Amirkabir University of Technology
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Cloud Computing

Apache Hadoop

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Apache Hadoop

- Apache Hadoop is the driving force behind the big data industry.
- It is an open-source, Java-based framework.
- Hadoop …
  - Stores data (Hadoop Distributed File System – HDFS)
  - Executes jobs (MapReduce) on large clusters of commodity servers.
- Hadoop is highly fault tolerant and it is scalable from a single server to thousands of servers.

Hadoop Components

- ***Common***
  - Utilities supporting the other Hadoop modules, components, etc.
- ***MapReduce (YARN)***
  - A framework for job scheduling and cluster resource management.
  - It is a programming model and an execution engine running on clusters of commodity servers.
- ***HDFS***
  - A distributed file system running on clusters of commodity computers.

Hadoop Components (cont.)

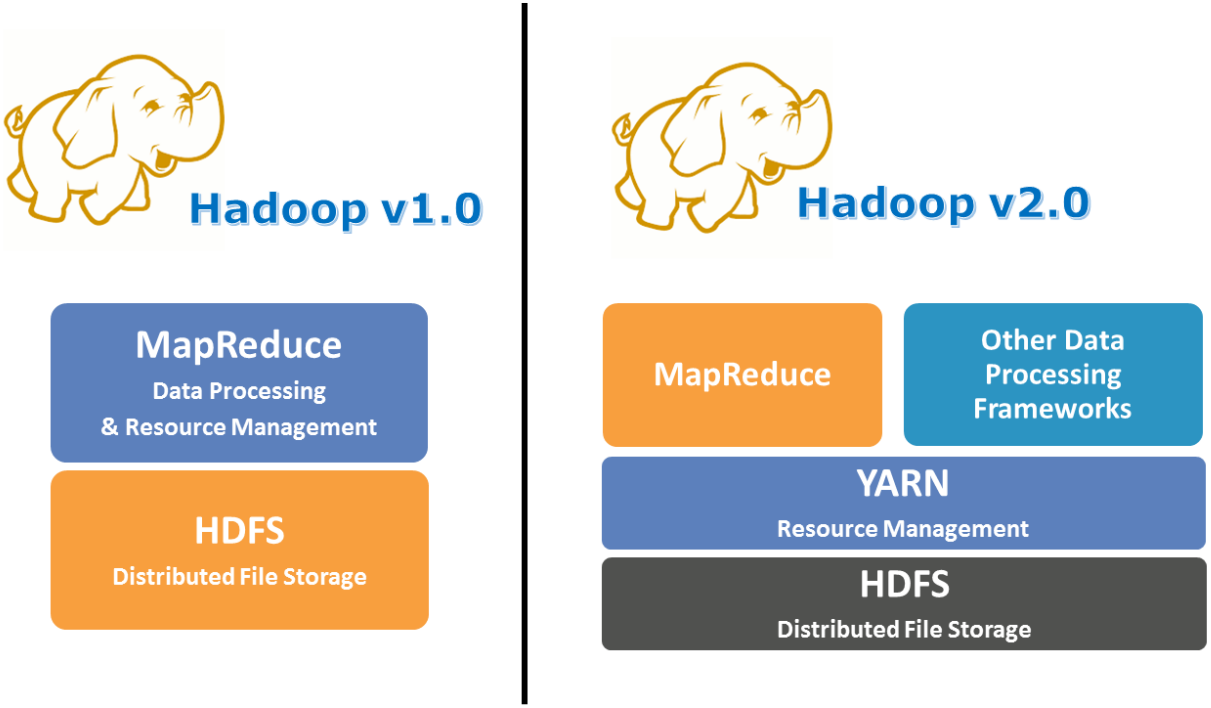
- ***Hbase***
  - A distributed, column-oriented database.
- ***Sqoop***
  - A tool for transfer of data between structured data and HDFS.
- ***ZooKeeper***
  - A distributed, highly available coordination service.
- ***Pig***
  - A data-flow language and an execution engine for big data.

