



Learning & Development

Enabling development, Impacting growth...

BIG-04

HADOOP – Module 02

INSIGHTS&DATA

Module outline

- Hadoop
 - History of Hadoop
 - Distributed File System
 - What is Hadoop
 - Characteristics of Hadoop
 - RDBMS Vs Hadoop
- Hadoop Generations
 - Components of Hadoop
- HDFS Blocks and Replication
 - How Files Are Stored
- HDFS Commands
- Hadoop Daemons
- Q & A

History of Hadoop

- Oct 2003: Google File system paper published
- Dec 2004: Jeffrey Dean & Sanjay Ghemawat from Google published MapReduce paper called “MapReduce: Simplified Data Processing on Large Clusters”
- Jan 2006: Above MapReduce Paper inspired Doug cutting, a yahoo employee then to develop an open source implementation of MapReduce framework
- Jan 2006: Hadoop subproject created as extension of Apache Nutch project, created by Doug Cutting.
- Apr 2006: Hadoop 0.1.0 released
- May 2006: Yahoo deploys 300 machine Hadoop cluster
- 2008: Cloudera, one of the major distributor of Hadoop founded



Hadoop was named after Doug Cutting's son's toy elephant.

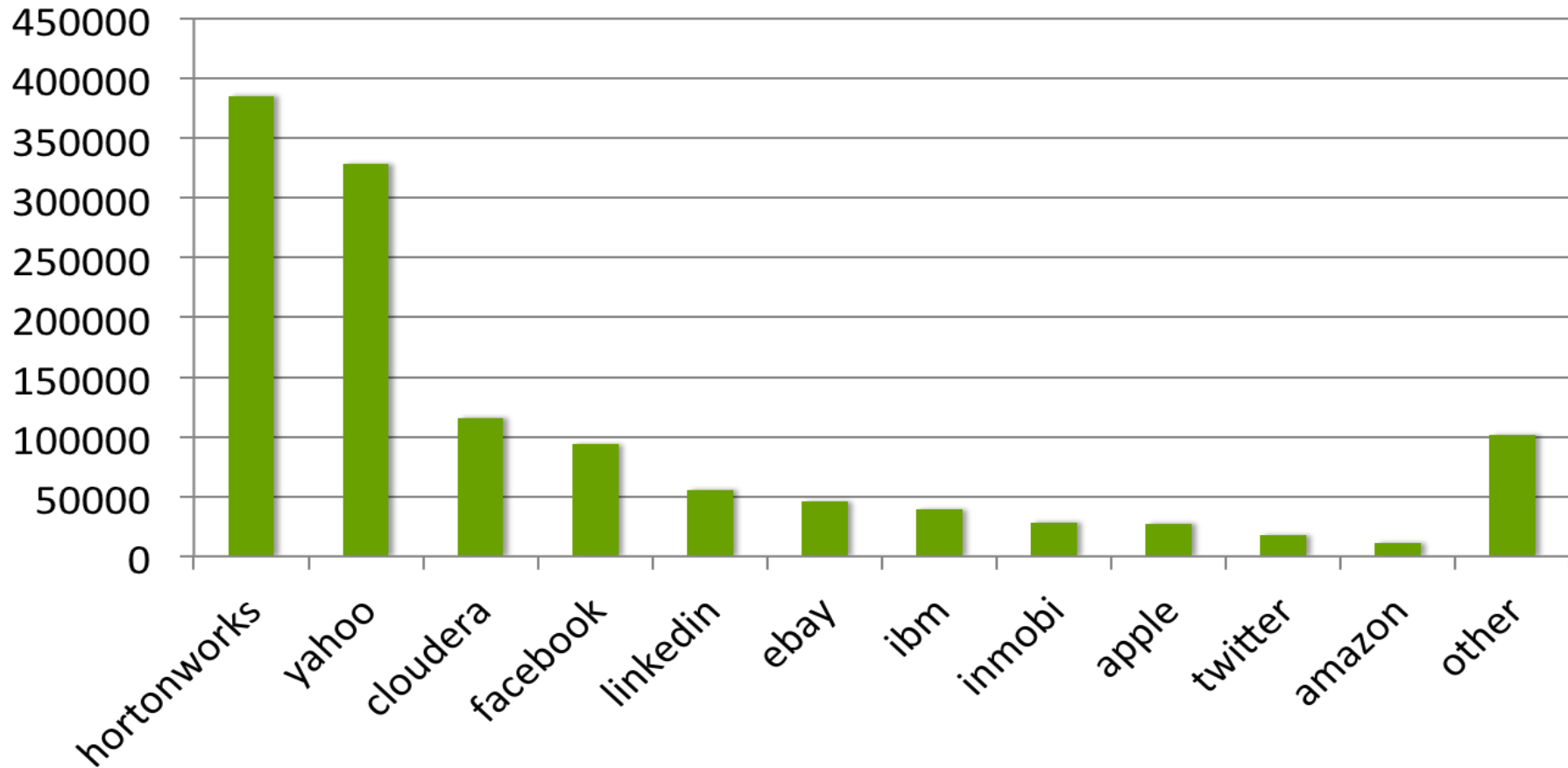
History of Hadoop(continued)

- Apr 2007: Yahoo runs 2 clusters of 1,000 machines
- Jul 2008: Hadoop wins TeraByte sort benchmark
(1st time a Java program won this competition)
- Jun 2010: Yahoo 4,000 nodes/70 petabytes
- Jun 2010: Facebook 2,300 clusters/40 petabytes
- Dec 2011: Apache Hadoop release 1.0.0 available
- 2011: Hortonworks, another major Hadoop distributor founded
- Oct 2013: Apache Hadoop release 2.2.0 (YARN)
- Dec 2015: Apache Hadoop release 2.6.3 available
- Feb 2016: Apache Hadoop release 2.6.4 available

- Source: <http://hadoop.apache.org/#News>
 - https://en.wikipedia.org/wiki/Apache_Hadoop#Papers

Contributions 2006 - 2011

Lines of Code Contributed Since 2006, Cloudera Method



(Source: . <http://hortonworks.com/blog/reality-check-contributions-to-apache-hadoop/>)

Quiz

1. Who was the creator of Hadoop?

- A. Sanjay Ghemawat
- B. Michael Franklin
- C. Doug Cutting
- D. Jeffrey Dean

2. What was Hadoop named after?

- A. Creator's favorite circus act
- B. The toy elephant of creator's son
- C. Creator's high school rock band
- D. A sound Creator's laptop made during Hadoop development

Quiz-Answers

1. Who was the creator of Hadoop?

- A. Sanjay Ghemawat
- B. Michael Franklin
- C. Doug Cutting
- D. Jeffrey Dean

C: Doug Cutting

2. What was Hadoop named after?

- A. Creator's favorite circus act
- B. The toy elephant of creator's son
- C. Creator's high school rock band
- D. A sound Creator's laptop made during Hadoop development

B: The toy elephant

Distributed File System (DFS)

Read 1 TB Data



1 Machine

50 Minutes



10 Machines

5 Minutes

What is Hadoop

- Hadoop is not a :
 - Database
 - Big Data
 - Networking Concept
 - Data warehouse
 - Programming Language

Then What Hadoop is.....??



