

# ISIT312 – Big Data Management

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Introduction to Hadoop

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# ISIT312-Big Data Management

Introduction to Hadoop

# What is Big data?

- With the advancement of technology, the data available for processing are becoming more complex, huge in volume, and of diverse types; they form multitude of unstructured, semi-structured, as well as structured data.

## 40 ZETTABYTES

[ 43 TRILLION GIGABYTES ]  
of data will be created by 2020, an increase of 300 times from 2005

6 BILLION PEOPLE  
have cell phones



WORLD POPULATION: 7 BILLION

## Volume SCALE OF DATA



It's estimated that  
**2.5 QUINTILLION BYTES**  
[ 2.3 TRILLION GIGABYTES ]  
of data are created each day



Most companies in the U.S. have at least  
**100 TERABYTES**  
[ 100,000 GIGABYTES ]  
of data stored



# The FOUR V's of Big Data

From traffic patterns and music downloads to web history and medical records, data is recorded, stored, and analyzed to enable the technology and services that the world relies on every day. But what exactly is big data, and how can these massive amounts of data be used?

As a leader in the sector, IBM data scientists break big data into four dimensions: **Volume, Velocity, Variety and Veracity**

Depending on the industry and organization, big data encompasses information from multiple internal and external sources such as transactions, social media, enterprise content, sensors and mobile devices. Companies can leverage data to adapt their products and services to better meet customer needs, optimize operations and infrastructure, and find new sources of revenue.

By 2015  
**4.4 MILLION IT JOBS**  
will be created globally to support big data, with 1.9 million in the United States



The New York Stock Exchange captures

**1 TB OF TRADE INFORMATION**  
during each trading session



## Velocity ANALYSIS OF STREAMING DATA

By 2016, it is projected there will be

**18.9 BILLION NETWORK CONNECTIONS**

— almost 2.5 connections per person on earth



Modern cars have close to  
**100 SENSORS**  
that monitor items such as fuel level and tire pressure



As of 2011, the global size of data in healthcare was estimated to be

**150 EXABYTES**  
[ 161 BILLION GIGABYTES ]



**30 BILLION PIECES OF CONTENT**  
are shared on Facebook every month

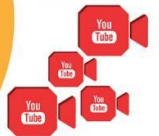


## Variety DIFFERENT FORMS OF DATA



By 2014, it's anticipated there will be  
**420 MILLION WEARABLE, WIRELESS HEALTH MONITORS**

**4 BILLION+ HOURS OF VIDEO**  
are watched on YouTube each month



**400 MILLION TWEETS**  
are sent per day by about 200 million monthly active users



**1 IN 3 BUSINESS LEADERS**

don't trust the information they use to make decisions



Poor data quality costs the US economy around  
**\$3.1 TRILLION A YEAR**



**27% OF RESPONDENTS**

in one survey were unsure of how much of their data was inaccurate

## Veracity UNCERTAINTY OF DATA

# What is big data?

- The terminology used to refer to these multitude of data is **big data**.

## Definition:

- **Big data** is **larger, more complex** data sets, especially from new data sources. These data sets are so **voluminous** that traditional data processing software just **cannot** manage them.

# What is Hadoop?

- Because of the voluminous size and complex form, big data is hard to capture, store, search, share, analyse, and visualize.
- What is the solution?

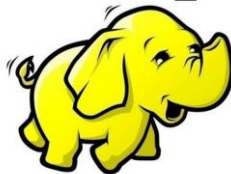


# What is Hadoop?

- Because of the voluminous size and complex form, big data is hard to capture, store, search, share, analyse, and visualize.
- What is the solution?



