Department of CSE

COURSE NAME: DBMS
COURSE CODE:23AD2102R

Topic: Distributed Storage and Processing Framework (Hadoop)

Session – 4

AIM OF THE SESSION

To familiarize students with the basic concept of BigData

INSTRUCTIONAL OBJECTIVES

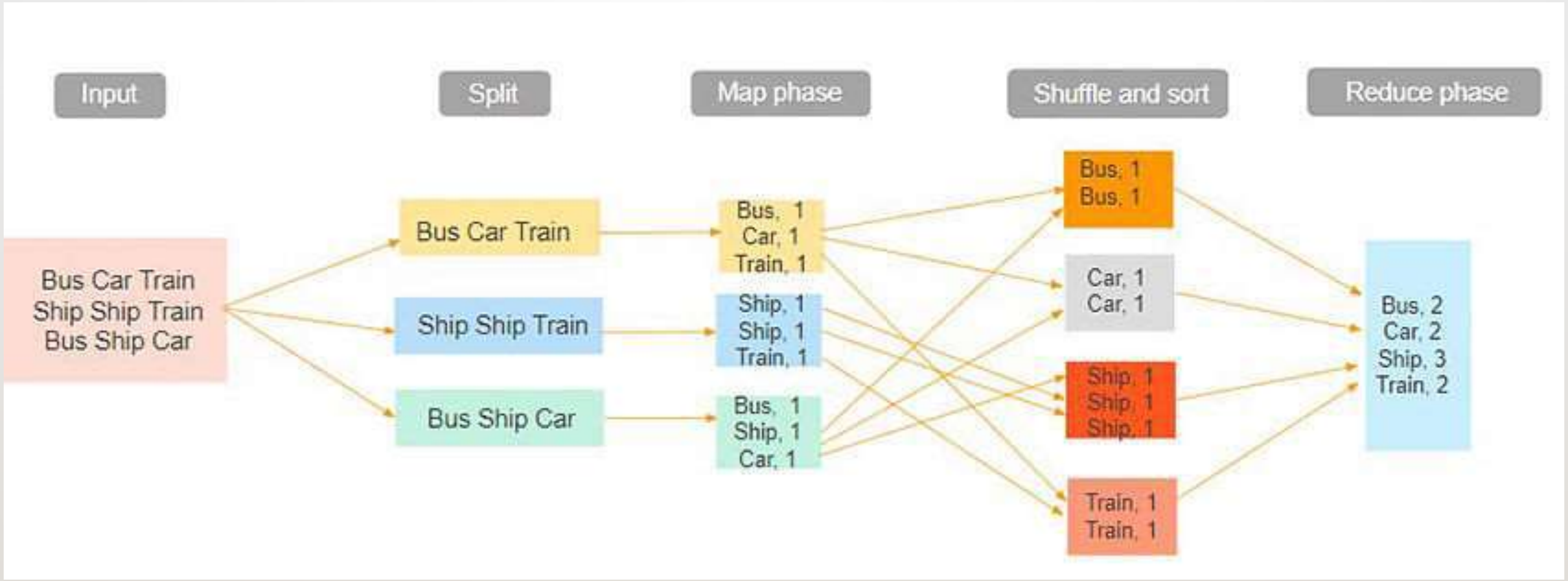
This Session is designed to: discuss and study the concepts of BigData Distributed Storage and Processing Framework (Hadoop)

LEARNING OUTCOMES

At the end of this session, you should be able to: understand Hadoop Framework

Hadoop MapReduce

- Hadoop MapReduce is the **processing unit of Hadoop**.
- In the MapReduce approach, the **processing is done at the slave nodes**, and the final result is sent to the **master node**.
- A data containing code is used to process the entire data. This coded data is usually very small in comparison to the data itself. You only need to send a few kilobytes worth of code to perform a heavy-duty process on computers.

