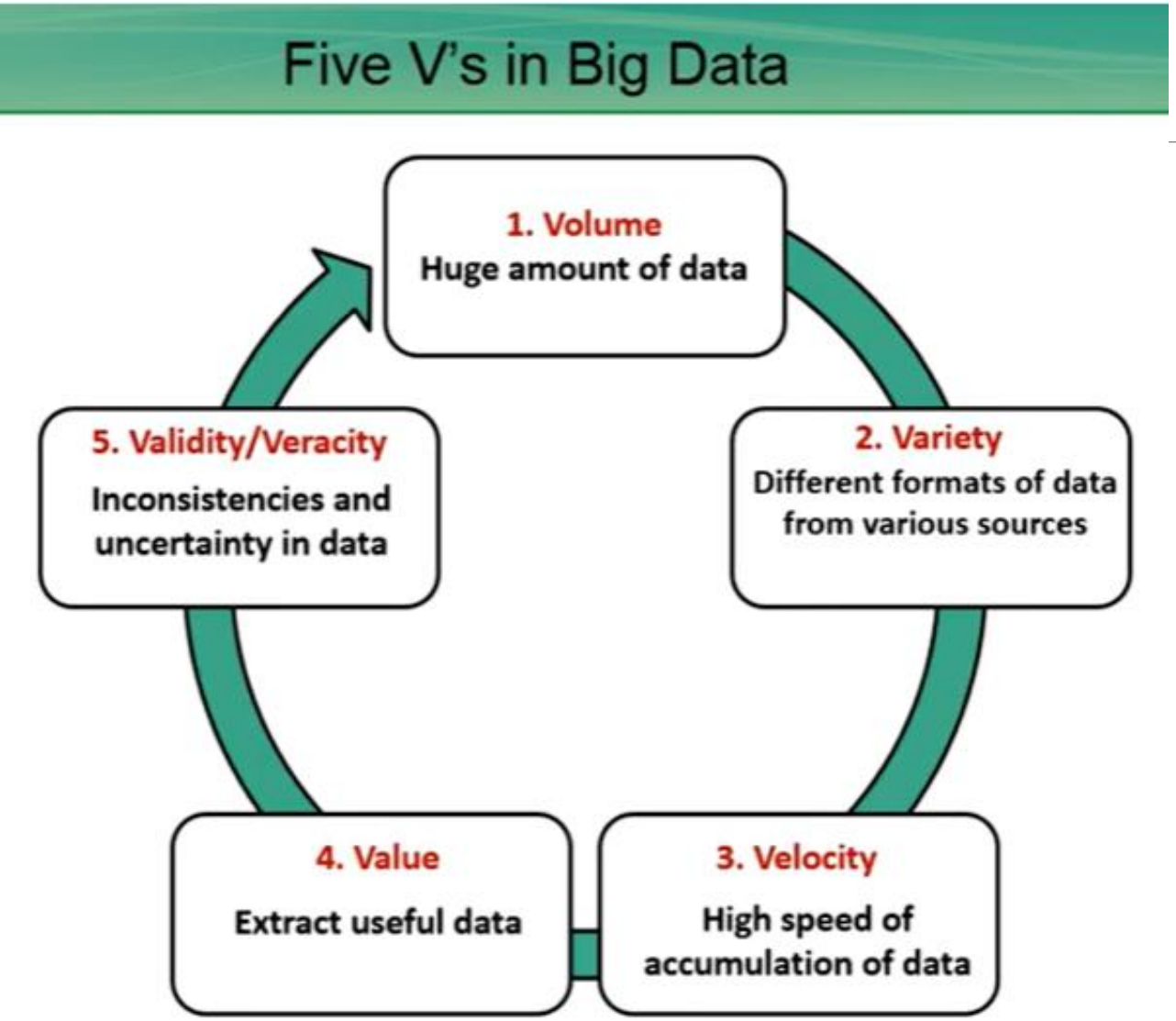
- Black Box Data: Black box data is a type of data that is collected from private and government helicopters, airplanes, and jets. This data includes the capture of Flight Crew Sounds, separate recording of the microphone as well as earphones, etc.
- Stock Exchange Data: Stock exchange data includes various data prepared about 'purchase' and 'selling' of different raw and well-made decisions.
- Social Media Data: This type of data contains information about social media activities that include posts submitted by millions of people worldwide.
- Transport Data: Transport data includes vehicle models, capacity, distance (from source to destination), and the availability of different vehicles.
- Search Engine Data: Retrieve a wide variety of unprocessed information that is stored in SE databases.

# Classify any data as Big Data ?

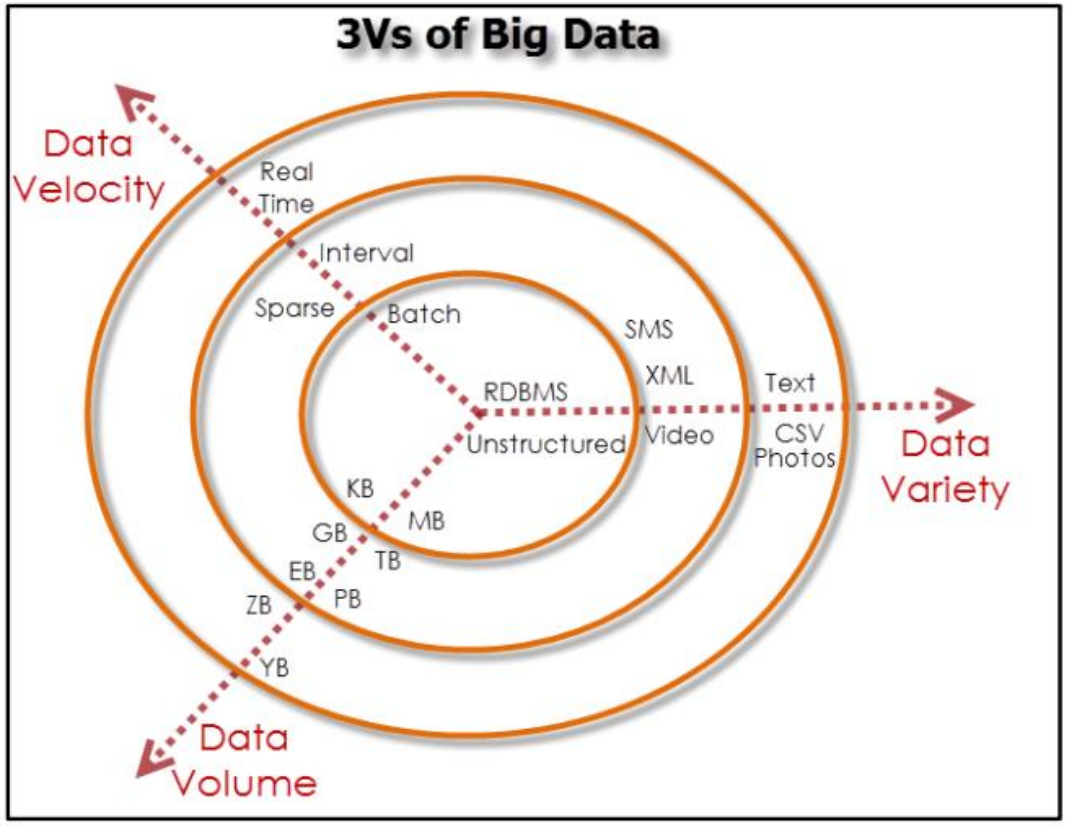
- Based on 5V's.



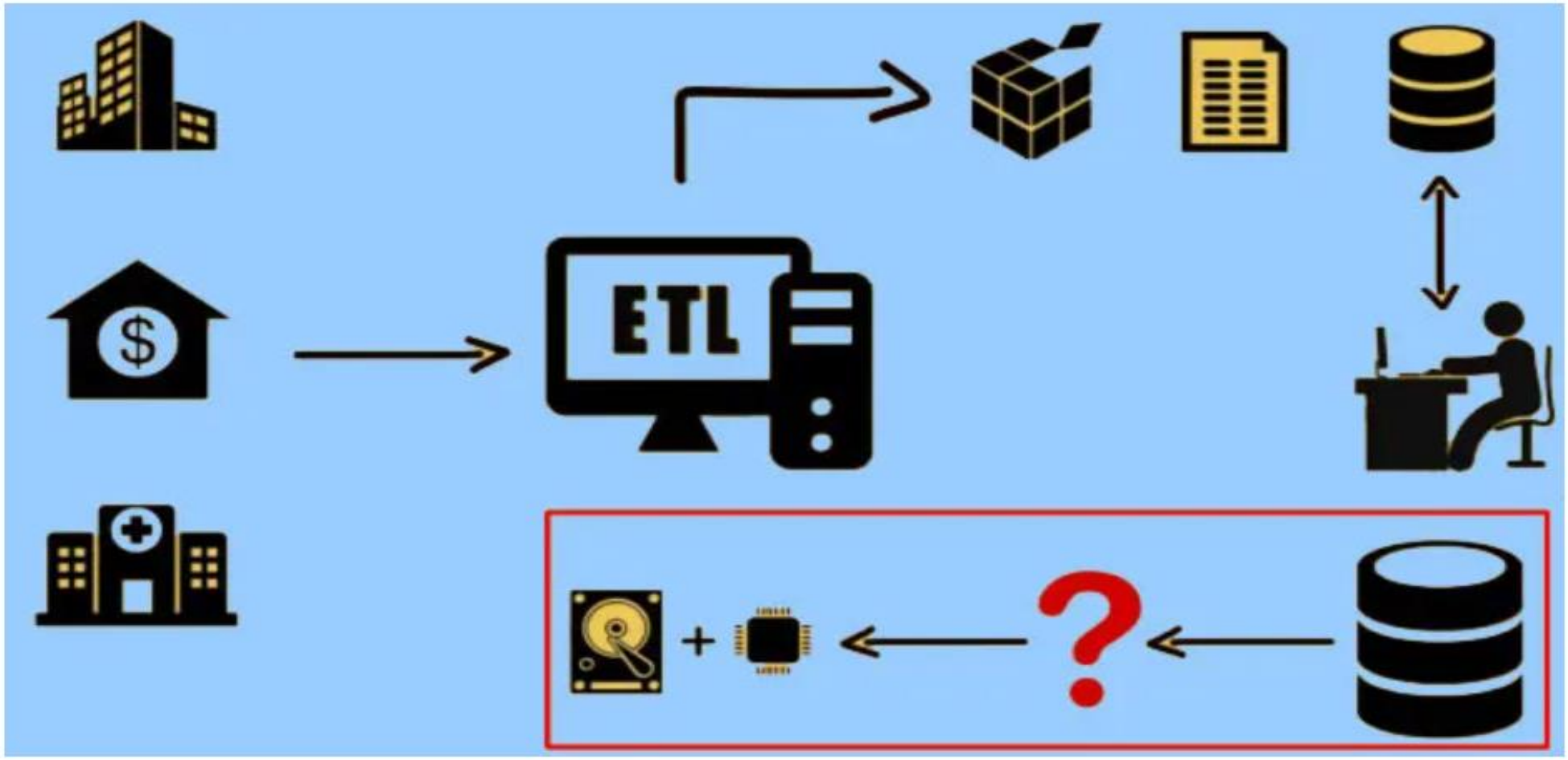
# Big Data Characteristics




- Volume: Related to size of the data
- Variety: Comprises of a variety of data
- Velocity: Refers to the speed of generation of data.
- Veracity: Quality of data captured, which can vary greatly, affecting its accurate analysis