What is Hadoop(continued)

- **Hadoop** is a framework that allows distributed processing of large data sets across clusters of commodity computers using simple programming models.

Definition In Depth:

- Distributed Processing :
 - Data is processed in multiple machines in a distributed manner
- Large Data sets:
 - Large data sets in this context means files that are hundreds of megabytes, gigabytes, or terabytes in size
- Clusters of commodity computers :
 - Cheap hardware (not expensive servers) are used to create a cluster
- Simple Programming Model:
 - Map Reduce/Spark is used as a programming model to manipulate/process the data

Characteristics of Hadoop

- **Scalable:** It can reliably store and process petabytes of data and can be scaled up anytime whenever required without any adverse impact of cluster.
- **Economical:** It distributes the data and processing across clusters of commonly available computers (in thousands).
- **Efficient:** By distributing the data, it can process it in parallel on the nodes where the data is located.
- **Reliable:** It automatically maintains multiple copies of data and automatically redeploys computing tasks based on failures.

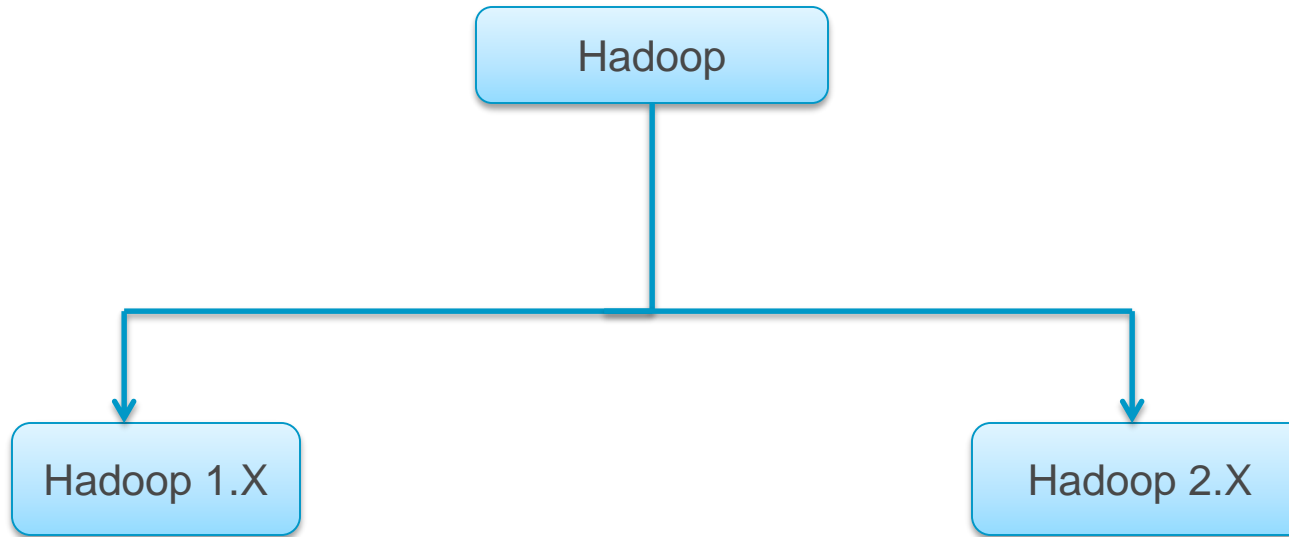
Relational DB vs. Hadoop



- Expensive dedicated HW
- Built for **performance**
- Designed for **high volumes** (eg 10s of TB)
- High availability
- Initially developed using Relational Data bases
- Supports only **modelled and structured data**
- Business As Usual ways to design, build and deliver
- Very mature solutions (skills, SW, HW, administration)
- Teradata, Oracle Exadata, IBM Netezza, ...

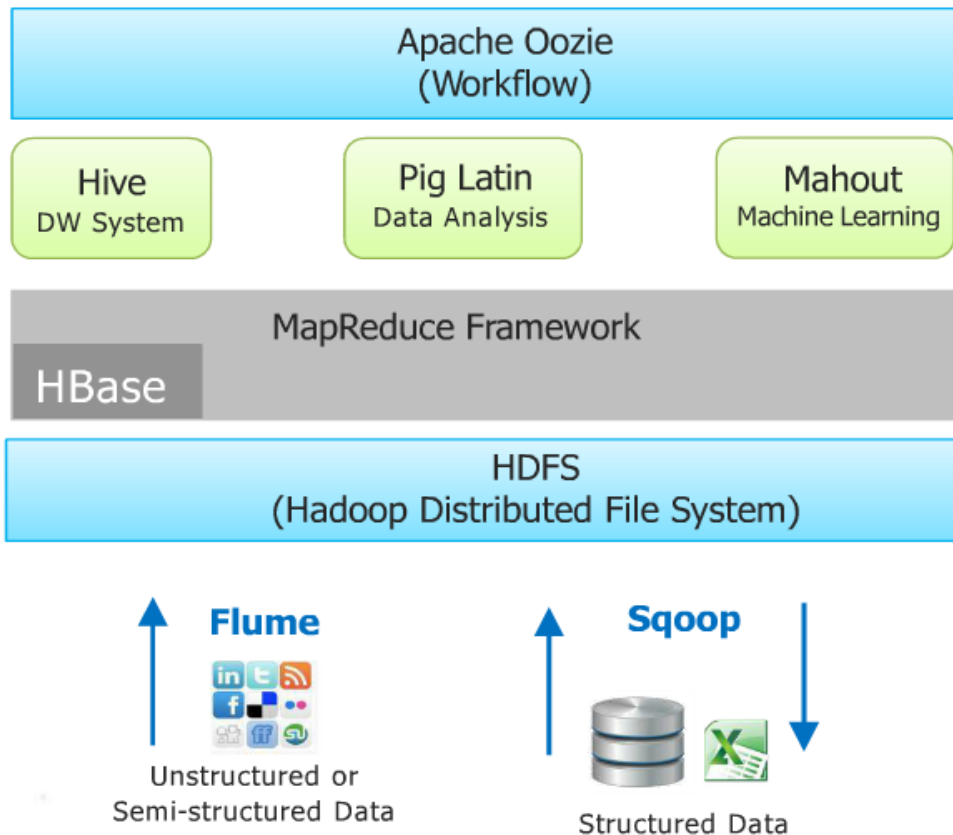
- Uses commodity PCs
- Built for **extreme scalability**
- Designed for **extreme volumes** (10s of PB and more)
- Very high availability (clouds like Amazon distributed all around the world)
- Initially developed by Google for storing Petabytes of web pages for ranking
- Not yet fully mature
- Hadoop = Data is distributed over many machines
- MapReduce = Computing is distributed and executed where data is (grid solution)
- Works on **Write Once read many times** approach