***hadoop***



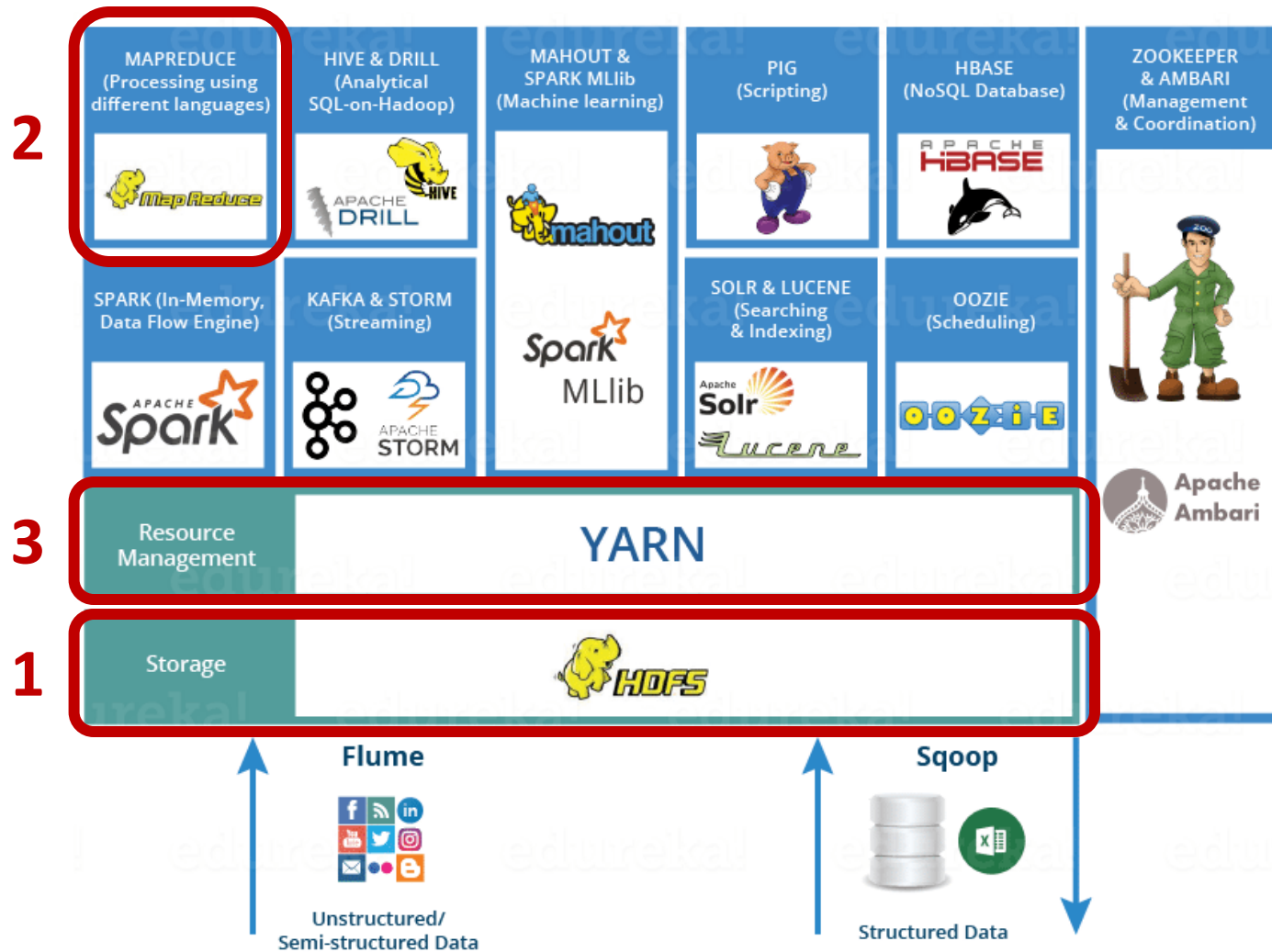
Hadoop to the rescue!!!

# How Hadoop Work?

- Hadoop is a framework that can store and process huge amounts of unstructured data ranging in size from terabytes to petabytes. It is a highly fault-tolerant and highly available system.
- Hadoop consisted of **three components** that were specifically designed to work on big data.
  1. Storage unit – Hadoop **HDFS** (Hadoop Distributed File System)
  2. Hadoop **MapReduce**, and
  3. Hadoop **YARN** (Yet Another Resource Negotiator)



# Hadoop Ecosystem



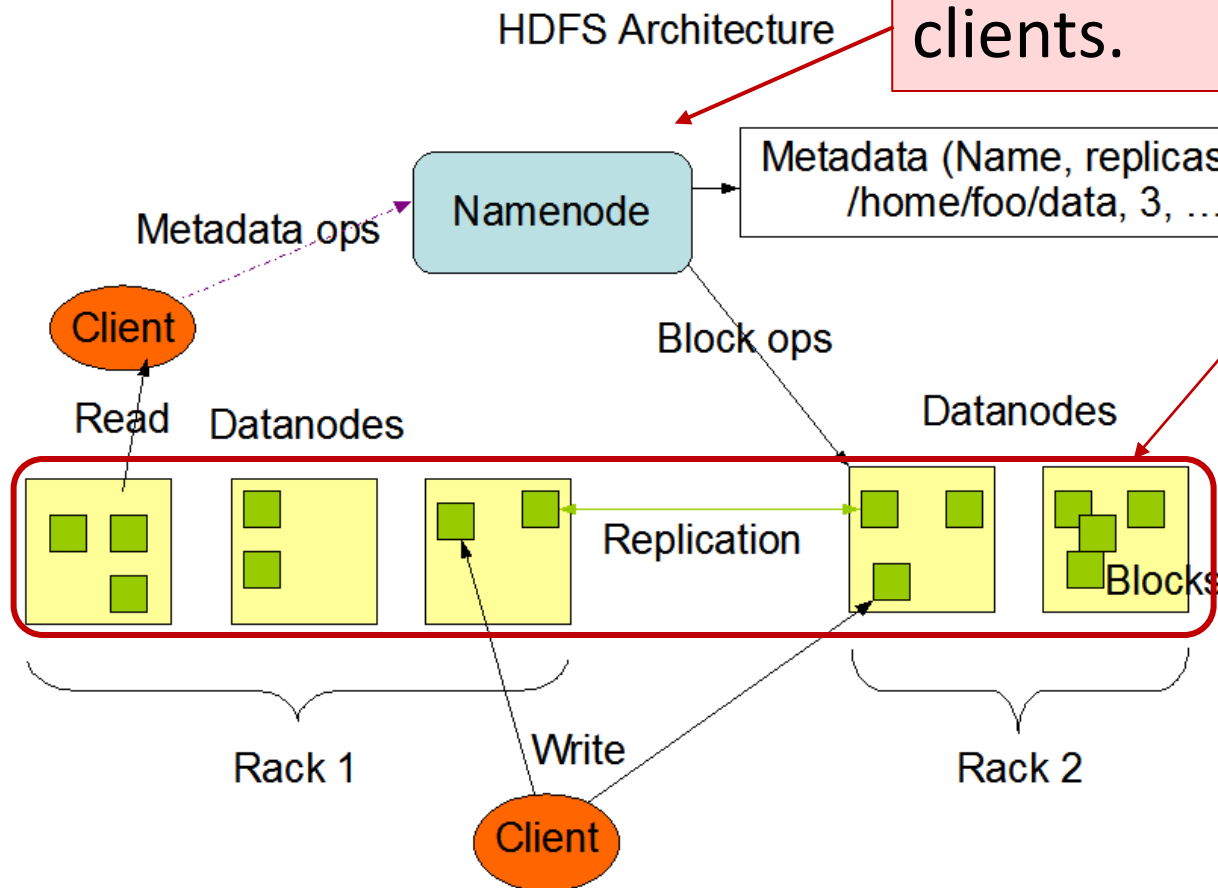
# How Hadoop Work?