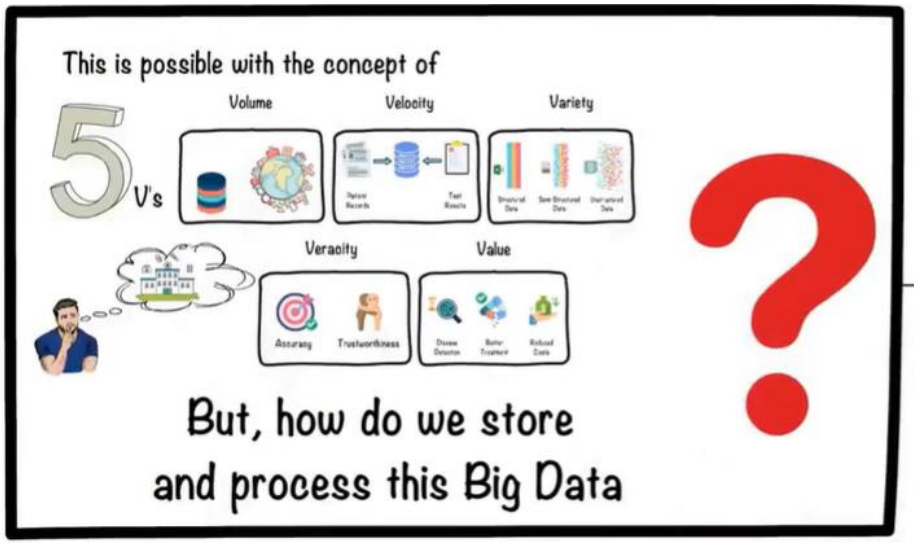


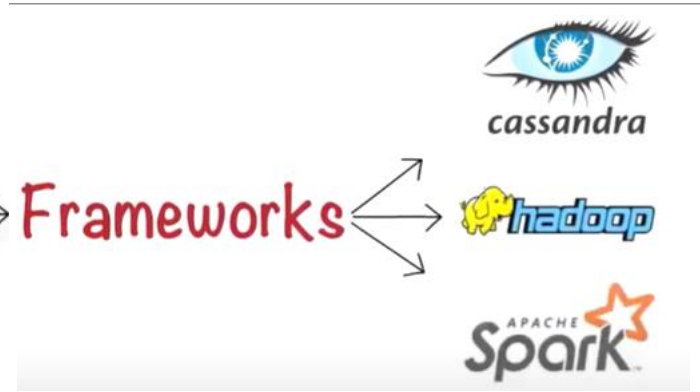
# Traditional Approach: Data storage and processing

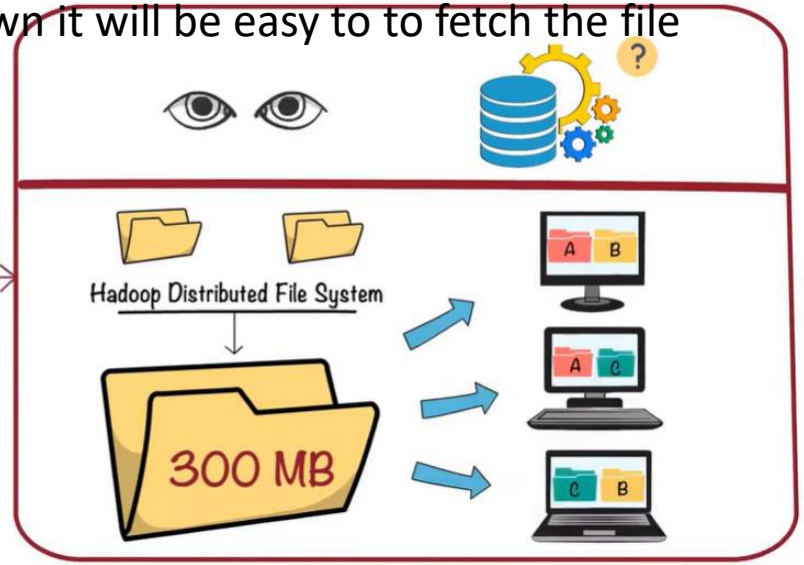


# How we store and process this Big Data?

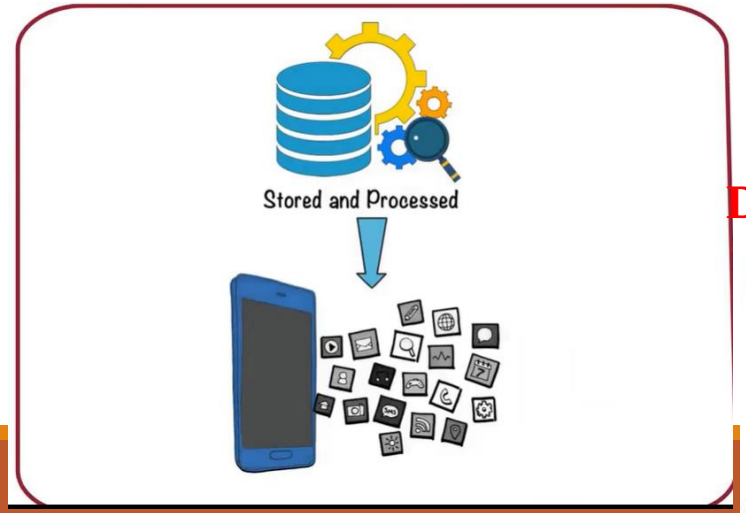
**Store** – Break file in to small sizes – 300 MB = 128Mb, 128 MB, 44MB
Store them with different nodes – when node breaks down it will be easy to to fetch the file



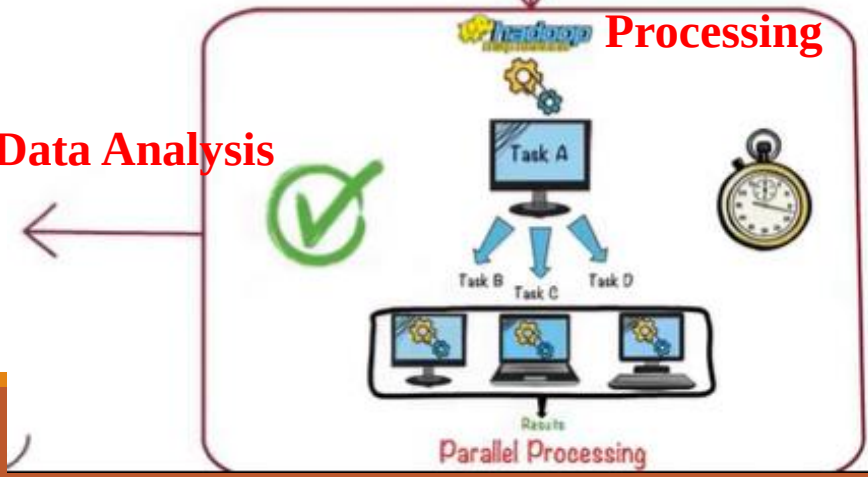



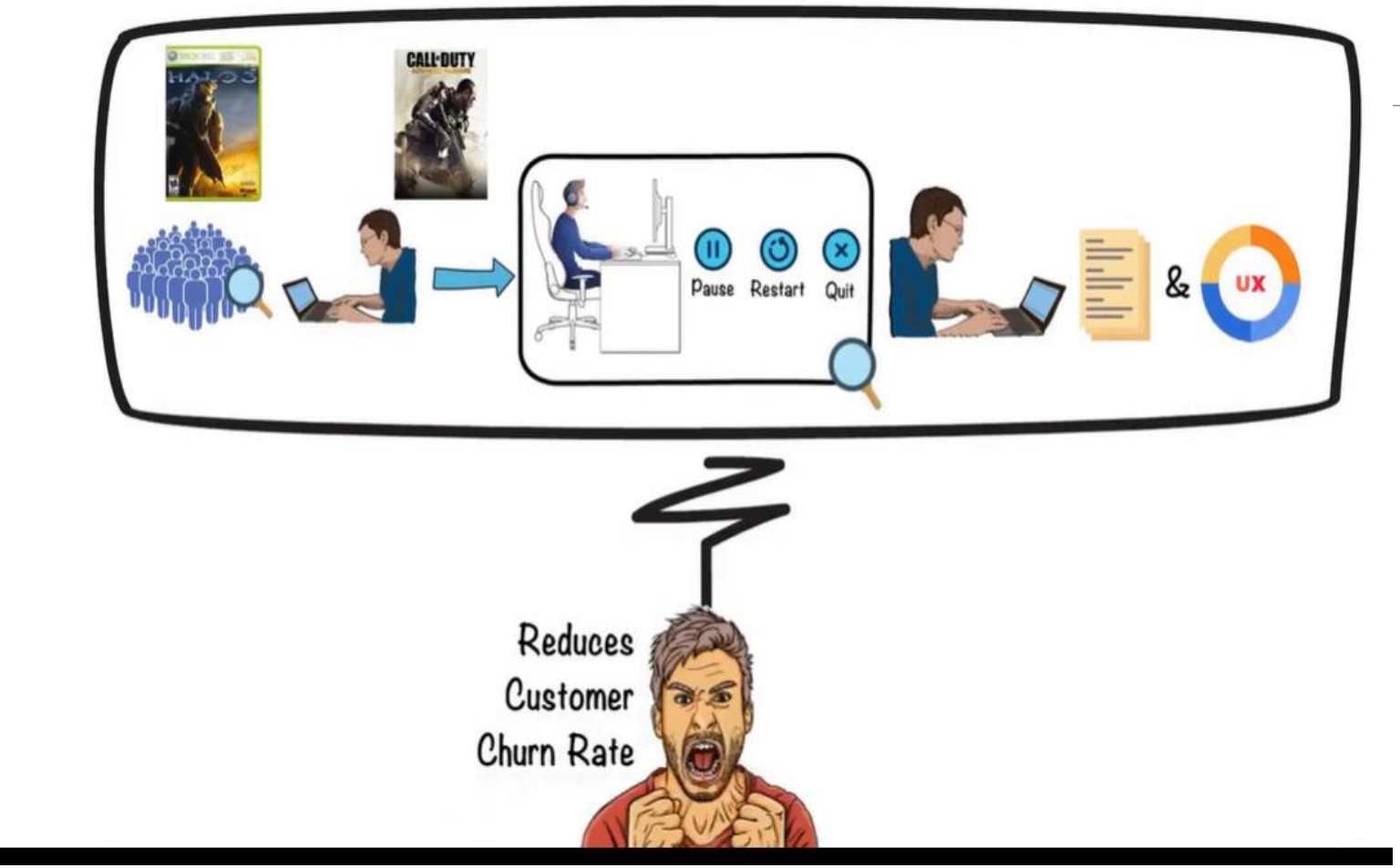

**MapReduce/ Processing**




**Data Analysis**



# Use case of Big Data Analysis – Gaming




- Designers Analyze gaming data at which stage customers pause , restart , quit etc.
- This analysis will help designers to work on enhancement of story line of games.
- Improve “user Experience”
- Reduce Churn rate.