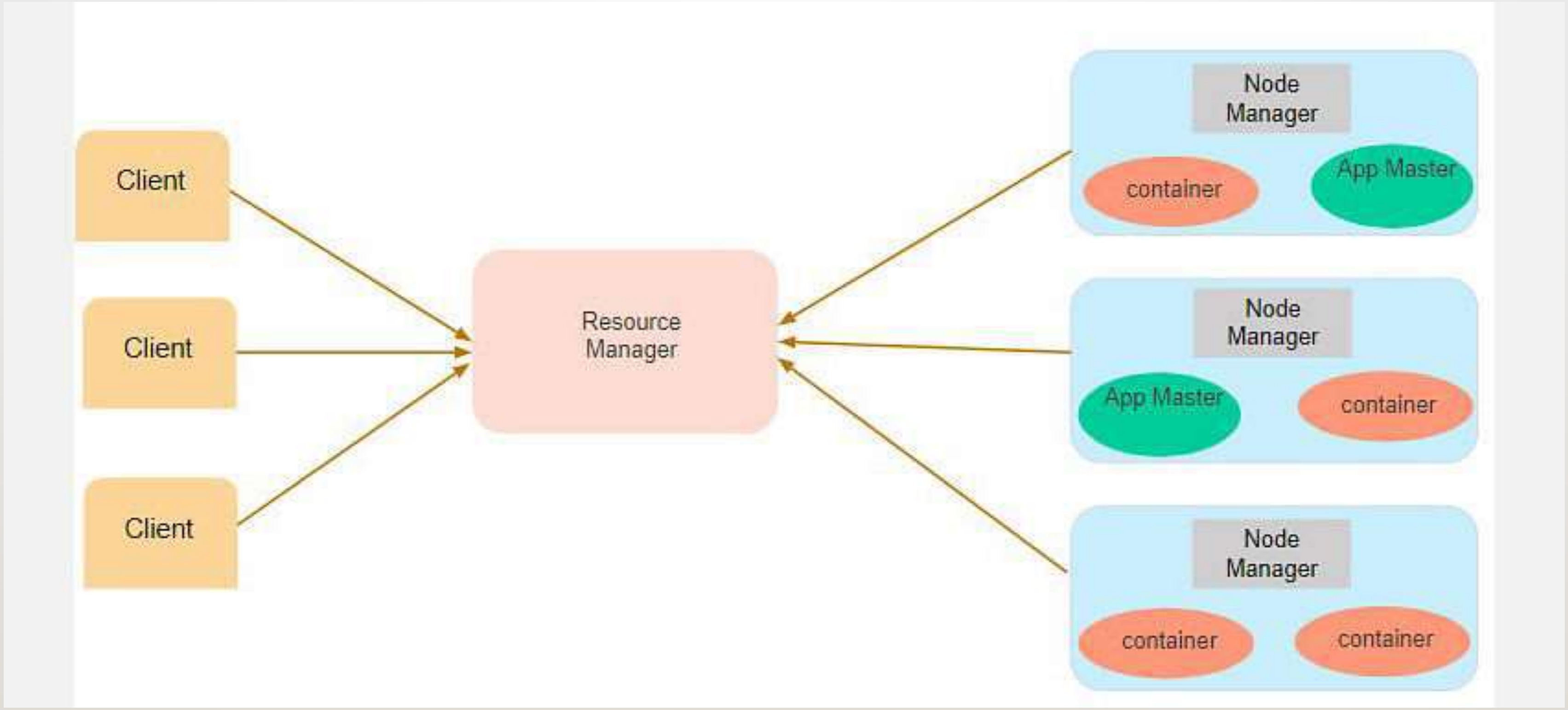

Input
Split
Map phase
Shuffle and sort
Reduce phase
Bus Car Train
Ship Ship Train
Bus Ship Car
Bus Car Train
Ship Ship Train
Bus Ship Car
Bus, 1
Car, 1
Train, 1
Ship, 1
Ship, 1
Train, 1
Bus, 1
Ship, 1
Car, 1
Bus, 1
Bus, 1
Car, 1
Car, 1
Ship, 1
Ship, 1
Ship, 1
Train, 1
Train, 1
Bus, 2
Car, 2
Ship, 3
Train, 2

- The input dataset is first split into **chunks of data**. In this example, the input has three lines of text with three separate entities - "bus car train," "ship ship train," "bus ship car." The dataset is then split into three chunks, based on these entities, and processed parallelly.
- In the **map phase**, the data is assigned a key and a value of 1. In this case, we have one bus, one car, one ship, and one train.
- These key-value pairs are then shuffled and sorted together based on their keys. At the **reduce phase,** the aggregation takes place, and the final output is obtained.

Hadoop YARN

➢ Hadoop **YARN** stands for Yet Another Resource Negotiator. It is the resource management unit of Hadoop and is available as a component of Hadoop version 2.