Generations of Hadoop

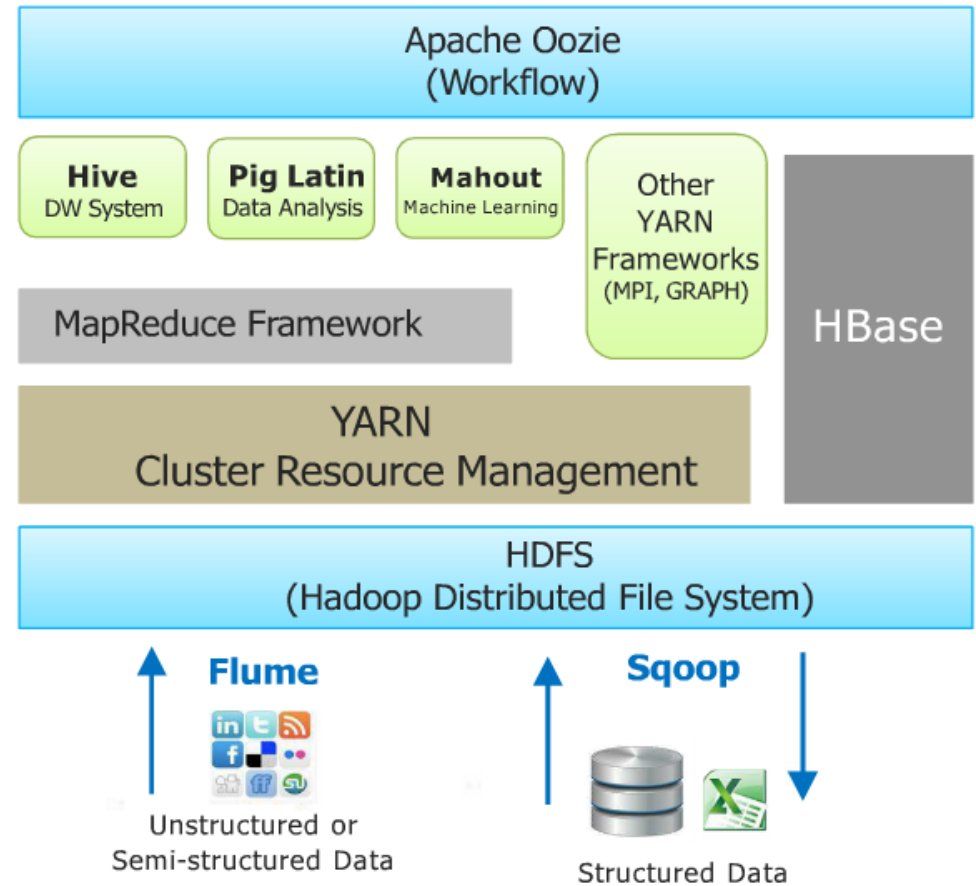


Hadoop Ecosystem

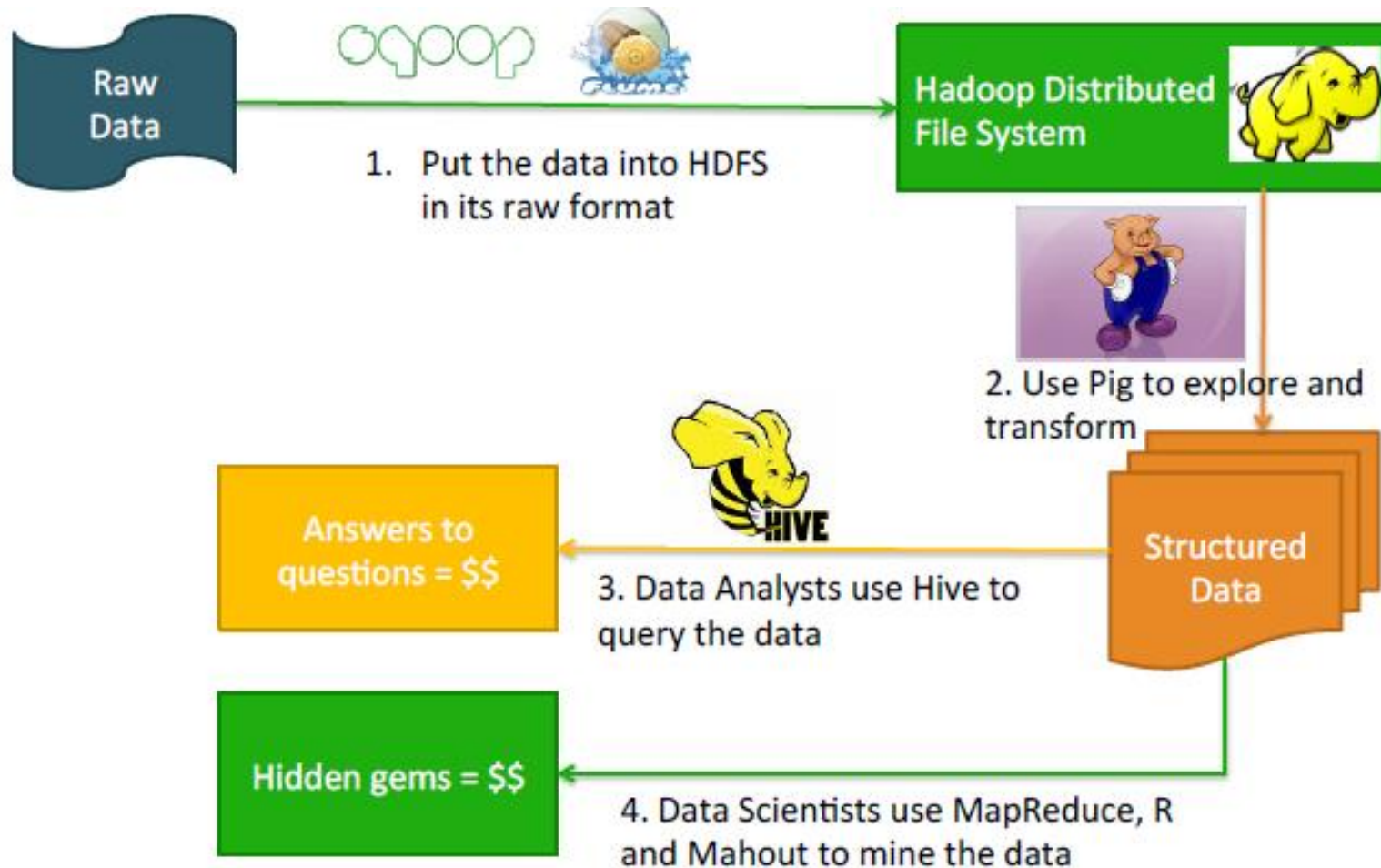
Hadoop 1.0



Hadoop 2.0



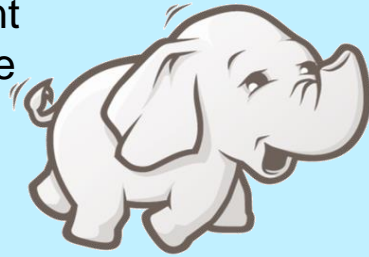
Usage of Hadoop and its eco-systems



Components of Hadoop

Hadoop is a platform for data storage and processing that is...

- ✓ Scalable
- ✓ Fault tolerant
- ✓ Open source



CORE HADOOP COMPONENTS

Hadoop Distributed File System (HDFS)

File Sharing & Data Protection Across Physical Servers



MapReduce

Distributed Computing Across Physical Servers

Components of Hadoop(continued)

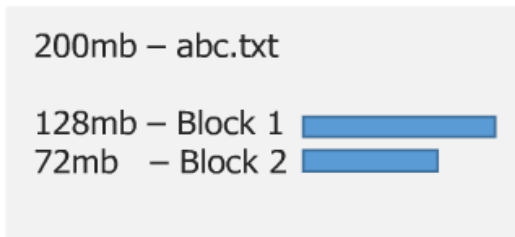
- Two core components of Hadoop :
 1. Hadoop Distributed File System (HDFS)
 2. Map Reduce
- HDFS :
 - Is the storage part of Hadoop framework
 - Data is stored in files under directories
 - Files are always divided into blocks