Hadoop Components (cont.)

- ***Ambari***
  - A Web-based tool for provisioning, managing, and monitoring Hadoop clusters.
- ***Hive***
  - A distributed data warehouse.
- ***Cassandra***
  - A scalable multimaster database with no single points of failure.

Hadoop MapReduce v.2

- **YARN (Yet Another Resource Negotiator)**
  - The major new improvement introduced in Hadoop v2.



https://www.h2kinfosys.com/blog/hadoop-yarn-tutorial-learn-the-fundamentals-of-yarn-architecture/

Hadoop MapReduce v.2

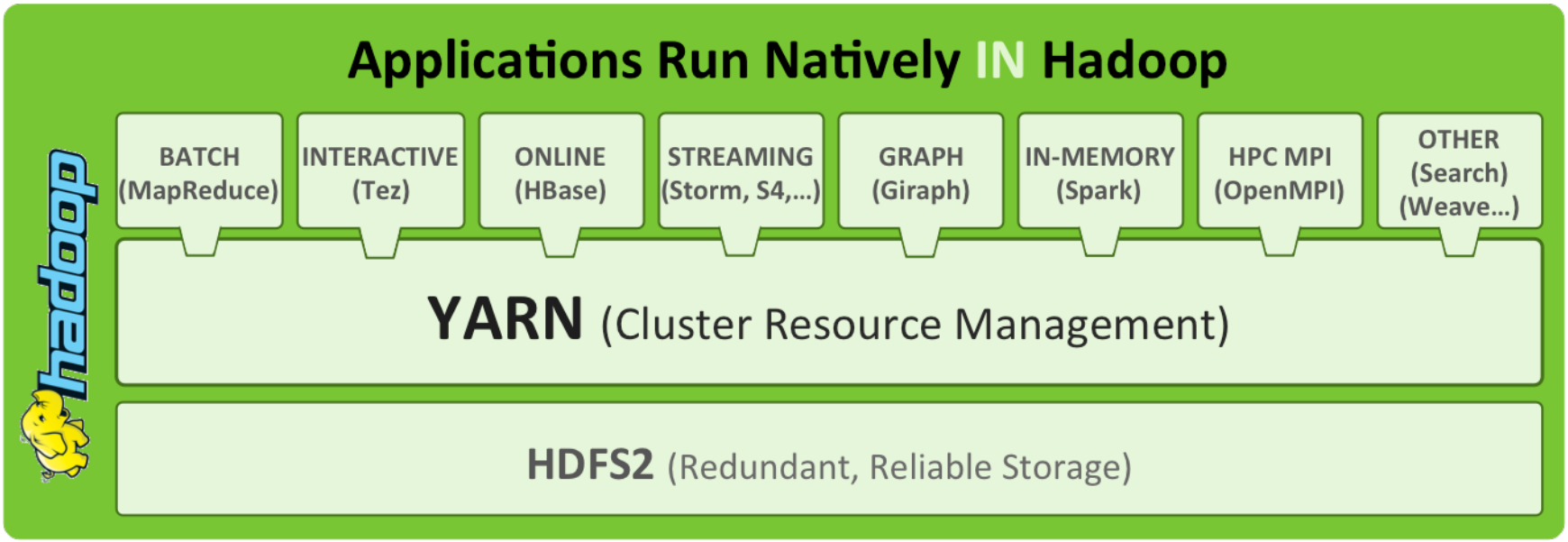
YARN is a resource management system that allows ***multiple distributed processing frameworks*** to effectively share the compute resources of a Hadoop cluster and to utilize the data stored in HDFS.

Hadoop MapReduce v.2 (cont.)

- YARN is **a central component** in the Hadoop v2 ecosystem and provides a common platform for many different types of distributed applications.

- Some examples of the current YARN applications include:
  - The **MapReduce** framework
  - **Spark** processing engine
  - The Storm real-time stream processing framework

Hadoop YARN



https://devveri.com/hadoop/hadoop-2-0-yarn

Hadoop YARN (cont.)