# Use case of Big Data Analysis: Predict Hurricane's landfall


Big Data

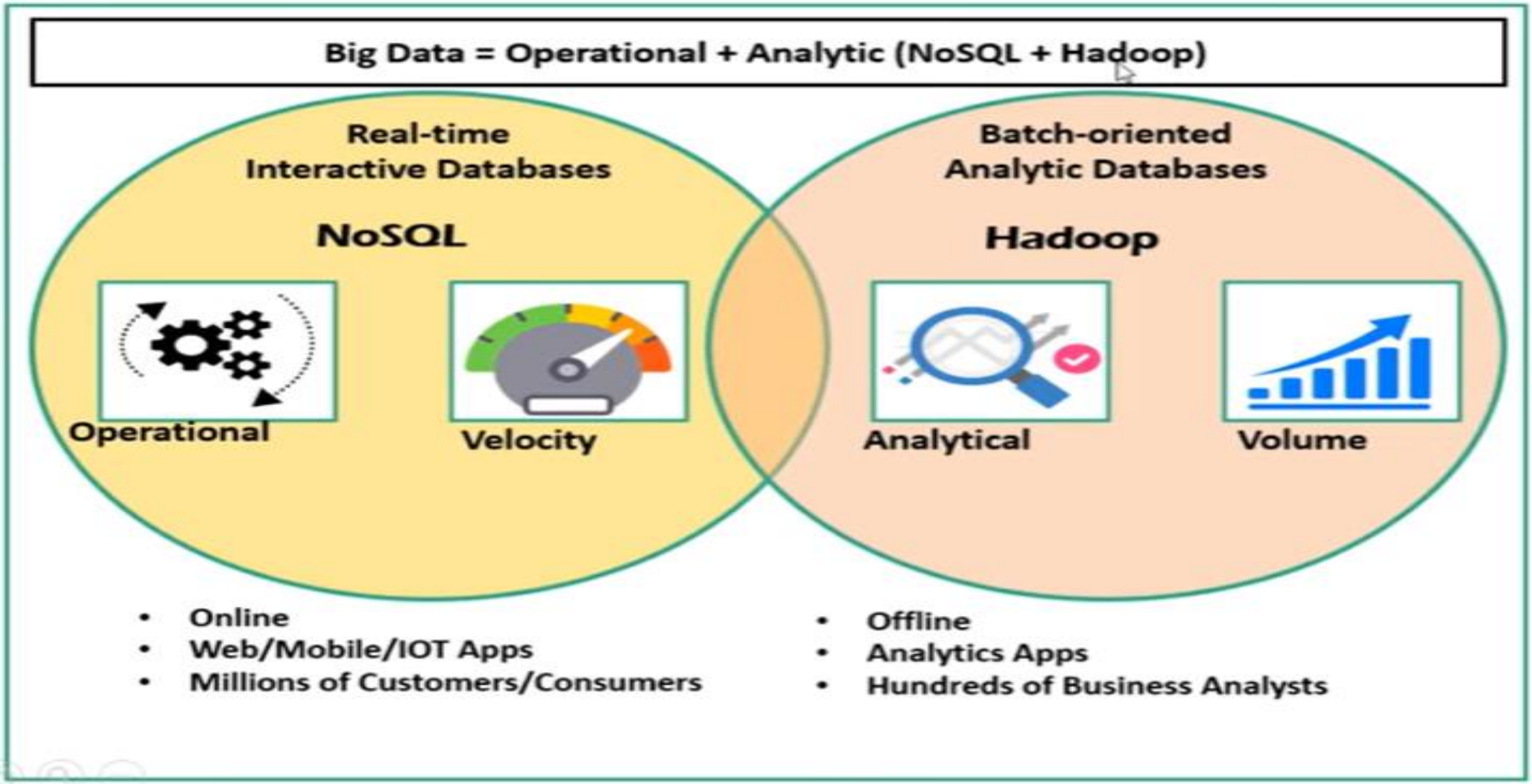
Hurricane Sandy in 2012

It could predict the hurricane's landfall five days in advance which wasn't possible earlier.

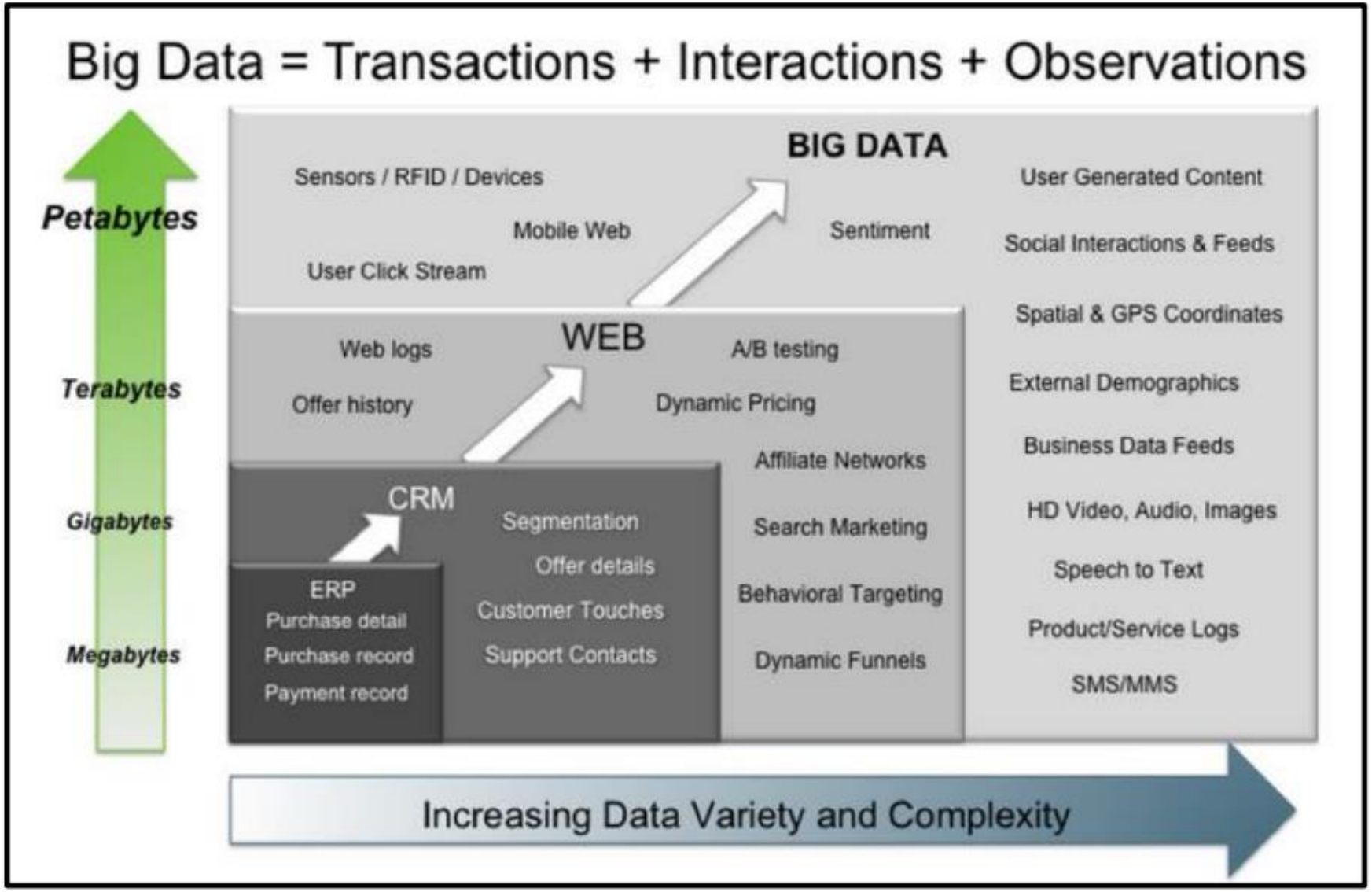
Necessary measures were taken

- Processed
- Analyzed Accurately

# Big data Technologies/ Classes



# Big Data?


Big Data = Transactions + Interactions + Observations
Petabytes
Terabytes
Gigabytes
Megabytes
BIG DATA
Sensors / RFID / Devices
Mobile Web
User Click Stream
Sentiment
User Generated Content
Social Interactions & Feeds
Spatial & GPS Coordinates
External Demographics
Business Data Feeds
HD Video, Audio, Images
Speech to Text
Product/Service Logs
SMS/MMS
WEB
Web logs
Offer history
A/B testing
Dynamic Pricing
Affiliate Networks
Search Marketing
Behavioral Targeting
Dynamic Funnels
CRM
Segmentation
Offer details
Customer Touches
Support Contacts
ERP
Purchase detail
Purchase record
Payment record
Increasing Data Variety and Complexity