- Map Reduce :
 - Is the programming/processing model of Hadoop framework
 - Is responsible for manipulation or processing on data
 - Preferably written as java programs

HDFS Blocks & Replication

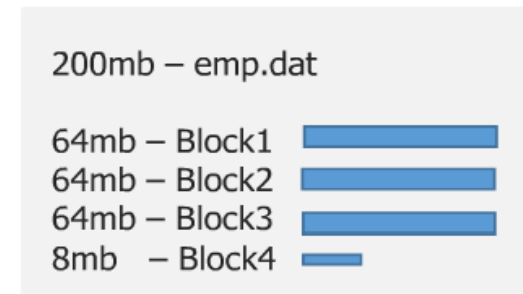
- Data files are divided into blocks and distributed across multiple nodes in the cluster
 - Each block is typically multiple of 64 MB in size in Hadoop 1.X and 128 MB in Hadoop 2.X

→ By Default, block size is **128mb** in Hadoop 2.x and **64mb** in Hadoop 1.x

Hadoop 2.x



Hadoop 1.x

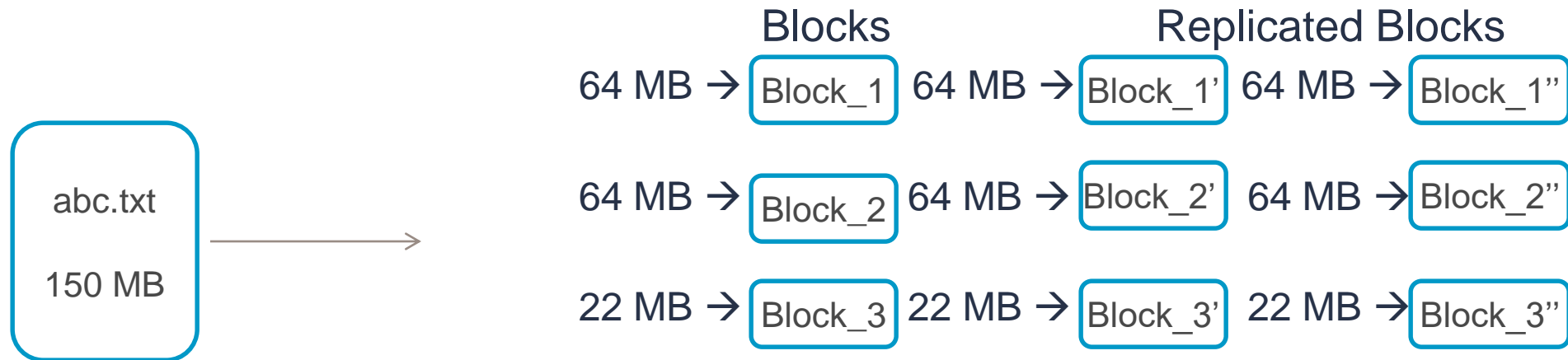


→ Why block size is large?

- » The main reason for having the HDFS blocks in large size is to reduce the cost of seek time.
- » The large block size is to account for proper usage of storage space while considering the limit on the memory of name node.