- The **YARN ResourceManager** process is the central resource scheduler that manages and allocates resources to the different applications (also known as jobs) submitted to the cluster .

- **YARN NodeManager is a per node process** that manages the resources of a single compute node .

Hadoop YARN (cont.)

- Scheduler component of the ResourceManager allocates resources in response to the applications resource request.

- Factors taken into consideration:
  - The cluster capacity
  - The other scheduling policies that can be specified through the YARN policy plugin framework.

Hadoop YARN (cont.)

- YARN has a concept called **containers**, which is the unit of resource allocation.
  - Each allocated container has the rights to a certain amount of CPU and memory in a particular compute node.
  - Applications can request resources from YARN by specifying the required number of containers and the CPU and memory required by each container.

Hadoop YARN (cont.)

- ApplicationMaster is a per-application process that coordinates the computations for a single application.

- The first step of executing a YARN application is to deploy the ApplicationMaster.

Hadoop YARN (cont.)

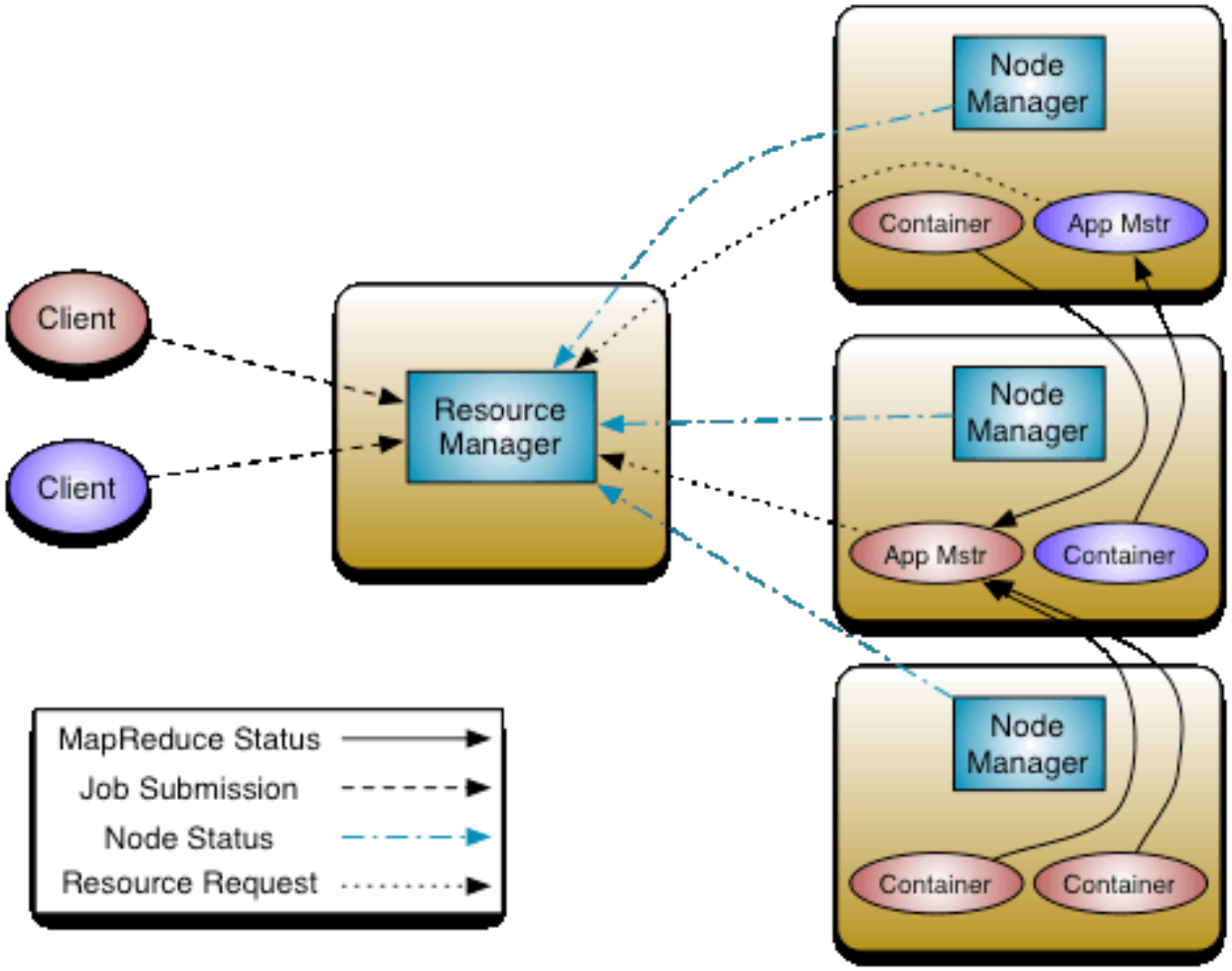
- After an application is submitted by a YARN client, the ResourceManager allocates a container and deploys the ApplicationMaster for that application.