# Big Data Layout

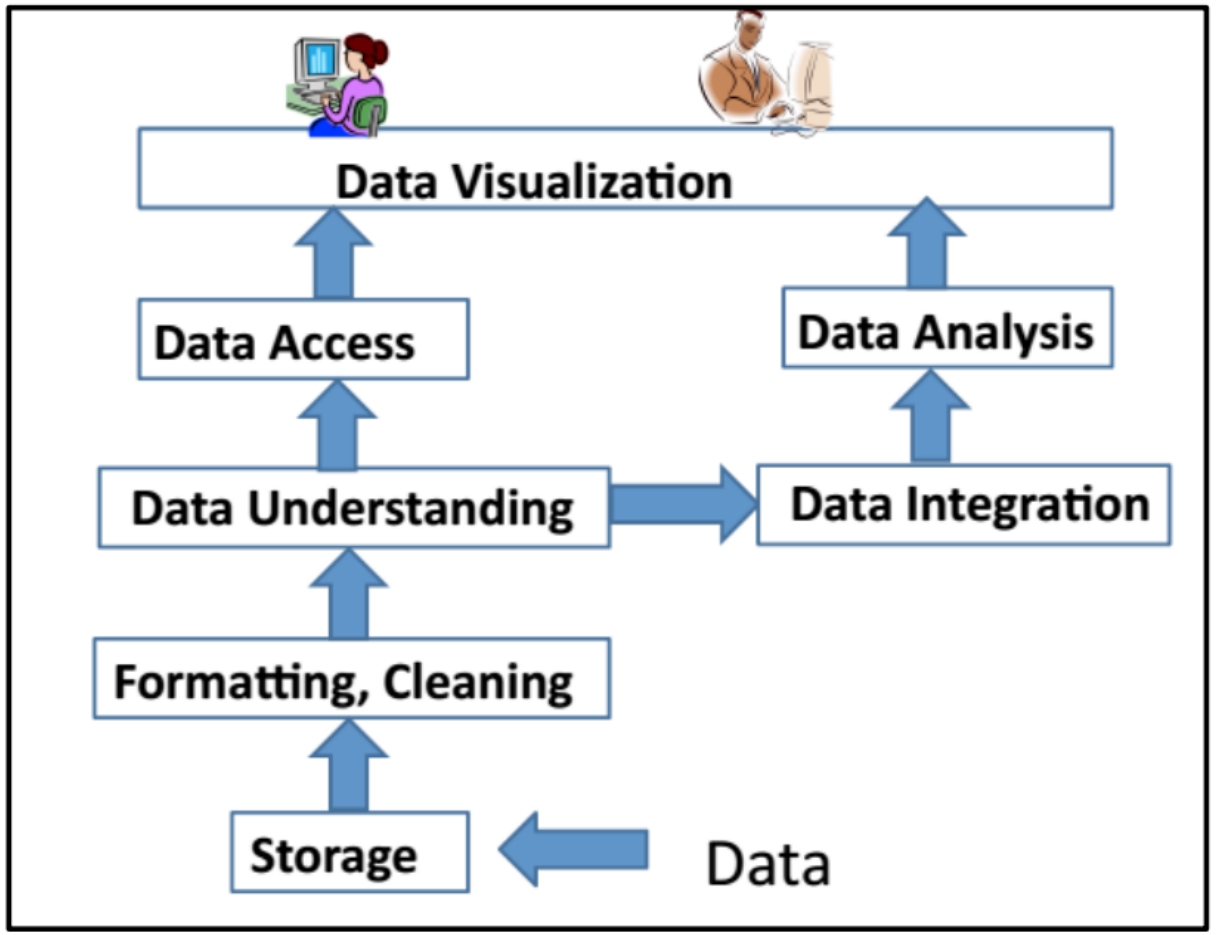



Figure : Big Data layout

- Apache Hadoop- Apache
- MapReduce – Google
- HDFS(Hadoop distributed file system) – Apache
- Hive – Facebook
- Pig - Yahoo

# Apache Hadoop

- Apache Hadoop is one of the main supportive element in Big Data technologies.
- It simplifies the processing of large amount of structured or unstructured data in a cheap manner.
- Hadoop is an open source project from Apache that is continuously improving over the years.
- Hadoop is basically a set of software libraries and frameworks to manage and process big amount of data from a single server to thousands of machines.
- It provides an efficient and powerful error detection mechanism based on application layer rather than relying upon hardware."
- In December 2012 Apache releases Hadoop 1.0.0, more information and installation guide can be found at Apache Hadoop Documentation.
- Hadoop is not a single project but includes a number of other technologies in it.

# Hadoop

## Main Components

1. HDFS (Hadoop Distributed File System)
2. YARN (Yet Another Resource Negotiator)
3. Mapreduce

**Includes several additional modules: Hive ,Pig**, and

**HBase**

## key features

- Distributed Storage
- Scalability
- Fault-Tolerance
- Data locality
- High Availability
- Flexible Data Processing
- Data Integrity
- Data Compression

# HDFS(Hadoop distributed file system)

- HDFS is a java based file system that is used to store structured or unstructured data over large clusters of distributed servers.
- The data stored in HDFS has no restriction or rule to be applied, the data can be either fully unstructured or purely structured.
- In HDFS the work to make data senseful, is done by developer's code only.
- Hadoop distributed file system provides a highly fault tolerant atmosphere with a deployment on low cost hardware machines.
- HDFS is now a part of Apache Hadoop project, more information and installation guide can be found at Apache HDFS documentation

# MapReduce

- MapReduce was introduced by google, which has mapper and reducer modules.
- Helps to analyze web logs to create large amount of web search indexes.
- It is basically a framework to write applications that processes a large amount of structured or unstructured data over the web. (programming model)
- MapReduce takes the query and breaks it into parts to run it on multiple nodes.
- By distributed query processing it makes it easy to maintain large amount of data by dividing the data into several different machines.
- Hadoop MapReduce is a software framework for easily writing applications to manage large amount of data sets with a highly fault tolerant manner.
- More tutorials and getting started guide can be found at Apache Documentation.

# HIVE

- Hive was originally developed by Facebook, now it is made open source.
- Hive works something like a bridge in between SQL and Hadoop, it is basically used to make SQL queries on Hadoop clusters.
- Apache Hive is basically a data warehouse that provides ad-hoc queries, data summarization and analysis of huge data sets stored in Hadoop compatible file systems.
- Hive provides a SQL like called HiveQL query based implementation of huge amount of data stored in Hadoop clusters.
- In January 2013 apache releases Hive 0.10.0

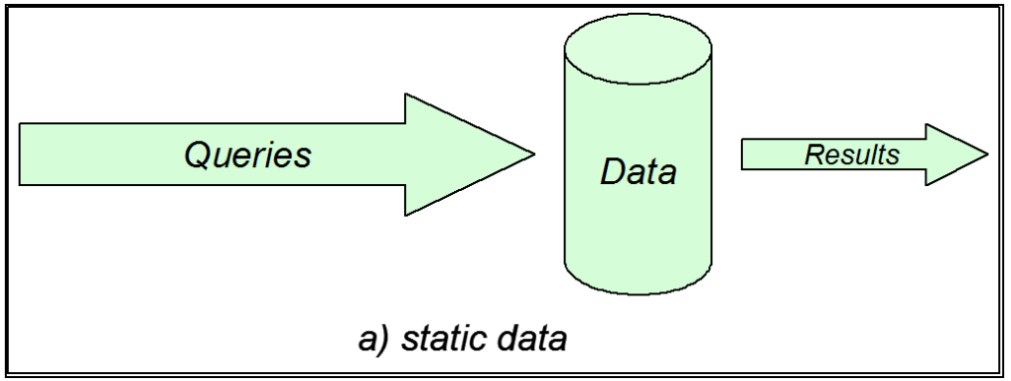
# Pig

- Pig was introduced by yahoo and later on it was made fully open source.
- It also provides a bridge to query data over Hadoop clusters but unlike hive, it implements a script implementation to make Hadoop data access able by developers and business persons.
- Apache pig provides a high level programming platform for developers to process and analyses Big Data using user defined functions and programming efforts.
- In January 2013 Apache released Pig 0.10.1 which is defined for use with Hadoop 0.10.1 or later releases.

# Traditional vs Big Data

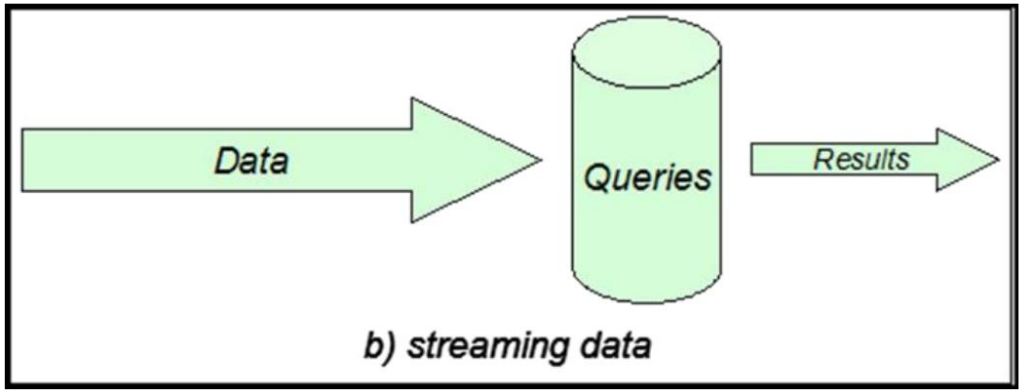
Schema Hard Code/SQL/Small Data

- online transactions and quick updates.
- Schema Based DB (hard code schema attachment)
- Structured
- Uses SQL for Data processing
- Maintains relationship between elements



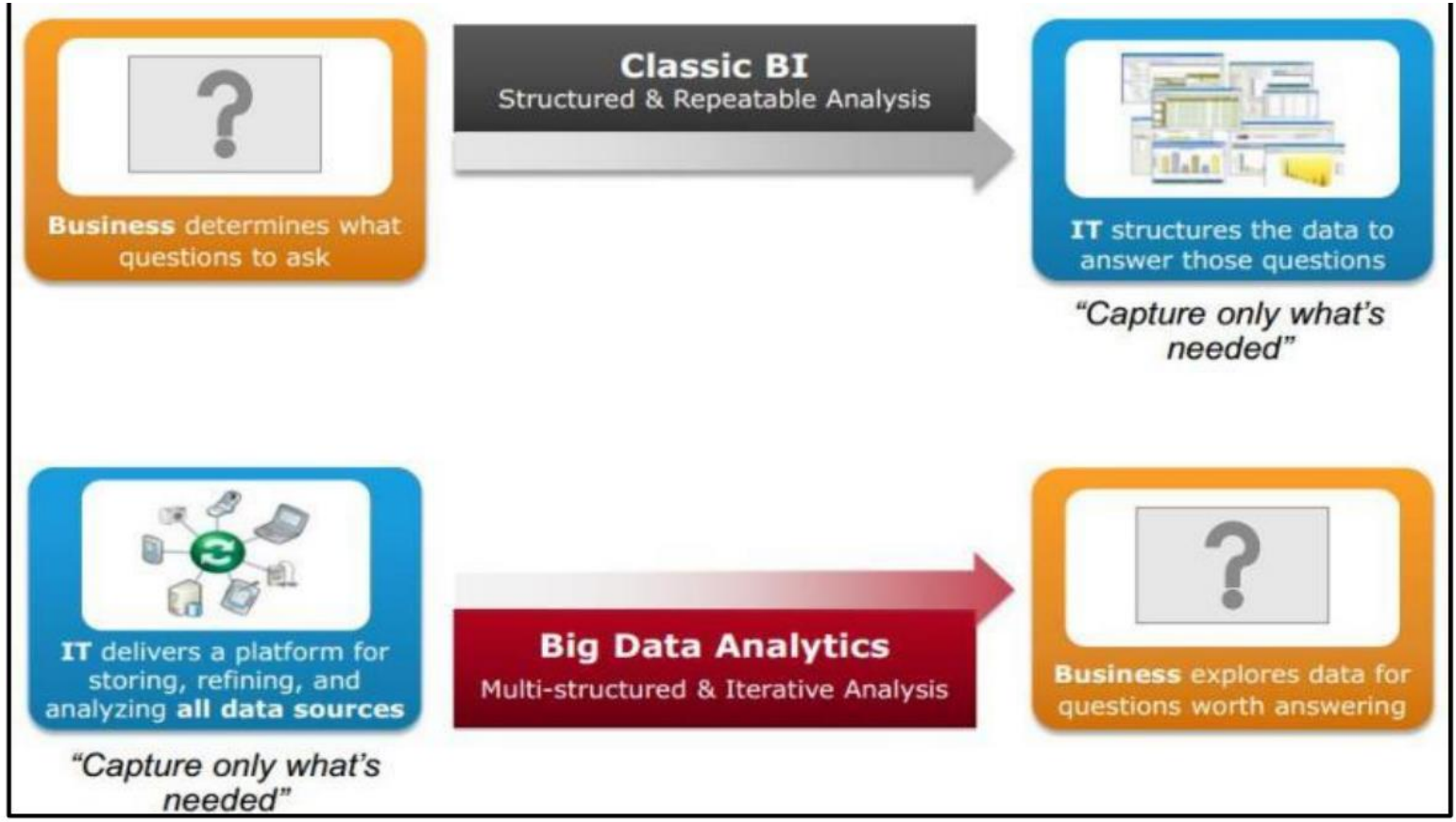

Schema Less /NoSQL/Big Data

- Migration Easy
- Schema Less Based DB
- store unstructured, semi structured or even fully structured data
- Store a huge amount of data and not to maintain relationship between elements.