## Hadoop HDFS

- The **Hadoop Distributed File System (HDFS)** is a distributed file system designed to run on commodity hardware. It is a storage layer for Hadoop suitable for distributed storage and processing.
- It divides the data into blocks and stores them across multiple systems.
- In this way, data is not lost at any cost, even if one data node crashes. Hence, this makes HDFS a highly fault-tolerant.
- The block size is 128 MB by default.

# Hadoop HDFS

NameNode – A master server that manages the file system namespaces and regulates access to files by clients.



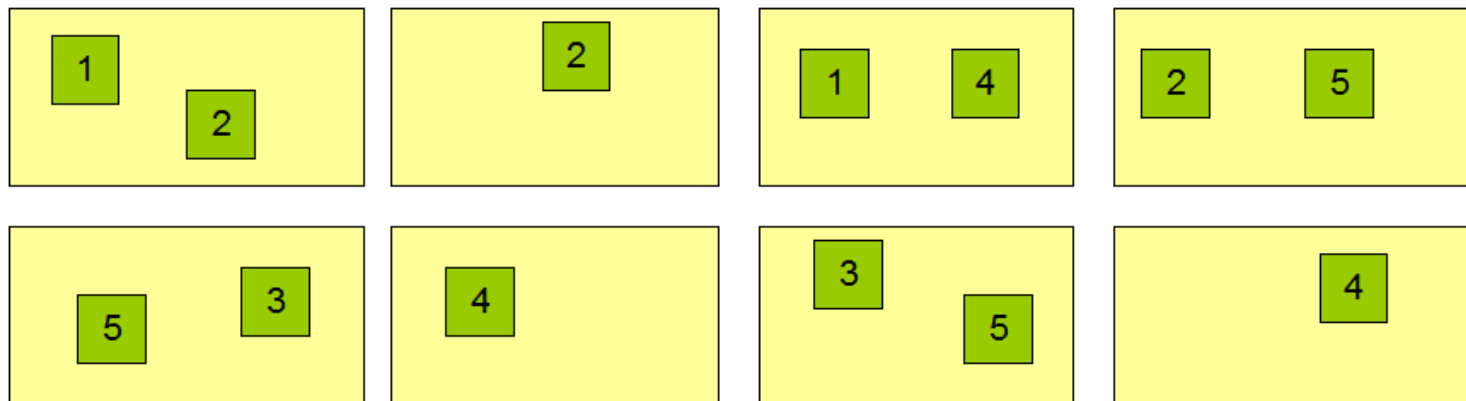
DataNodes – manage storage attached to the nodes that they run on.

# Hadoop HDFS

## Block Replication

Namenode (Filename, numReplicas, block-ids, ...)  
/users/sameerp/data/part-0, r:2, {1,3}, ...  
/users/sameerp/data/part-1, r:3, {2,4,5}, ...