- Once deployed, the ApplicationMaster is responsible for requesting and negotiating the necessary resource containers from the ResourceManager.

Hadoop YARN (cont.)

- Once the resources are allocated by the ResourceManager, ApplicationMaster coordinates with the NodeManagers to launch and monitor the application containers in the allocated resources.

Hadoop MapReduce (cont.)



https://hadoop.apache.org/docs/stable/hadoop-yarn/hadoop-yarn-site/YARN.html

Hadoop MapReduce (cont.)

- A MapReduce **job** is a unit of work that the client wants to be performed.
  - It consists of the **input data**, the **MapReduce program**, and **configuration information**.

- Hadoop runs the job by dividing it into tasks, of which there are two types: **map tasks** and **reduce tasks.**

Hadoop MapReduce (cont.)

- Hadoop divides the input to a MapReduce job into fixed-size pieces called **input splits**, or just **splits**.

- Hadoop creates **one map task for each split**, which runs the user defined map function for each record in the split.

Hadoop MapReduce (cont.)

- For most jobs, a good split size tends to be the size of an HDFS block, 64 MB by default.

- Hadoop does its best **to run the map task on a node where the input data resides in HDFS**.

- **Why does Hadoop do this?**

Hadoop MapReduce (cont.)

- Hadoop does its best **to run the map task on a node where the input data resides in HDFS**.

- This is called the **data locality optimization**
  - It should now be clear why the optimal split size is the same as the block size.

- **Map tasks write their output to the local disk, not to HDFS**
  - Because the Map output is intermediate output, not the final output.

Hadoop MapReduce (cont.)

- Reduce tasks don't have the advantage of data locality.