- Hadoop YARN acts like an OS to Hadoop. It is a file system that is built on top of HDFS.
- It is responsible for managing cluster resources to **make sure you don't overload one machine**.
- It performs **job scheduling** to make sure that the jobs are scheduled in the right place

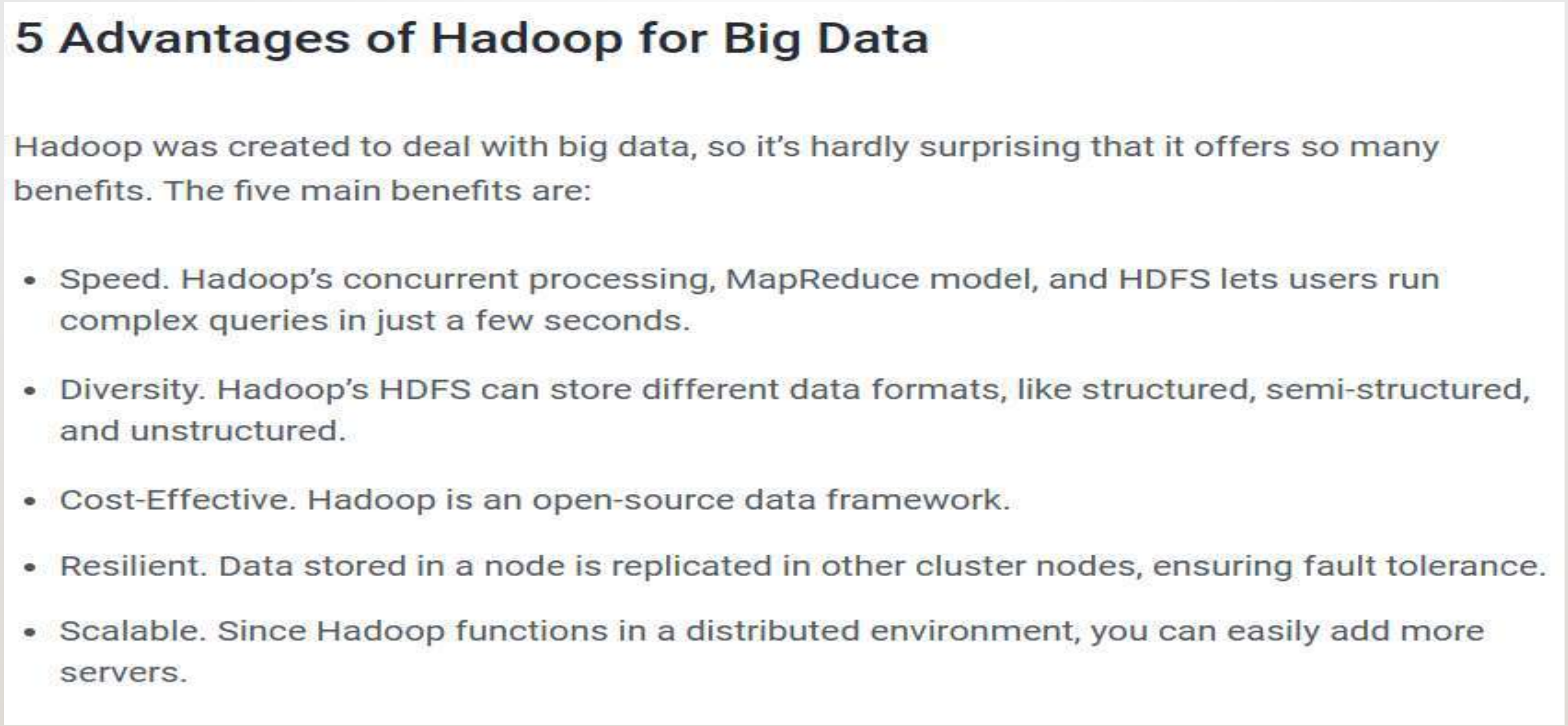

Client
Client
Client
Resource Manager
Node Manager
container
App Master
Node Manager
App Master
container
Node Manager
container
container

- Suppose a **client machine** wants to do a query or fetch some code for data analysis. This job request goes to the **resource manager** (Hadoop Yarn), which is responsible for **resource allocation** and **management**.
- In the **node section**, each of the nodes has its node managers.
- These **node managers** manage the **nodes** and **monitor** the resource usage in the node.
- The **containers** contain a collection of physical resources, which could be **RAM**, **CPU**, or **hard drives.** Whenever a job request comes in, the app master requests the container from the node manager. Once the node manager gets the resource, it goes back to the Resource Manager.