## Datanodes

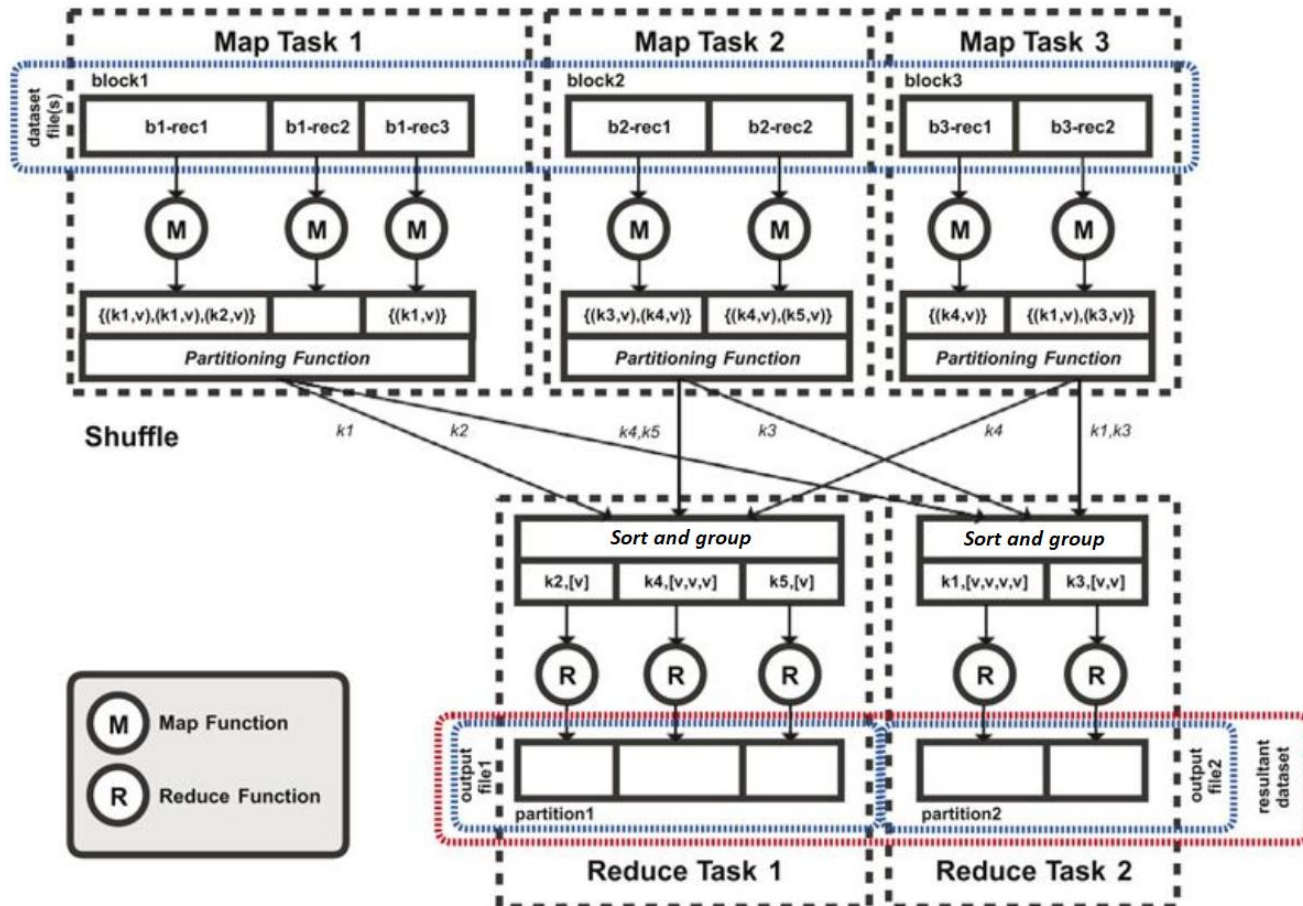


# How Hadoop Work?

## **Hadoop MapReduce**

- Hadoop MapReduce processes the data stored in Hadoop HDFS in parallel across various nodes in the cluster.
- It works in two phases:
  - i. It splits data into parts and processes each of them separately on different data nodes.
  - ii. The individual results are then aggregated to give the final output.

# MapReduce



# MapReduce

Based on a word-count example:

Input Splits:

- Data set is divided into fixed-size chunk (block) that is consumed by a single map.

Mapping:

- Data in each chunk is passed to a mapping function to produce counts of occurrences of each word, and prepare a list of key-value pair where key is the word, and value is the frequency of occurrences.

Shuffling

- Shuffling process will consolidate the relevant records from Mapping phases by clubbing together the same words and accumulate their frequency.

# MapReduce

## Reducing

- In this phase, the output values from the Shuffling phase are aggregated, by combining all the words into a single output, that is, producing a complete dataset.