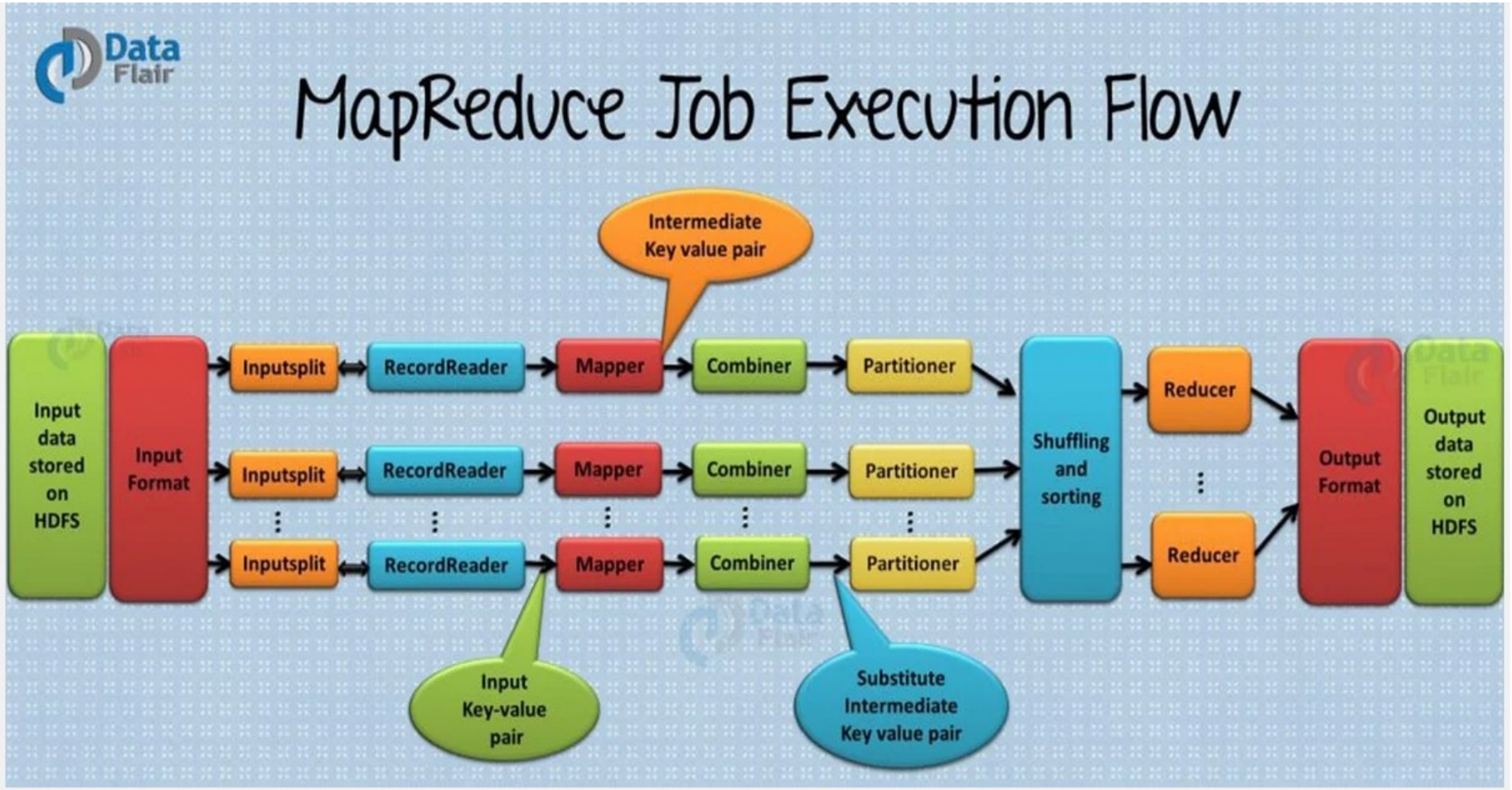
- When there are multiple reducers, the map tasks **partition** their output, each creating one partition for each reduce task.

Hadoop MapReduce (cont.)

- There can be many keys (and their associated values) in each partition, but the records for **any given key are all in a single partition.**