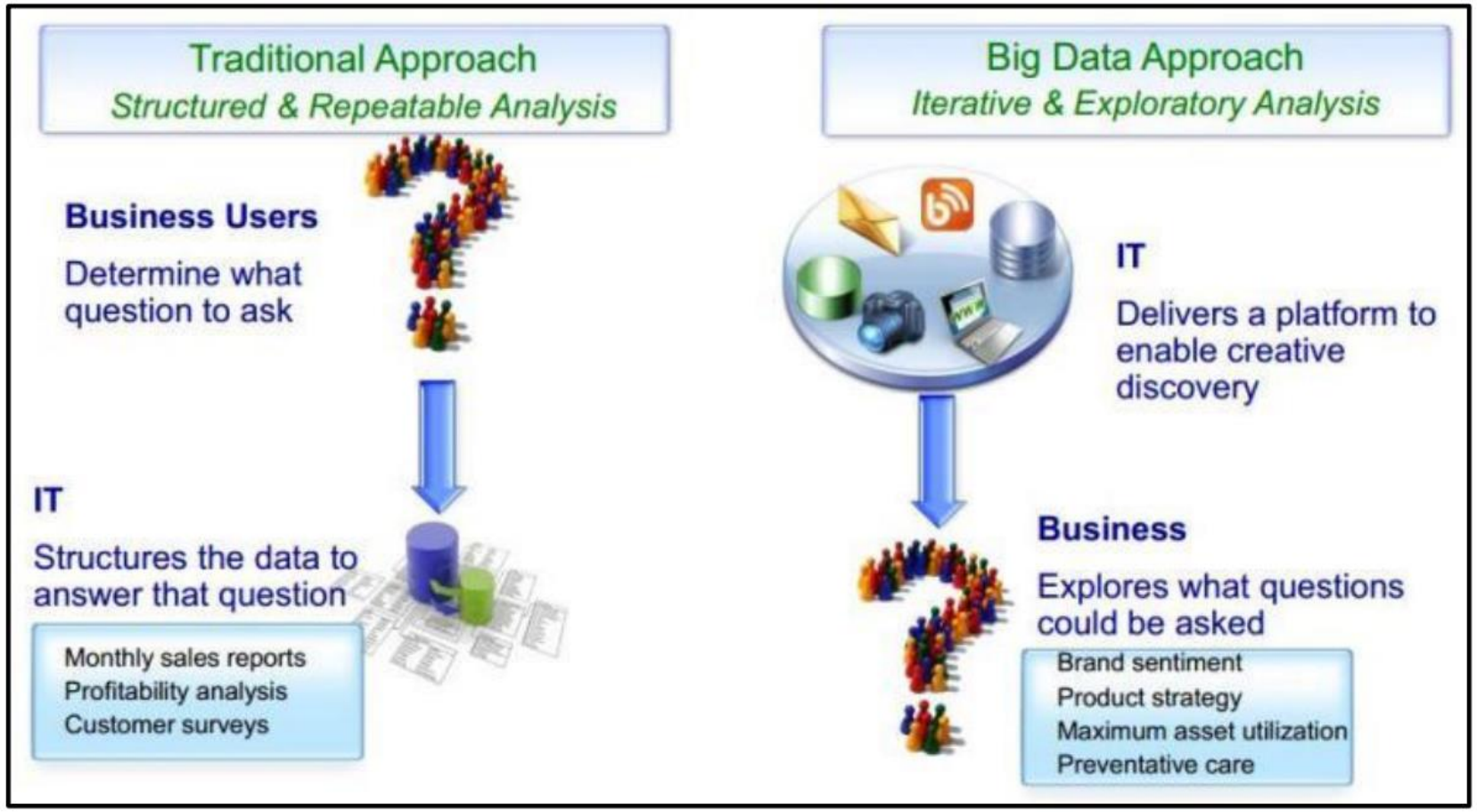
# Traditional BI Vs. Big Data Analytics

- Working on the live coming data, which can be an input from the ever-changing scenario cannot be dealt in the traditional approach.



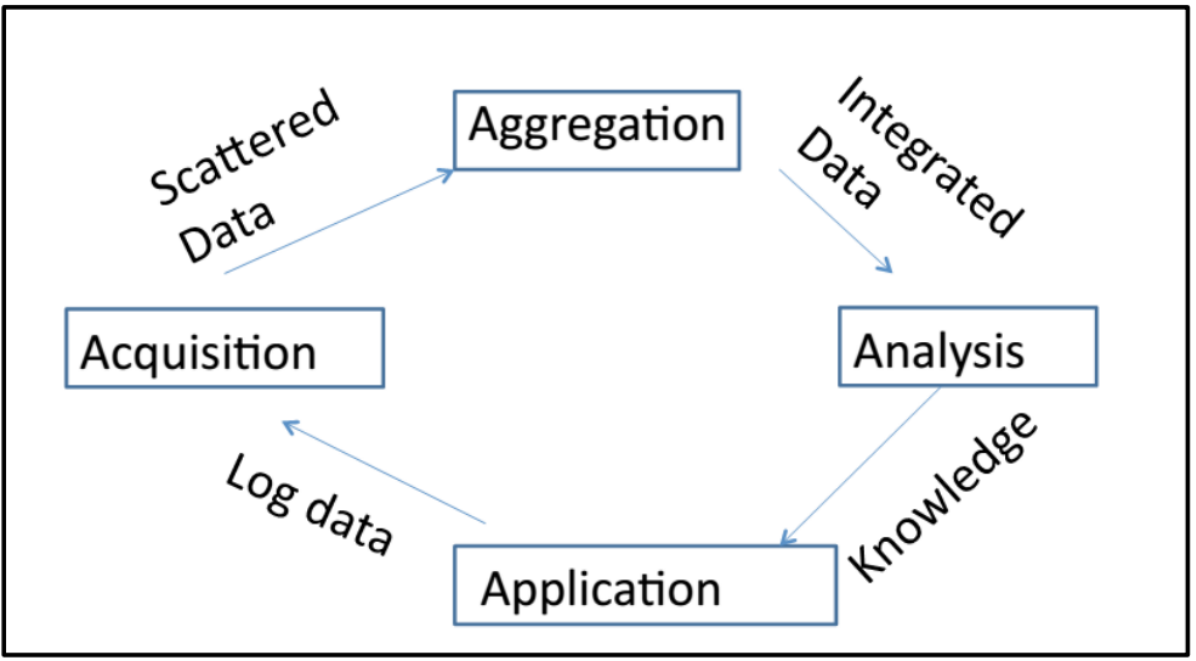

- The live flow of data is captured and the analysis is done on it.
- Efficiency increases when the data to be analyzed is large

# Traditional vs Big data  Approaches



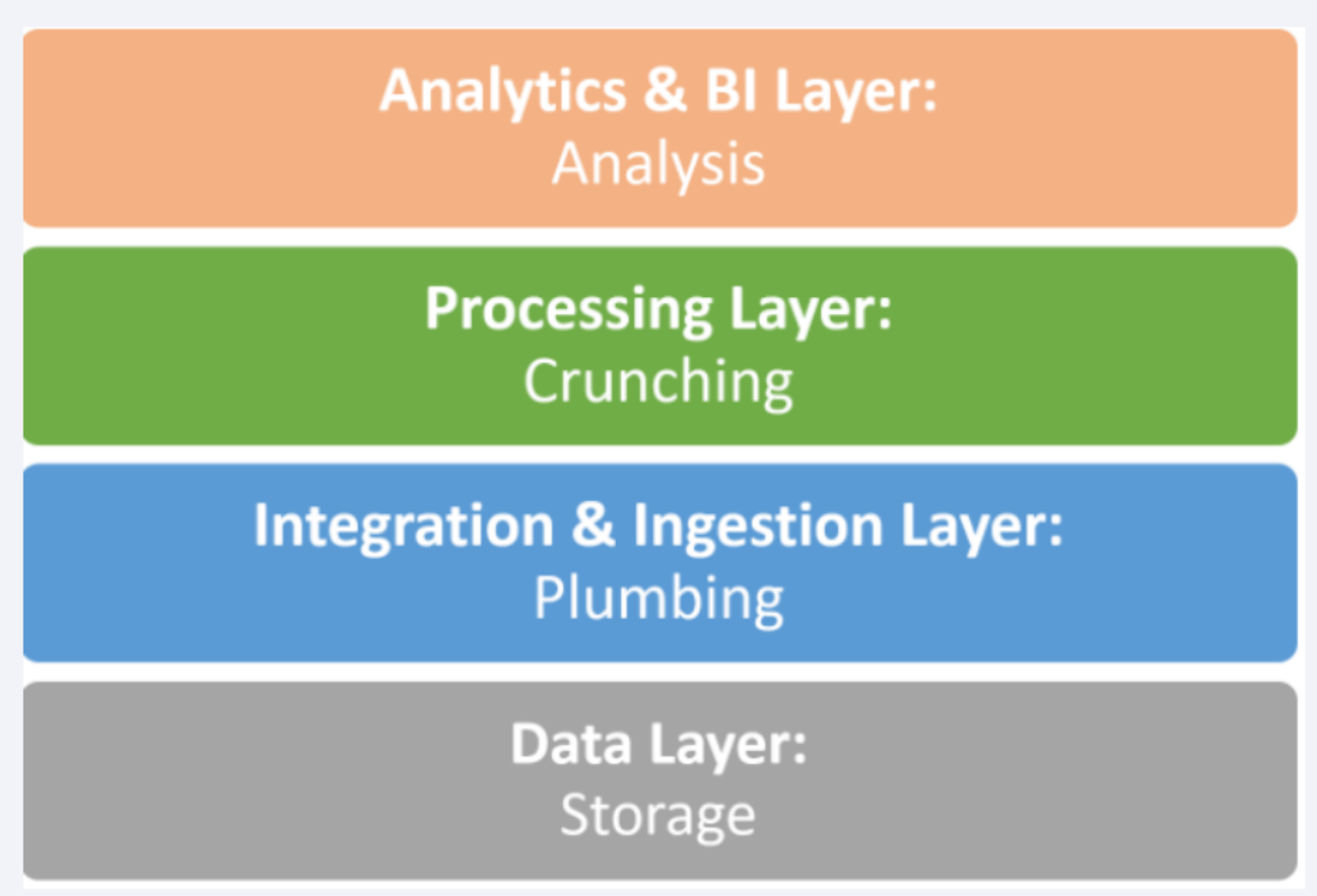
# What is Changing in the Realms of Big Data ??????