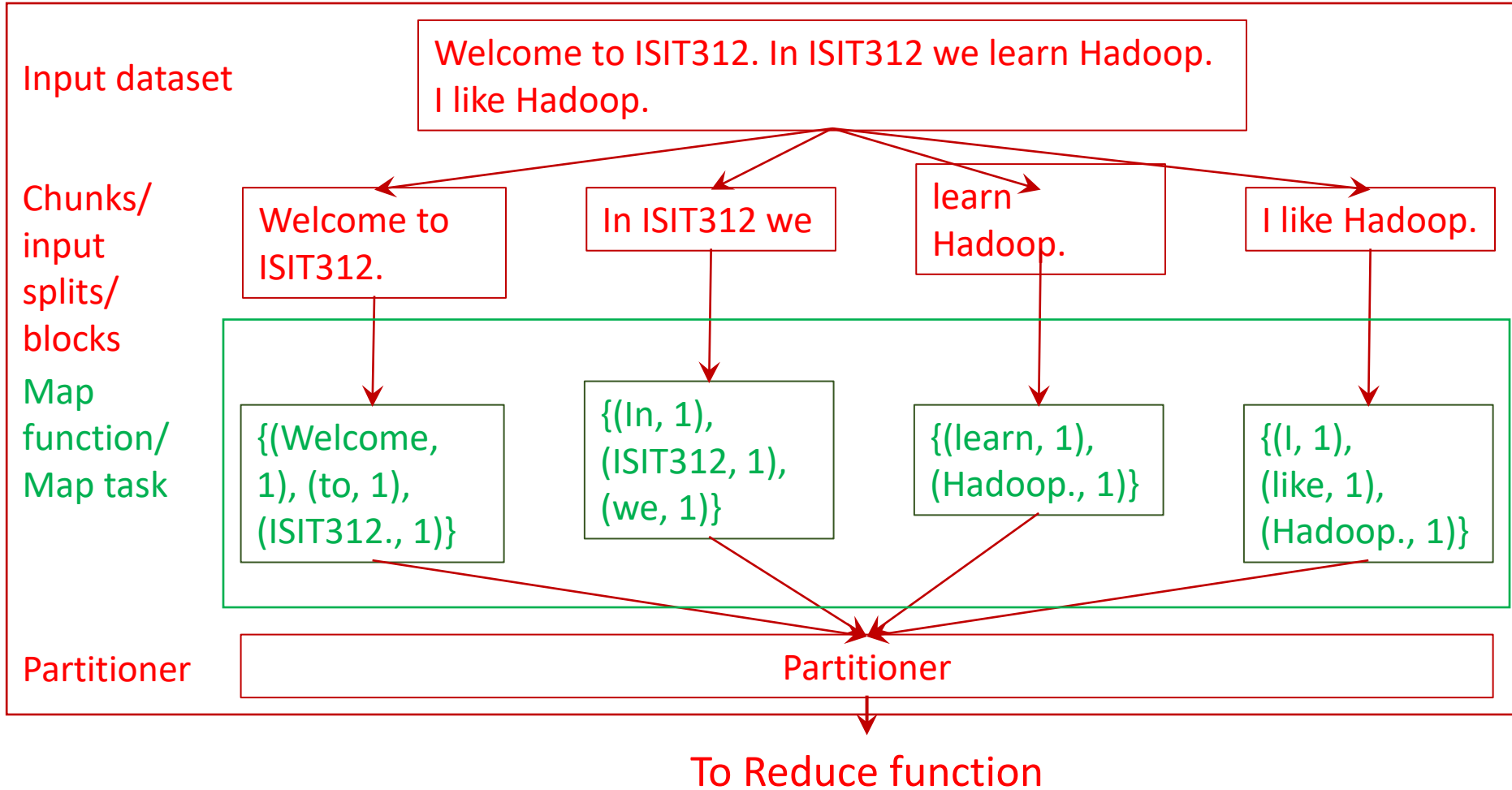


# MapReduce (Without Combiner)

## – Map Phase

- The following example depicts a MapReduce function without a combiner in the Map function.
- Dataset is split into blocks/chunks of fixed size.
- Map function is then assigned to process each block, that is, each Map function operates only one block.
- Each Map function outputs (produces) sets of key-value pair records.
- If without combiner, the sets of key-value pair records are passed to *Partitioner*, which ensures each key-value pair record is passed to one and only one Reducer.

## Map Phase:



# MapReduce (Without Combiner)

## – Reduce Phase

- Input to Reduce Phase is the output from Map Phase, that is, the *Partitioner* ensures each key-value pair is passed to one and only one Reducer.
- The Reduce will perform a sort and group function to sort and group the key-value pair by the key and accumulate the values for each key.
- The Reduce function will then output a set consisting of all the key-value pairs.
- Note: A reducer may be receiving input from multiple Map functions.