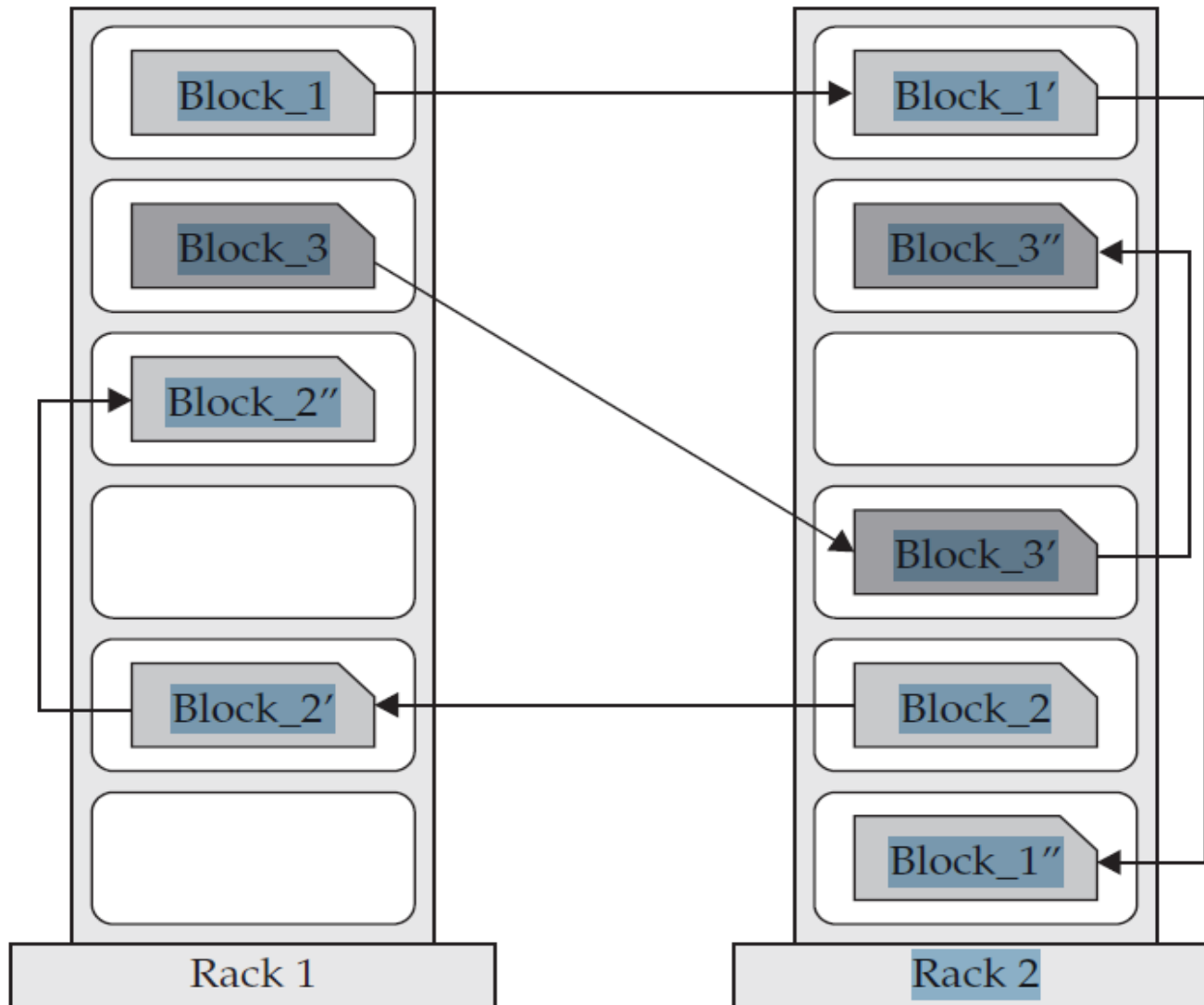
HDFS Blocks & Replication(continued)

- Each block is replicated multiple times
 - Default replication factor is 3 (configurable)
 - Replicas are stored on different nodes
 - This ensures both reliability and availability



Considered Hadoop 1.X in above example.

Rack Awareness



How Files Are Stored

- Files are split into blocks
- Data is distributed across many machines at load time
 - Different blocks from the same file will be stored on different machines
 - This provides for efficient MapReduce processing.
- Blocks are replicated across multiple machines, known as Data Nodes
 - Default replication is three-fold meaning that each block exists on three different machines
- A master node called the Name Node keeps track of which blocks make up a file, and where those blocks are located
 - Known as the metadata

How Files Are Stored: Example

- Name Node holds metadata for the two files (Foo.txt and Bar.txt)
- Data Nodes hold the actual blocks
 - Each block will be 64 MB or 128 MB in size
 - Each block is replicated three times on the cluster

NameNode

Foo.txt: blk_001, blk_002, blk_003

Bar.txt: blk_004, blk_005

DataNodes



Fault Tolerance in Hadoop

- If a data node fails, the master(Name Node) will detect that failure and re-assign the task to a different node on the cluster
- Restarting a task does not require communication with nodes working on other portions of the data
- If a failed node recovers, it is automatically added back to the cluster and assigned new tasks
- If a node appears to be running slowly, the master can redundantly execute another instance of the same task
 - Results from the first to finish will be used
 - Known as 'speculative execution'

Quiz

1. What is Hadoop?

- A. Database
- B. Framework
- C. Programming Language
- D. File

2. What is a Hadoop cluster?

- A. Group of machines connected in a network
- B. Group of machines sharing same software
- C. Group of connected machines running HDFS & Map Reduce
- D. Group of machines sharing same printer

Quiz-Answers

1. What is Hadoop?

- A. Database
- B. Framework
- C. Programming Language
- D. File

B: Framework

2. What is a Hadoop cluster?

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**C: Group of Machines
Running HDFS & MR**

Quiz(continued)

3. Default block size in Hadoop 2.X is :

- A. 64 MB
- B. 68 MB
- C. 188 MB
- D. 128 MB

4. Data Blocks are stored in ?

- A. Name Node
- B. Data Node
- C. Database
- D. A&B

Quiz-Answers(continued)

3. Default block size in Hadoop 2.X is :

- A. 64 MB
- B. 68 MB
- C. 188 MB
- D. 128 MB

D: 128 MB

4. Data Blocks are stored in ?

- A. Name Node
- B. Data Node
- C. Database
- D. A&B

B: Data Node

Quiz(continued)

5. How many number of blocks will be created for a file xyz.txt of size 200 MB considering Hadoop 1.x environment?
- A. 4
 - B. 5
 - C. 2
 - D. 3

Quiz-Answers(continued)

5. How many number of blocks will be created for a file xyz.txt of size 200 MB considering Hadoop 1.x environment?

- A. 4
- B. 5
- C. 2
- D. 3

A: 4

Hadoop Cluster Modes

Hadoop can run in any of the following three modes:

Standalone (or Local) Mode

- No daemons, everything runs in a single JVM.
- Suitable for running MapReduce programs during development.
- Has no DFS.