# Life Cycle of Data

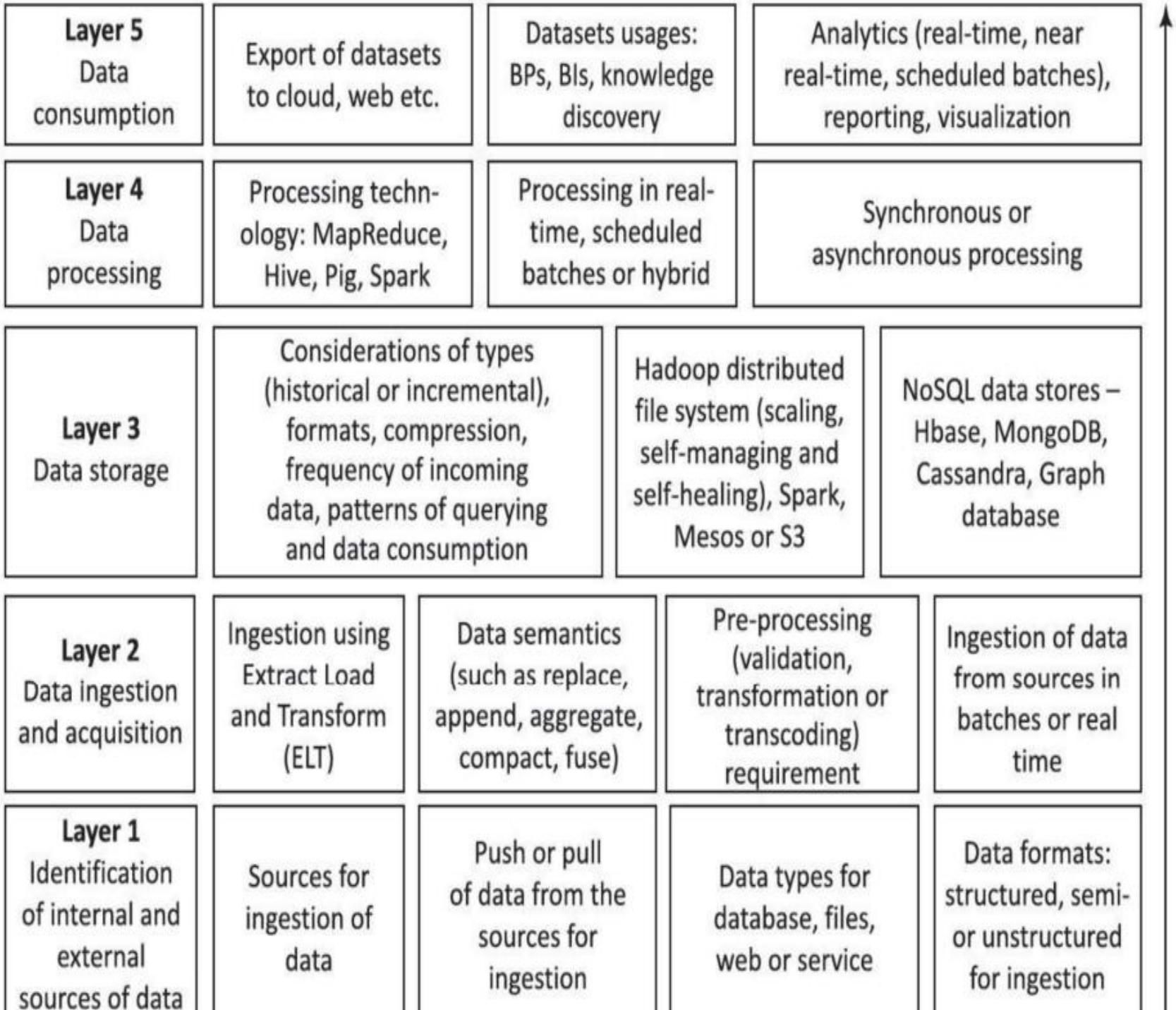



1) The analysis of data is done from the knowledge experts and the expertise is applied for the development of an application.
2) The streaming of data after the analysis and the application, the data log is created for the acquisition of data.
3) The data id mapped and clustered together on the data log.
4) The clustered data from the data acquisition is then aggregated by applying various aggregation algorithms.
5) The integrated data again goes for an analysis.
6) The complete steps are repeated till the desired, and expected output is produced

# Big Data Technology Stack



# Design of logical layers in a data processing



# Various Data Storage and Usage, Tools

| Data Source | Examples of Usages | Example of Tools |
|---|---|---|
| Relational databases | Managing business applications involving structured data | Microsoft Access, Oracle, IBM DB2, SQL Server, MySQL, PostgreSQL Composite, SQL on Hadoop [HPE (Hewlett Packard Enterprise) Vertica, IBM BigSQL, Microsoft Polybase, Oracle Big Data SQL] |
| Analysis databases (MPP, columnar, In-memory) | High performance queries and analytics | Sybase IQ, Kognitio, Terradata, Netezza, Vertica, ParAccel, ParStream, Infobright, Vectorwise, |
| NoSQL databases (Key-value pairs, Columnar format, documents, | Key-value pairs, fast read/write using collections of name-value pairs for storing any type of data; Columnar format, documents, | Key-value pair databases: Riak DS (Data Store), OrientDB, Column format databases (HBase, Cassandra), Document oriented databases: CouchDB, MongoDB; Graph |

# Various Data Storage and Usage, Tools

| | | |
|---|---|---|
| Objects, graph) | objects, graph DBs and DSs | databases (Neo4j, Tetan) |
| Hadoop clusters | Ability to process large data sets across a distributed computing environment | Cloudera, Apache HDFS |
| Web applications | Access to data generated from web applications | Google Analytics, Twitter |
| Cloud data | Elastic scalable outsourced databases, and data administration services | Amazon Web Services, Rackspace, GoogleSQL |
| Individual data | Individual productivity | MS Excel, CSV, TLV, JSON, MIME type |
| Multidimensional | Well-defined bounded exploration especially popular for financial applications | Microsoft SQL Server Analysis Services |
| Social media data | Text data, images, videos | Twitter, LinkedIn |

# Components Classification in Hadoop

Mainly components are classified into 4 categories:

- Data Storage
  HDFS:Hadoop Distributed File System
  HBase: A columnar database that uses HDFS for tis storage

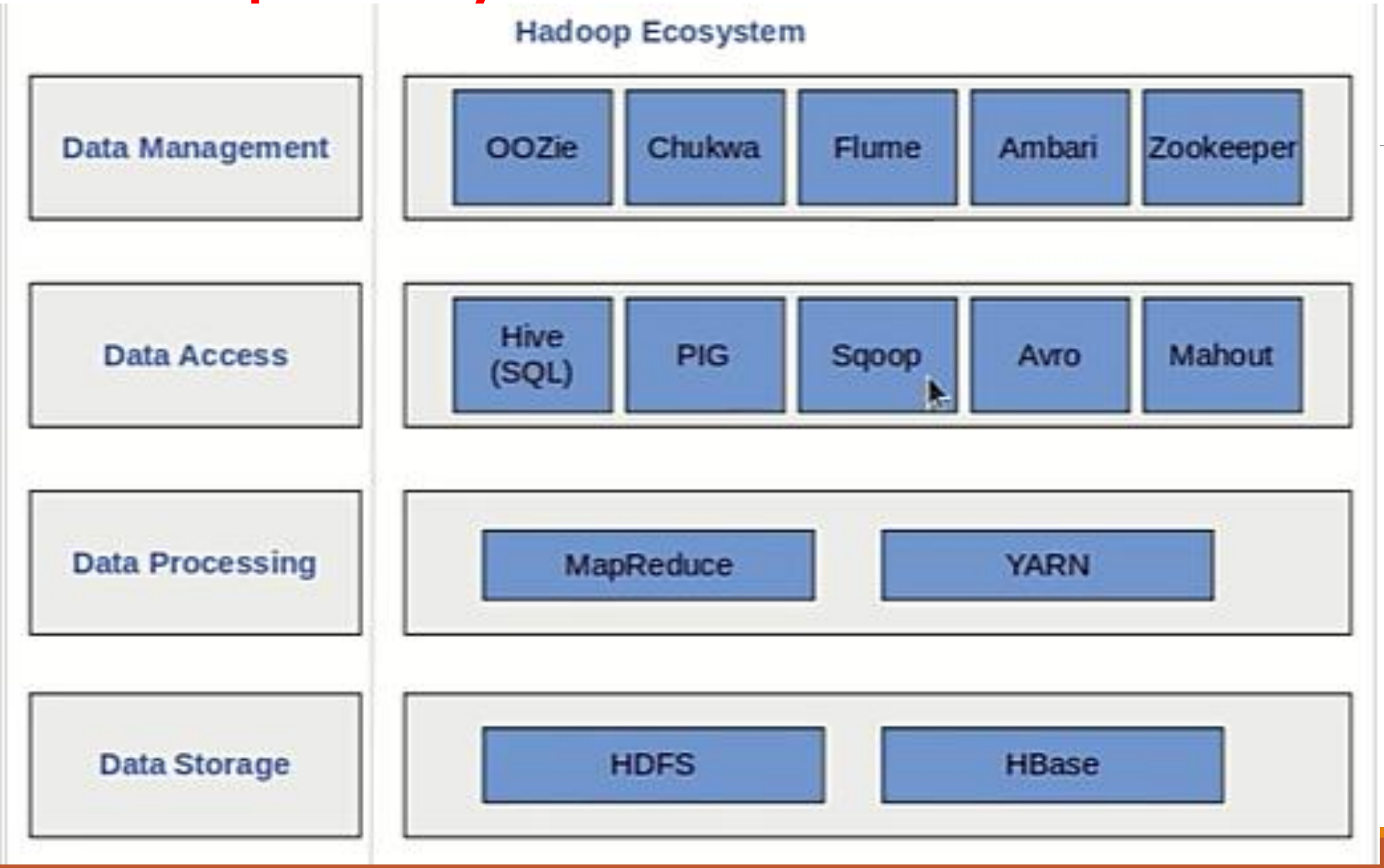
- Data Processing
  YARN: Operating system/scheduler
  MapReduce: Data processing programming model