From Map function

## Reduce Phase:

Shuffling

Sort and group

Reduce function

{(Hadoop., 1),  
(Hadoop., 1)}

{(I,  
1)}

{(In, 1)}

{(ISIT312,  
1)}

{(learn,  
1)}

{(like,  
1)}

{(to,  
1)}

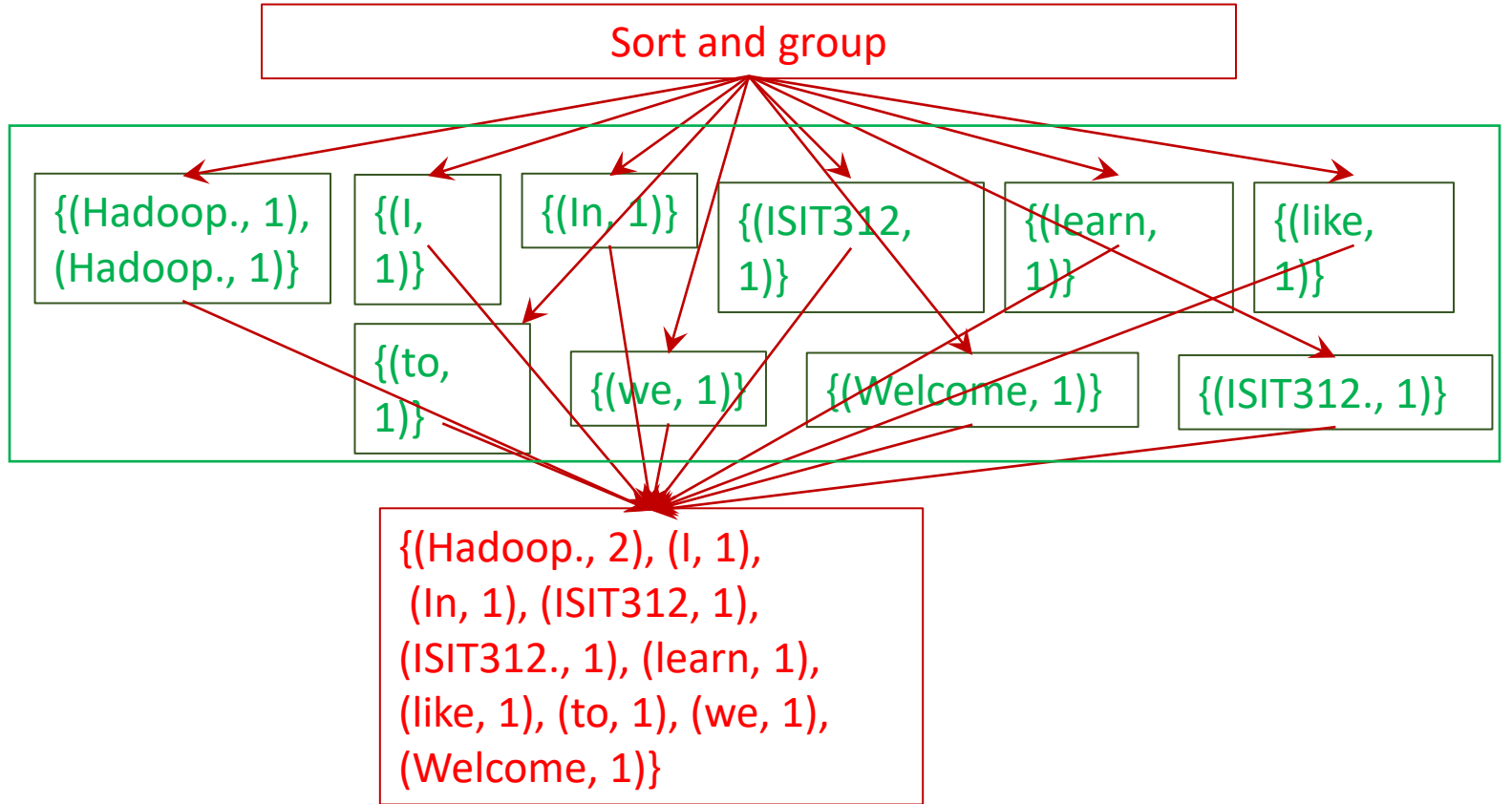
{(we, 1)}

{(Welcome, 1)}

{(ISIT312., 1)}

Output

{(Hadoop., 2), (I, 1),  
(In, 1), (ISIT312, 1),  
(ISIT312., 1), (learn, 1),  
(like, 1), (to, 1), (we, 1),  
(Welcome, 1)}