Pseudo-Distributed Mode

- Hadoop daemons run on the local machine.

Fully-Distributed Mode

- Hadoop daemons run on a cluster of machines.

HDFS Commands

- HDFS Commands are used to
 - access Hadoop Distributed File System (HDFS)
 - list down files and directories present in HDFS
 - create and remove directory in HDFS
 - push the data present in landing zone(local machine) to HDFS
 - copy the data back to landing zone(local machine) from HDFS

HDFS Commands(continued)

- Get a directory listing of the HDFS root directory

```
hadoop fs -ls /
```

- Create a directory called input under the user directory

```
hadoop fs -mkdir /user/input
```

- Copy file foo.txt from local disk to the input directory in HDFS

```
hadoop fs -copyFromLocal foo.txt /user/input/foo.txt
```


HDFS Commands(continued)

- Display the contents of the HDFS file */user/input/foo.txt*

```
hadoop fs -cat /user/input/foo.txt
```

- Copy the file foo.txt from HDFS to local

```
hadoop fs -copyToLocal /user/input/foo.txt foo.txt
```

- Delete the file bar.txt in HDFS

```
hadoop fs -rm /user/input/bar.txt
```

HDFS Commands(continued)

- Delete the input directory in HDFS

```
hadoop fs -rm [-r ] /user/input/
```

→ -r used for recursive, deletes directory even if some file is present under that.

For more commands please refer:

<http://hadoop.apache.org/docs/current/hadoop-project-dist/hadoop-common/FileSystemShell.html>

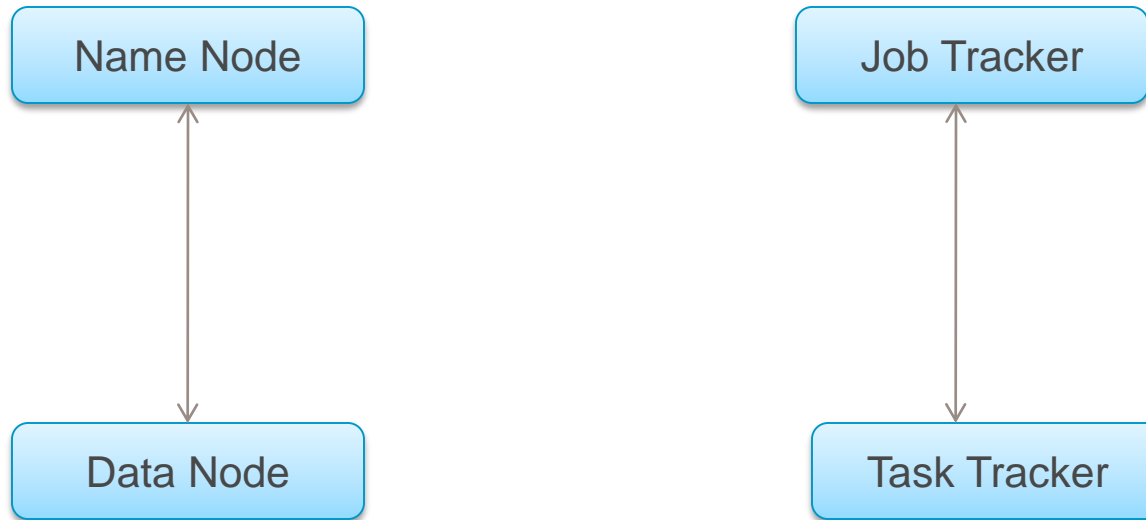
Hadoop Daemons

- Hadoop Works on Master-Slave pattern
- There are 5 daemons in Hadoop 1.x
 1. Name Node → Master Node
 2. Secondary Name Node → Master Node
 3. Job Tracker → Master Node
 4. Task Tracker → Slave Node
 5. Data Node → Slave Node

Hadoop Daemons(continued)