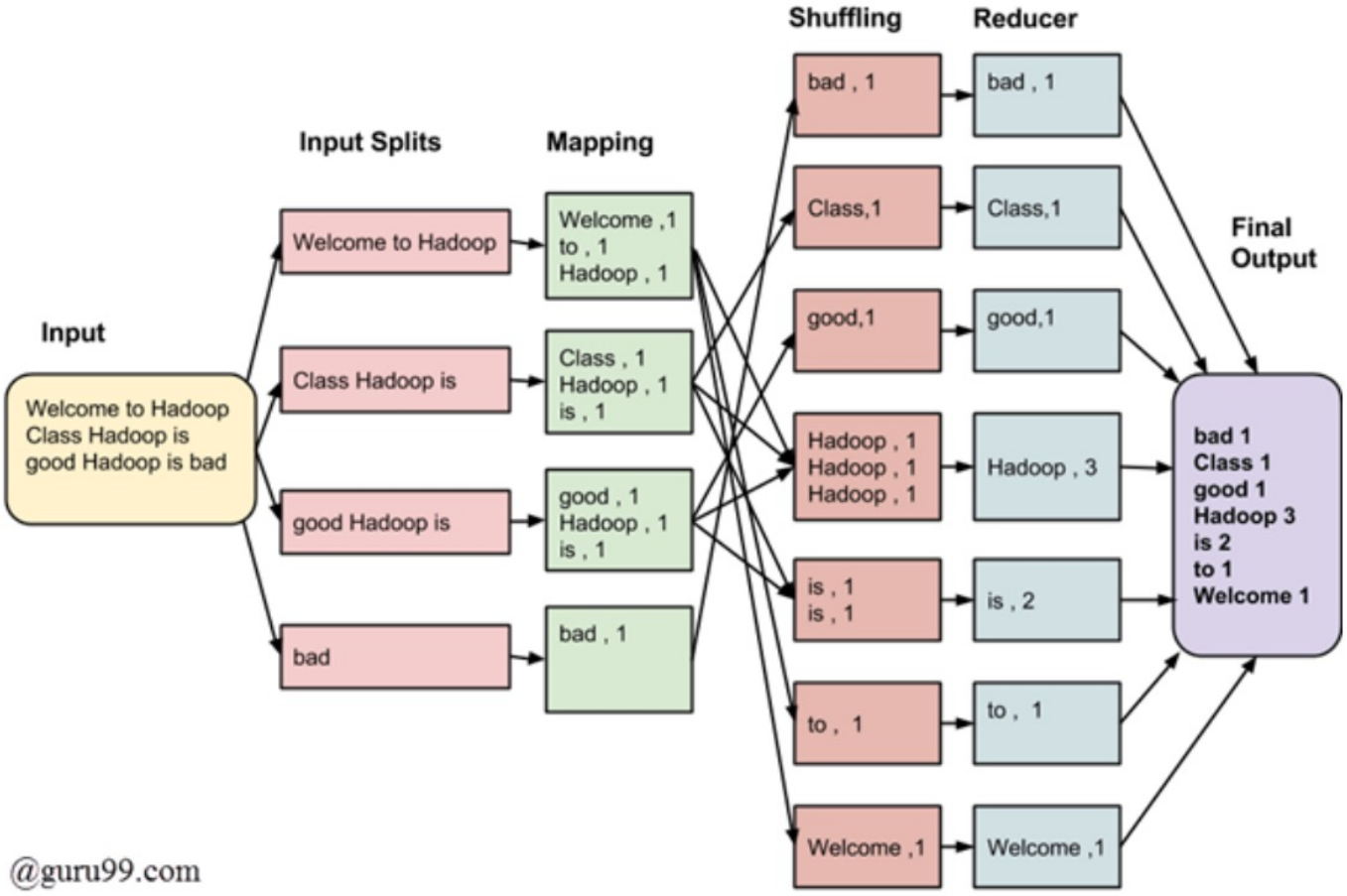
- The partitioning can be controlled by a user-defined partitioning function, but normally the default partitioner works very well.
  - Default partitioner buckets keys using a **hash function**.

MapReduce Job Execution Flow



https://data-flair.training/blogs/how-hadoop-mapreduce-works/

MapReduce Example



https://www.guru99.com/introduction-to-mapreduce.html

MapReduce on Utility Clouds

- Amazon offers an analytic cloud service called Amazon Elastic MapReduce (EMR) which provides a managed Hadoop MapReduce on Amazon EC2 instances.

- Microsoft also offers a big data service, which is called Windows Azure HDInsight Service, which deploys and provisions ApacheHadoop clusters in the Azure cloud.

MapReduce on Utility Clouds (cont.)

- AppEngine-MapReduce is an open-source library for doing MapReduce-style computations on the Google App Engine platform with pricing that is completive with Amazon EMR.