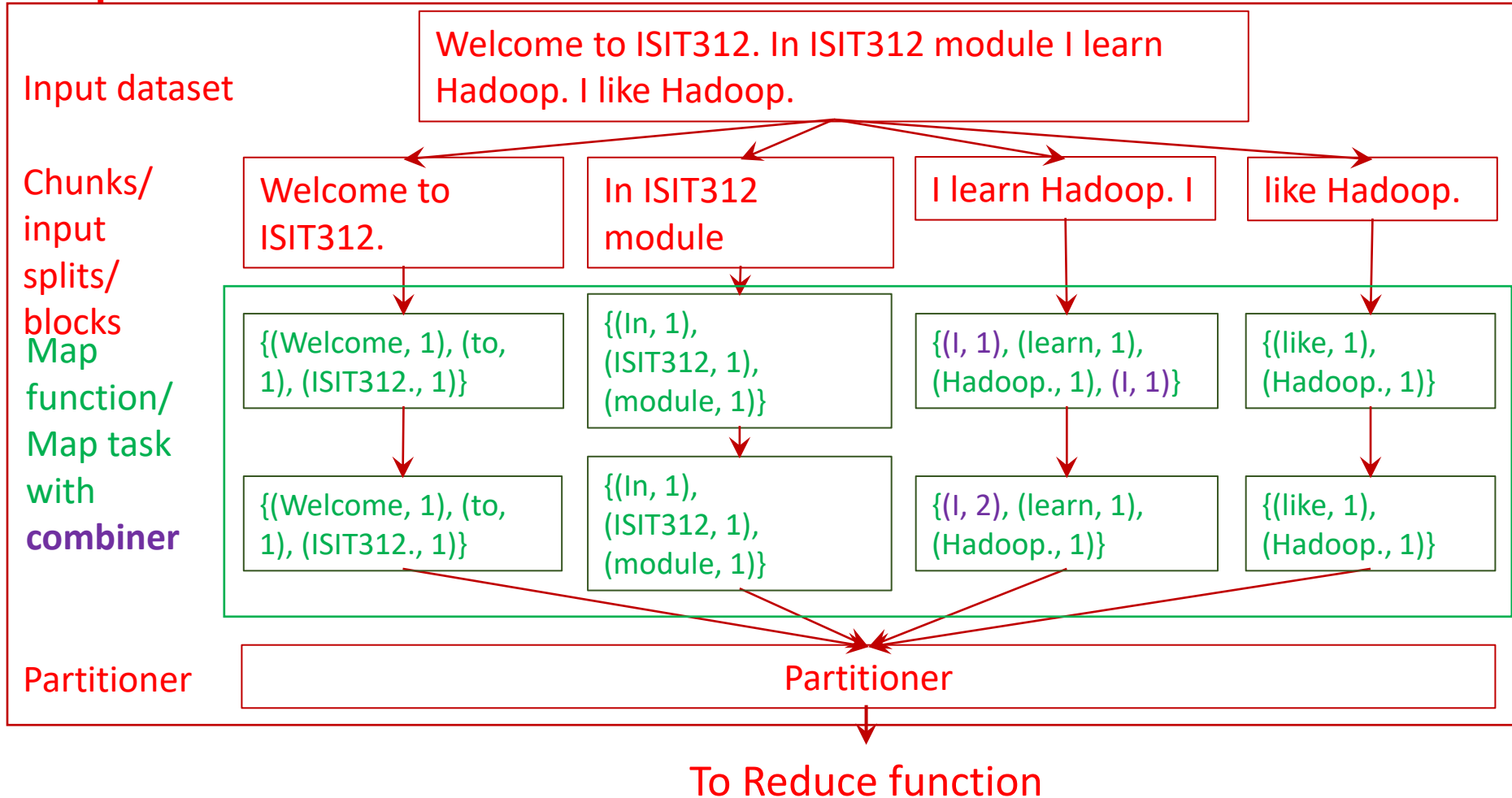
# MapReduce (With Combiner) – Map Phase

- The following example depicts a MapReduce function with a combiner in the Map function.
- Dataset is split into blocks/chunks of fixed size.
- Map function is then assigned to process each block, that is, each Map function operates only one block.
- Each Map function outputs (produces) sets of key-value pair records.

# MapReduce (With Combiner) – Map Phase

- Combiner performs sum or count function to combine each key and its value before passing the key-aggregateValue pairs to *Partitioner*, which ensures each key-aggregateValue pair record is passed to one and only one Reducer.

## Map Phase:



# MapReduce (With Combiner) – Reduce Phase

- Input to Reduce Phase is the output from Map Phase, that is, the *Partitioner* ensures each key-value pair is passed to one and only one Reducer.
- The Reduce will perform a sort and group function to sort and group the key-value pair by the key and accumulate the values for each key.
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From Map function

## Reduce Phase:

Shuffling

Sort and group

Reduce function

{(Hadoop., 1),  
(Hadoop., 1)}

{(I, 2)}

{(In, 1)}

{(ISIT312, 1)}

{(learn, 1)}

{(like, 1)}

{(module, 1)}

{(to, 1)}

{(Welcome, 1)}

{(ISIT312., 1)}

Output

{(Hadoop., 2), (I, 2),  
(In, 1), (ISIT312, 1), (ISIT312.,  
1), (learn, 1), (like, 1),  
(module, 1), (to, 1),  
(Welcome, 1)}

# How Hadoop Work?

- The MapReduce processes (shown earlier), improve load balancing and saves a considerable amount of time.
- Now that we have the output of MapReduce jobs ready, it is time for us to run them on the Hadoop cluster. This is done with the help of a set of resources such as RAM, network bandwidth and CPU.
- Multiple jobs are run on Hadoop simultaneously, and each of them needs some resources to complete the task successfully.

# How Hadoop Work?

- To efficiently manage these resources, we have the third component of Hadoop, that is YARN.

## **YARN (Yet Another Resource Negotiator)**

- YARN is responsible for sharing resources amongst the applications running in the cluster and scheduling the task in the cluster.
- It consists of a resource manager, node manager, application master, and containers.

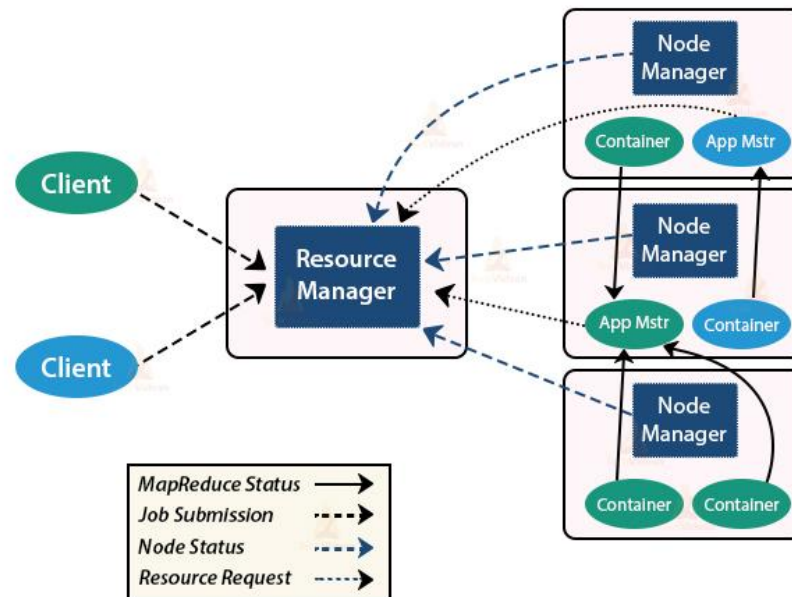
# How Hadoop Work?

- The resource manager assigns resources.
- The node managers handle the nodes and monitor the resources usage in the node.
- The containers hold a collection of physical resources.
- Now, suppose we want to process the MapReduce jobs, we had created,
  - i. The application master requests the container from the node manager
  - ii. Once the node manager gets the resources, it sends the jobs to the resource manager.

# How Hadoop Work?

- This YARN processes job requests and manages cluster resources in Hadoop.