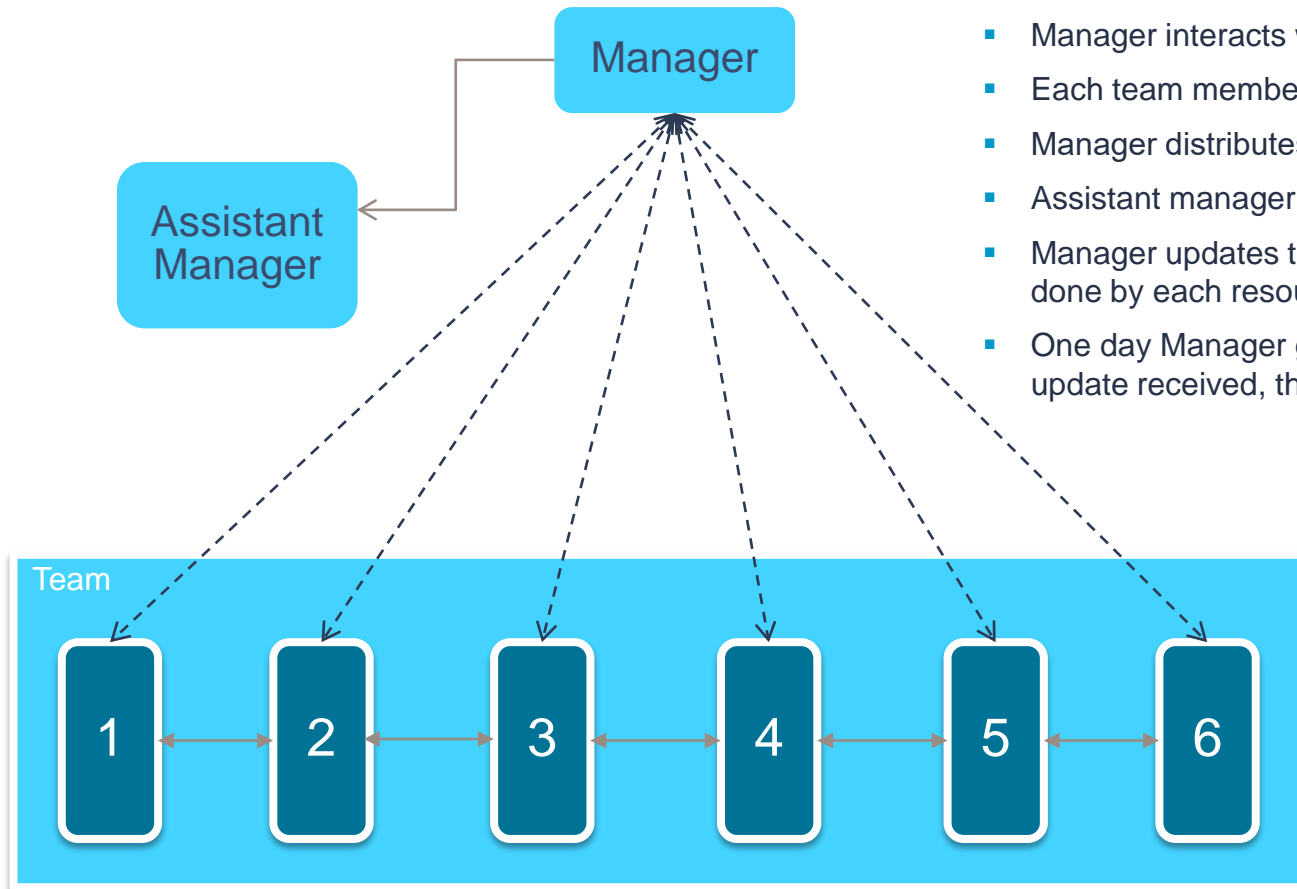
- **Name Node** stores metadata of cluster
 - Block details
 - Replication details
 - Load Balancing
 - High configuration machine, 1 Name Node per cluster
- **Secondary Name Node** is the backup of Name Node
 - Takes backup of Name Node in a regular interval
 - Not called as complete backup of Name Node
- **Job Tracker** is the daemon where hadoop jobs are submitted
- **Task Tracker** accomplish the task which are submitted to job tracker
- **Data Node** is the daemon where actual data in the form of blocks reside

Hadoop Daemons(continued)



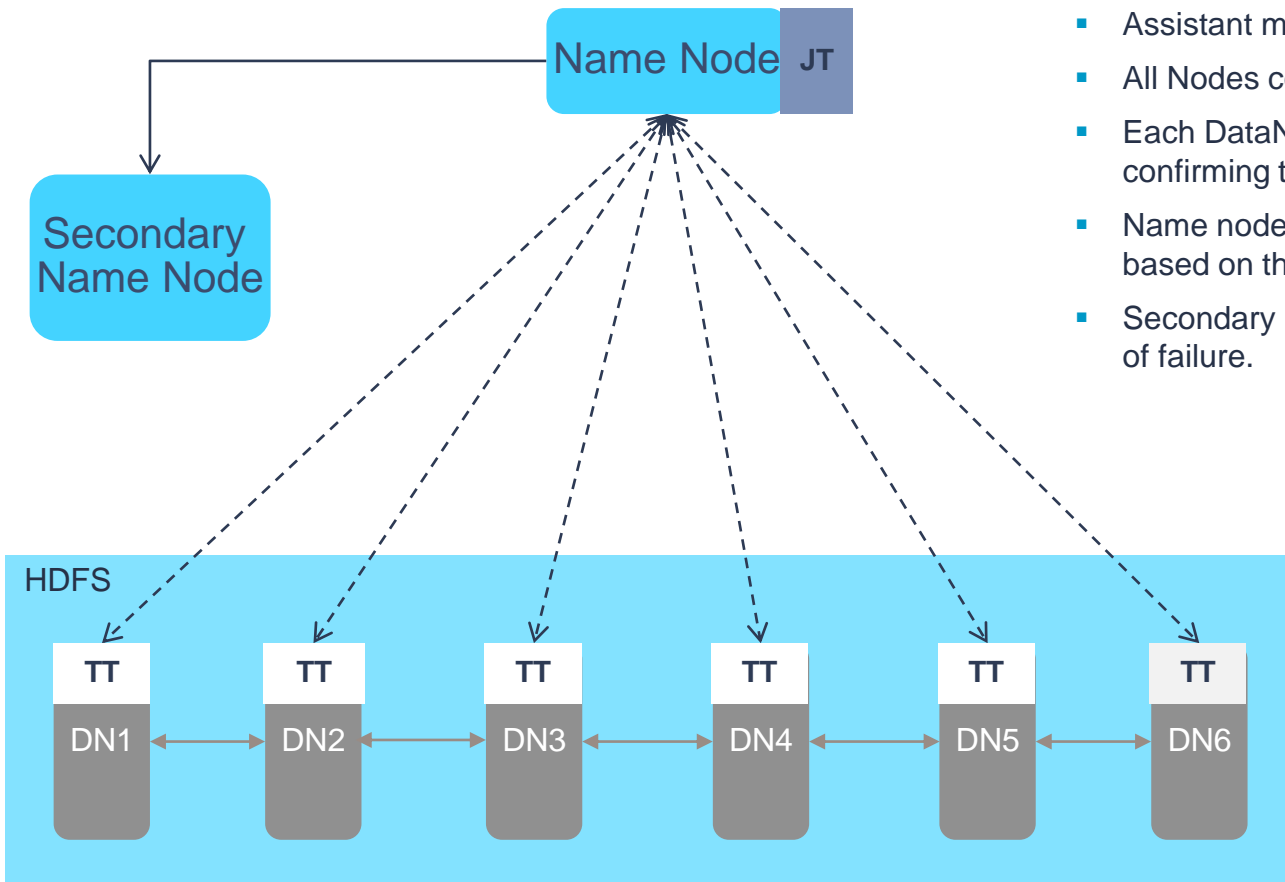
- Name Node coordinates with Data Nodes
 - In turn, all Data Nodes send heart beats to Name Node periodically
- Job Tracker coordinates with Task Tracker

Hadoop Daemons– Corporate Analogy



- Manager is appointed who will govern the project.
- Manager recruits 6 Members to Join the project team.
- They all communicate with each other.
- Manager interacts with each of the 6 Team members.
- Each team member confirms his presence to the manger everyday
- Manager distributes the work volume based on Team's utilization.
- Assistant manager is provisioned as a backup manager.
- Manager updates the Assistant manager every day about activities done by each resource.
- One day Manager goes on unplanned leave and based on the last update received, the asst. manager takes over the activities.