# Components Classification

- Data Access
  Hive(SQL): A distributed data warehouse for HDFS data that provides a SQL-like layer to this data
  Pig: Framework for analyzing large data sets that let you create data pipelines
  Mahout: Machine learning algorithm libraries
  Sqoop: Data movement tool that moves data b.w HDFS and relational db
  Avro : Framework for transforming data into a compact binary form

- Data Management
  Zookeeper: Managing clusters/coordination service
  Oozie: Job scheduling tool

# Hadoop Ecosystem



# Hadoop 1 vs Hadoop 2 [MRV1 vs MRV2]

1) Components

| Hadoop1 | Hadoop2 |
| --- | --- |
| - HDFS | - HDFS |
| - MapReduce | - YARN / MapReduce |

2) Services/ Daemonds

| | |
| --- | --- |
| - Namenode | - Namenode/Secondary Namenode |
| - Datanode | - Datanode |
| - Job tracker | - Resource manager |
| - Task traker | - Node manager |

3) Working

| | |
| --- | --- |
| - HDFS: Data storage | - HDFS: Data storage |
| - MapReduce: Data processing + Resource management | - YARN: Resource managment<br>- MapReduce: Data processing |

# Hadoop 1 vs Hadoop 2 [MRV1 vs MRV2]

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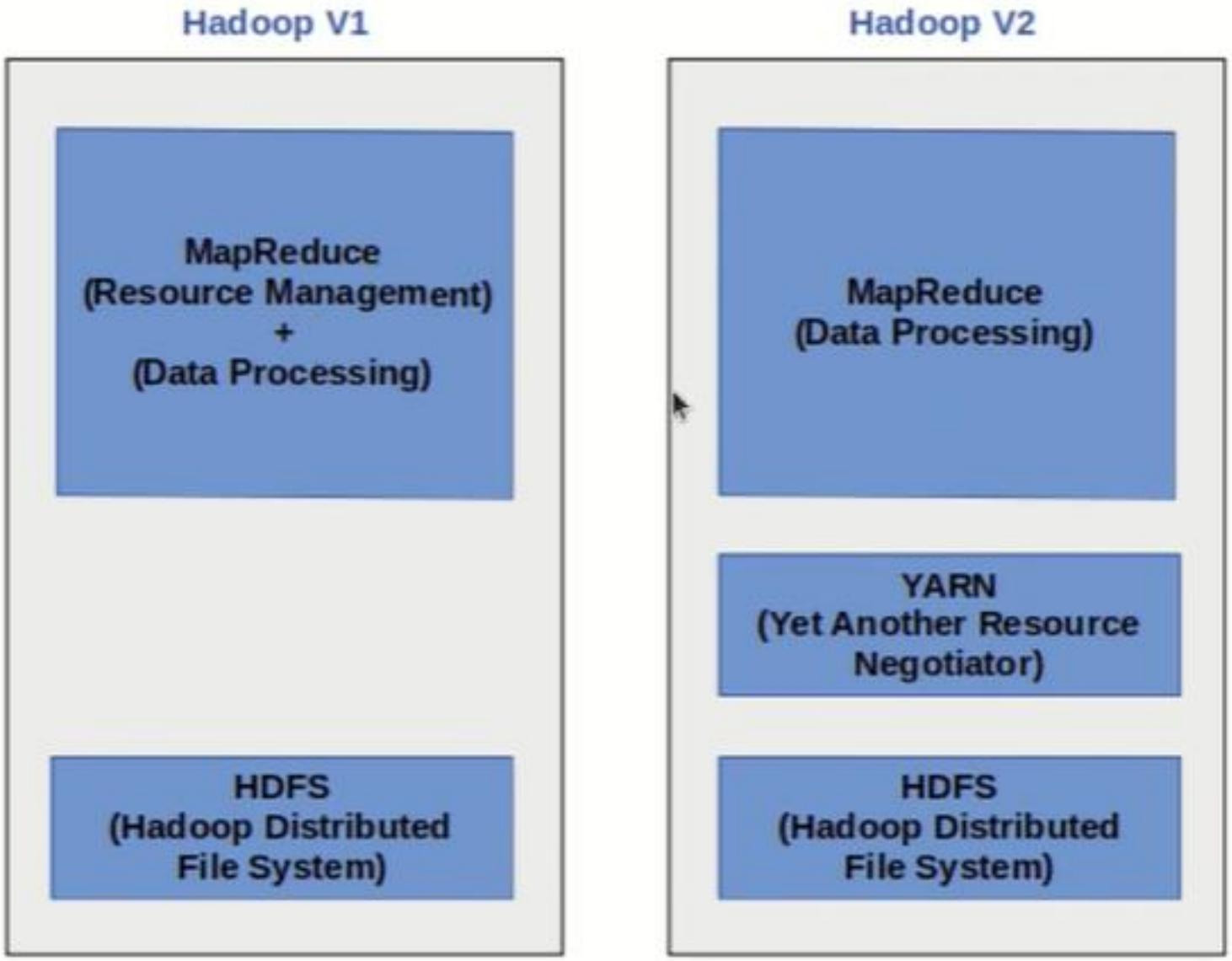
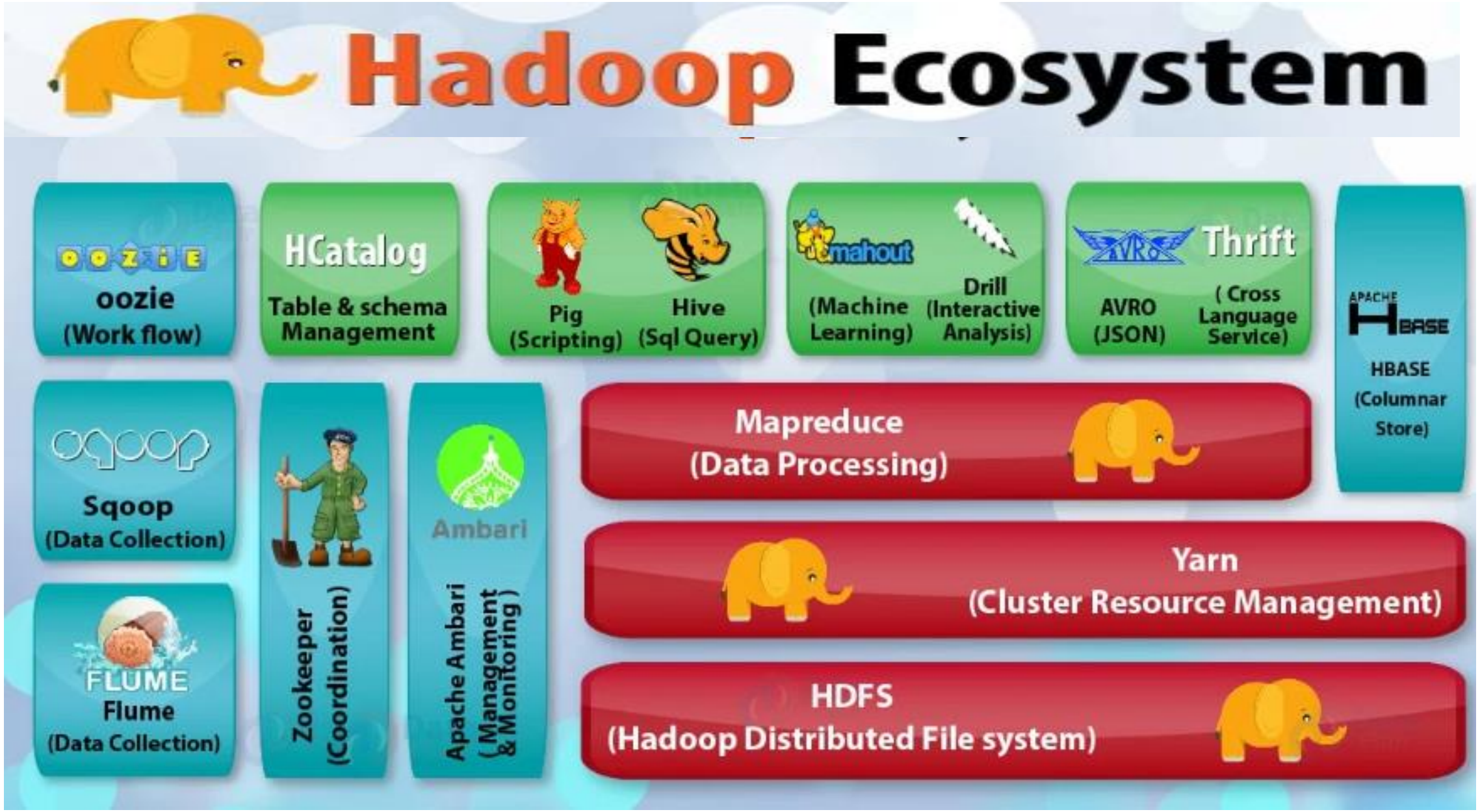
4) Limitation
- Single master multiple slaves
- Multiple masters and slaves

5) Cluster capability
- Around 5000 nodes
- Around 10000 nodes

6) Ecosystem
- Less services and tools
- More services and tools

# Hadoop V1 vs Hadoop V2




Hadoop Ecosystem
oozie
(Work flow)
HCatalog
Table & schema Management
Pig
(Scripting)
Hive
(Sql Query)
mahout
(Machine Learning)
Drill
(Interactive Analysis)
AVRO
(JSON)
Thrift
( Cross Language Service)
APACHE HBASE
HBASE
(Columnar Store)
Sqoop
(Data Collection)
Zookeeper
(Coordination)
Ambari
Apache Ambari
( Management & Monitoring )
Mapreduce
(Data Processing)
FLUME
Flume
(Data Collection)
Yarn
(Cluster Resource Management)
HDFS
(Hadoop Distributed File system)