## Apache Hadoop YARN



# How Hadoop Work?

- In addition to these components, Hadoop also has various data tools and frameworks dedicated to managing, processing, and analysing data.
- These tools and frameworks are also commonly referred to as the Hadoop echosystem.

# Hadoop Ecosystem

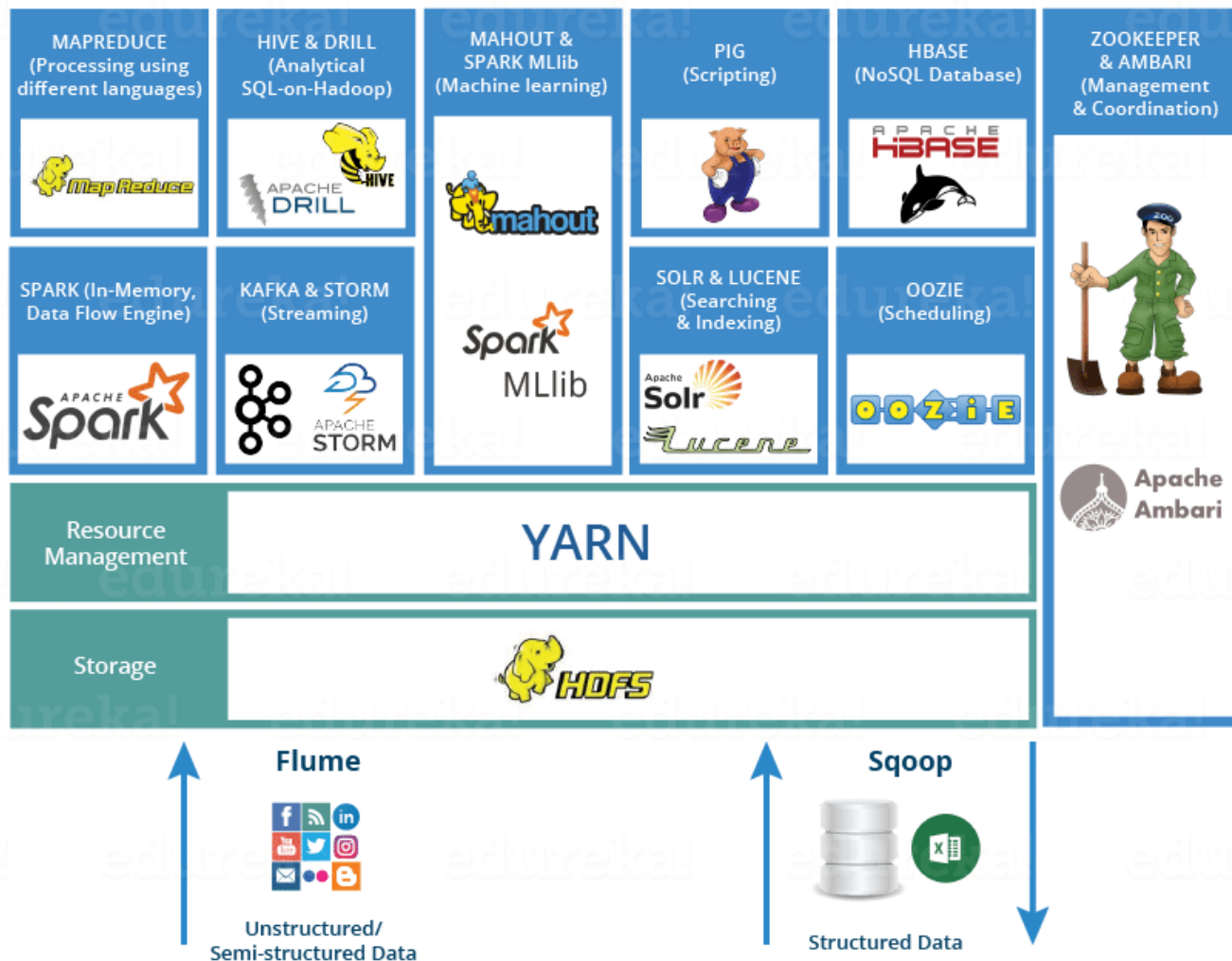
- The Hadoop ecosystem comprises of several other components such as:
  - Hive (Analytical SQL on Hadoop),
  - Pig (Scripting),
  - Apache Spark (In-Memory, Data flow engine)
  - Spark Mlib (Machine Learning),
  - Apache Hbase (NoSQL database),
  - Apache Zookeeper and Ambari (Management and coordination),
  - KAFKA and STORM (Streaming),

# Hadoop Ecosystem

- The Hadoop ecosystem comprises of several other components such as: (continue...)
  - SOLR and LUCENE (Searching and Indexing),
  - OOZIE (Scheduling)
  - Flume (Unstructured/semi-structured data), and
  - Sqoop (Structured data)



# Hadoop Ecosystem



# References

- <https://www.oracle.com/in/big-data/what-is-big-data/>
- [https://hadoop.apache.org/docs/r1.2.1/hdfs\\_design.html](https://hadoop.apache.org/docs/r1.2.1/hdfs_design.html)

Other useful links:

- <https://hadoop.apache.org/docs/r3.1.0/api/org/apache/hadoop/fs/FileSystem.html>
- <https://www.techtarget.com/searchdatamanagement/definition/Hadoop-Distributed-File-System-HDFS>