Hadoop Daemons(continued)



- Manager : Name node
- 6 Team Members : 6 data Nodes.
- Assistant manager : Secondary Name Node
- All Nodes communicate via SSH password less protocol.
- Each DataNode sends heartbeat signals to the Name node confirming they are live.
- Name node distributes the data Blocks across Datanodes based on their memory utilization and alive status.
- Secondary NameNode acts as a failover to avoid single point of failure.

1. When a MR program is submitted it goes to the Job Tracker(JT)
2. JT talks with NameNode to understand which Data Nodes have the required data blocks of the source files.
3. Once identified, JT talks to the TTs on those Nodes and use them to perform the assigned Tasks.
4. On task completion, JT updates the NameNode on the new Block location where the output is stored.

Quiz

1. Which of the below HDFS command is used to create a directory in hdfs

- A. `hadoop fs -dir /user/abc`
- B. `hadoop fs -crdir /user/abc`
- C. `hadoop fs -mkdir /user/abc`
- D. `Hadoop fs -mdir /user/abc`

2. Which of the below HDFS command is used to copy file from local to HDFS?

- A. `hadoop fs -copy 1.txt /user/abc/1.txt`
- B. `hadoop fs -copyfromlocal 1.txt /user/abc/1.txt`
- C. `hadoop fs -copyFromLocal 1.txt /user/abc/1.txt`
- D. `Hadoop fs -CopyToLocal 1.txt /user/abc/1.txt`

Quiz-Answers(continued)

1. Which of the below HDFS command is used to create a directory in hdfs

- A. `hadoop fs -dir /user/abc`
- B. `hadoop fs -crdir /user/abc`
- C. `hadoop fs -mkdir /user/abc`
- D. `Hadoop fs -mdir /user/abc`

C: mkdir

2. Which of the below HDFS command is used to copy file from local to HDFS?

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- B. `hadoop fs -copyfromlocal 1.txt /user/abc/1.txt`
- C. `hadoop fs -copyFromLocal 1.txt /user/abc/1.txt`
- D. `Hadoop fs -CopyToLocal 1.txt /user/abc/1.txt`

C: copyFromLocal

Quiz

3. Which of the below HDFS command is incorrect?

- A. `hadoop fs -copytolocal /user/abc/1.txt 1.txt`
- B. `hadoop fs -mkdir /user/abc`
- C. `hadoop fs -ls /user/abc/`
- D. `Hadoop fs -cat /user/abc.txt`

4. Name Node stores _____ of cluster :

- A. Actual data
- B. Blocks
- C. Metadata
- D. Replicated blocks

Quiz-Answers(continued)

3. Which of the below HDFS command is incorrect?

- A. `hadoop fs -copytolocal /user/abc/1.txt 1.txt`
- B. `hadoop fs -mkdir /user/abc`
- C. `hadoop fs -ls /user/abc/`
- D. `Hadoop fs -cat /user/abc.txt`

A:
Reason: copyToLocal
Command is case sensitive

4. Name Node stores _____ of cluster :

- A. Actual data
- B. Blocks
- C. Metadata
- D. Replicated blocks

C: Metadata

Quiz

5. Secondary Name Node is complete Backup of Name Node?

- A. True
- B. False

6. Which of the following are Master Nodes?

- A. Name Node and Data Node
- B. Name Node and Job Tracker
- C. Secondary Name Node
- D. Both A & C
- E. Both B & C

Quiz-Answers(continued)

5. Secondary Name Node is complete Backup of Name Node?

- A. True
- B. False

B: False
It takes backup in regular intervals only.

6. Which of the following are Master Nodes?

- A. Name Node and Data Node
- B. Name Node and Job Tracker
- C. Secondary Name Node
- D. Both A & C
- E. Both B & C

E: Both B & C

Final Quiz

1. Hadoop is a framework that works with a variety of related tools. Common cohorts include:
 - A. MapReduce, Hive and HBase
 - B. MapReduce, MySQL and Google Apps
 - C. MapReduce, Hummer and Iguana
 - D. MapReduce, Heron and Trumpet

2. What technology might you use to stream Twitter feeds into Hadoop?
 - A. Sqoop
 - B. Flume
 - C. Pig
 - D. Hive

Final Quiz-Answers

1. Hadoop is a framework that works with a variety of related tools. Common cohorts include:

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- C. MapReduce, Hummer and Iguana
- D. MapReduce, Heron and Trumpet

A: MR ,Hive & HBase

2. What technology might you use to stream Twitter feeds into Hadoop?

- A. Sqoop
- B. Flume
- C. Pig
- D. Hive

B: Flume

Q & A

Thank You

People matter, results count.

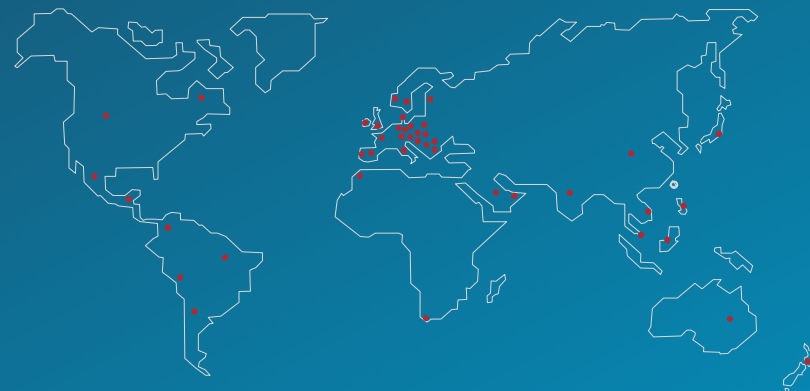


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