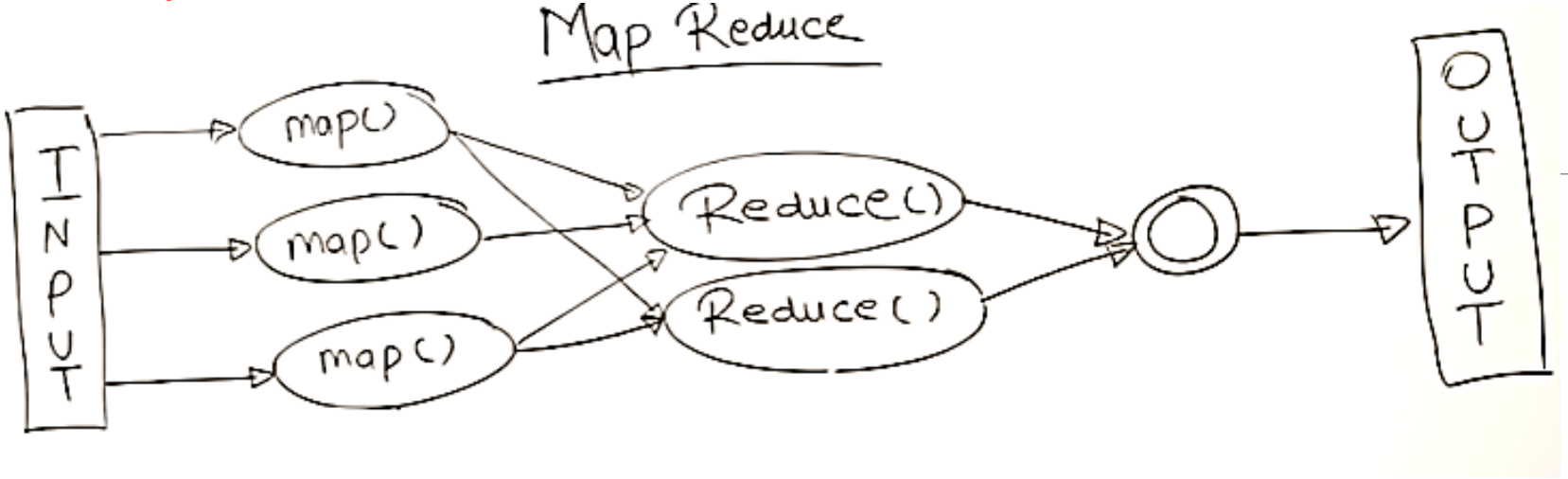
# Hadoop Technology

- Hadoop is Open Source tool from the Apache Software Foundation. As the open source project, we can even change the source codes of the Hadoop system. Most of the Hadoop codes are written by Yahoo, IBM, Cloudera etc.
- Hadoop provides parallel processing through different commodity hardware simultaneously.
- As it works on Commodity hardware so the cost is very low. Commodity hardware is low-end and very cheap hardware. So the Hadoop Solution is also economic

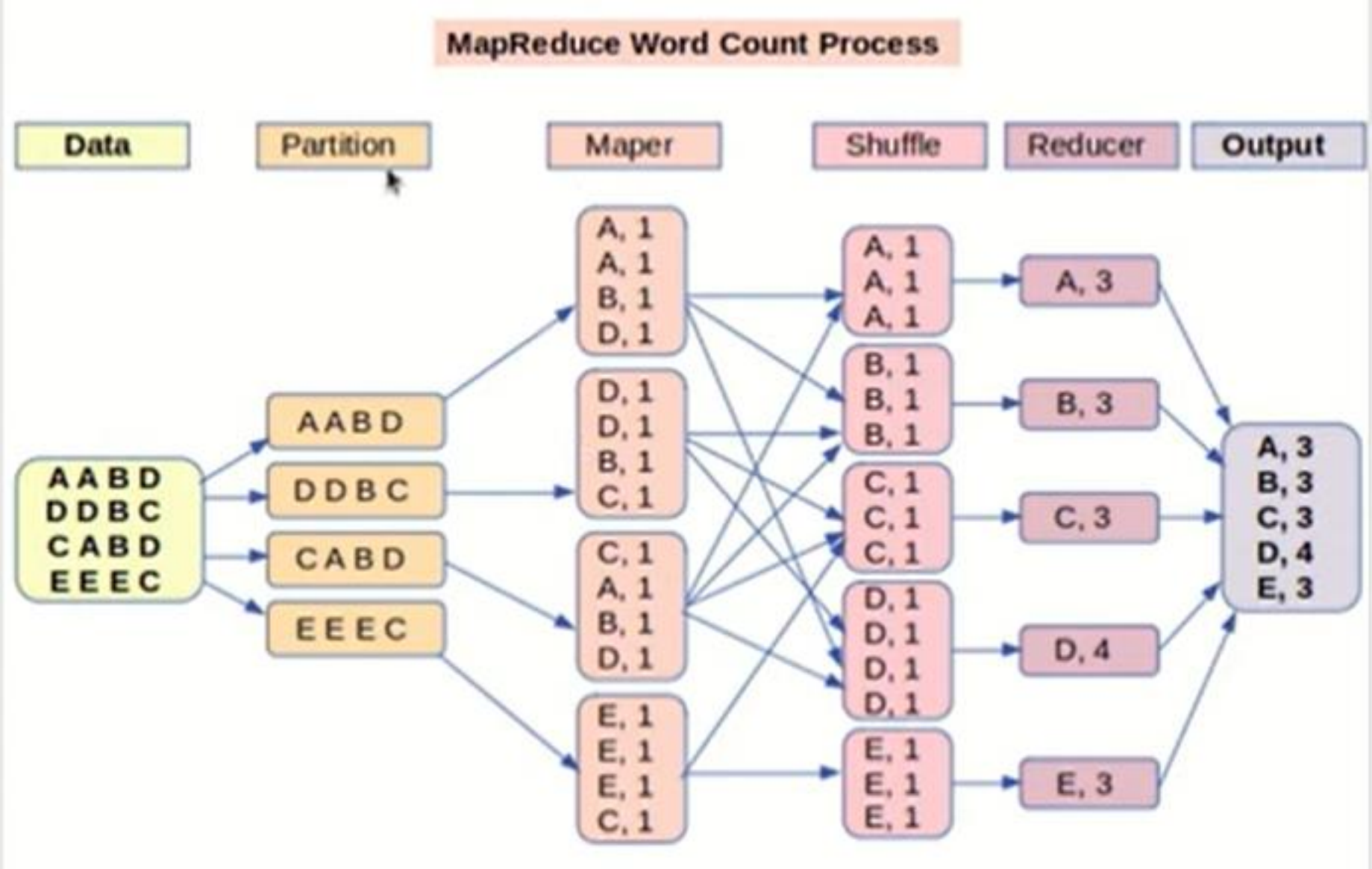
# Why TO Use Hadoop?

- The Hadoop solution is very popular. It has captured at least 90% of Big data market.
- Hadoop has some unique features that make this solution very popular.
- Hadoop is Scalable. So we can increase the number of commodity hardware easily.
- It is a fault tolerant solution. When one node goes down other nodes can process the data.
- Data can be stored as a Structured, Unstructured and semi-structured mode. So it to more flexible.

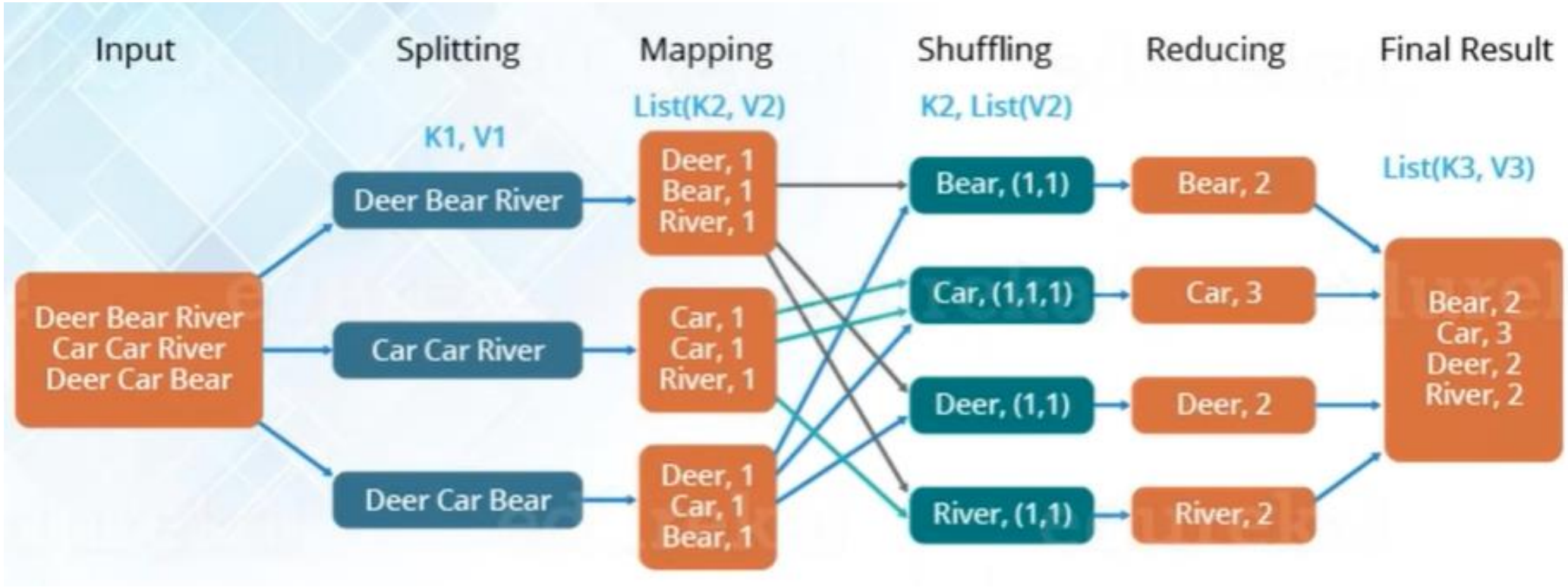
# MapReduce:



# MapReduce


MapReduce Word Count Process
Data
Partition
Maper
Shuffle
Reducer
Output
AABD
DDBC
CABD
EEEC
AABD
DDBC
CABD
EEEC
A, 1
A, 1
B, 1
D, 1
D, 1
D, 1
B, 1
C, 1
C, 1
A, 1
B, 1
D, 1
E, 1
E, 1
E, 1
C, 1
A, 1
A, 1
A, 1
B, 1
B, 1
B, 1
C, 1
C, 1
C, 1
D, 1
D, 1
D, 1
D, 1
E, 1
E, 1
E, 1
A, 3
B, 3
C, 3
D, 4
E, 3
A, 3
B, 3
C, 3
D, 4
E, 3

# Phases of MapReduce: Word Count



# MapReduce : Case Study (Paper Correction and Identifying Topper)

- Map : Parallelism , Reduce : Grouping
- Total = 20 Papers
- Time = 1 min/Paper

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Without (MPP):

- 20 Papers Corrections = 20 mins

With (MPP/MapReduce)

- Divide Task – 4 groups / 4 districts (D1, D2, D3, D4) [Divide Tasks – Mapper Class]
- Assign 5 papers- Each district
- To fetch “District Topper” = (D1 =T1, D2= T2, D3 = T3, D4 = T4) = 4 Toppers ; 5 minutes
- To fetch “State Topper” = T1, T2, T3, T4 = Topper; 4 minutes [Aggregation: Reducer Class]
- Total job “To Fetch Topper” = 9 Minutes

- Summary/ Technicality of MapReduce : Time is reduced rapidly in case of MPP application.