How Does Hadoop Work?

The primary function of Hadoop is to process the data in an organised manner among the cluster of commodity software. The client should submit the data or program that needs to be processed. Hadoop HDFS stores the data. YARN, MapReduce divides the resources and assigns the tasks to the data. Let's know the working of Hadoop in detail.

- The client input data is divided into 128 MB blocks by HDFS. Blocks are replicated according to the replication factor: various DataNodes house the unions and their duplicates.
- The user can process the data once all blocks have been put on HDFS DataNodes.
- The client sends Hadoop the MapReduce programme to process the data.
- The user-submitted software was then scheduled by ResourceManager on particular cluster nodes.
- The output is written back to the HDFS once processing has been completed by all nodes.

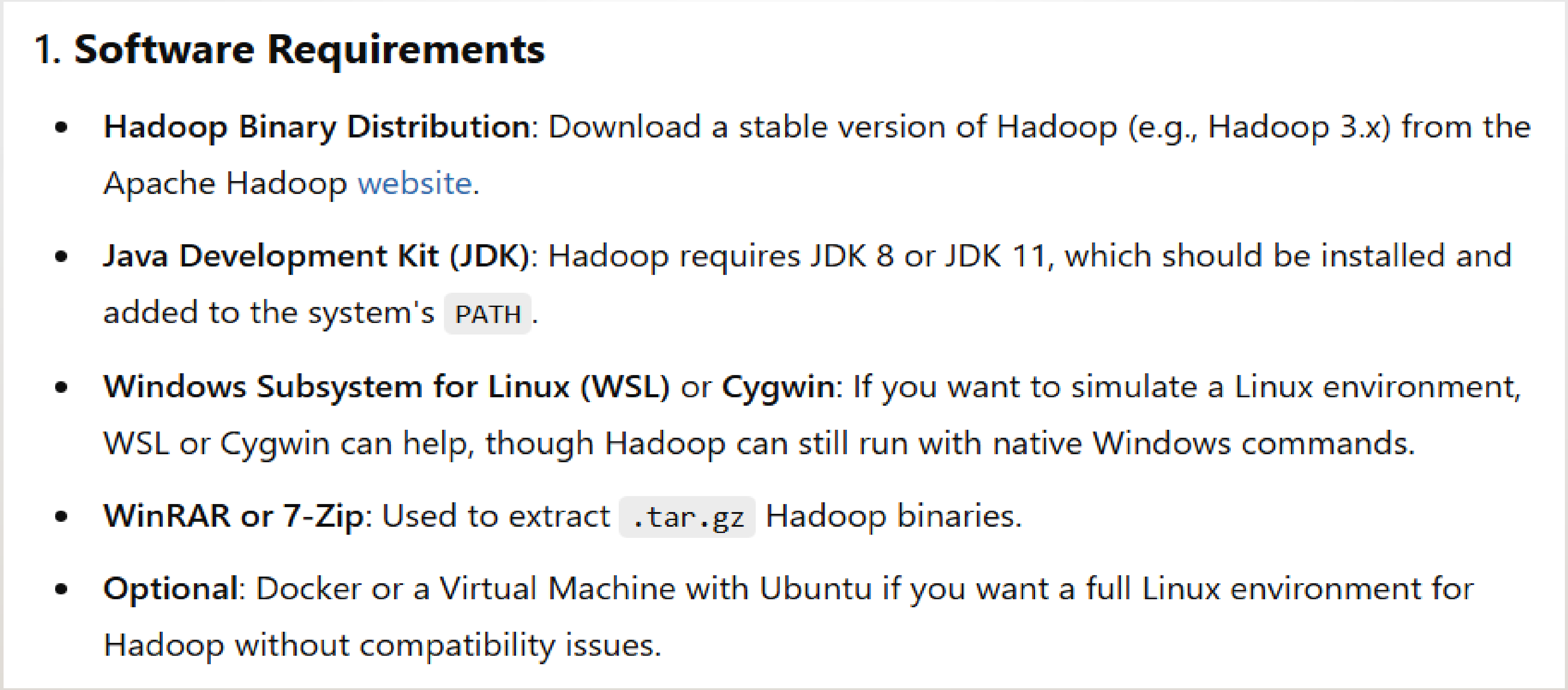


5 Advantages of Hadoop for Big Data

Hadoop was created to deal with big data, so it's hardly surprising that it offers so many benefits. The five main benefits are:

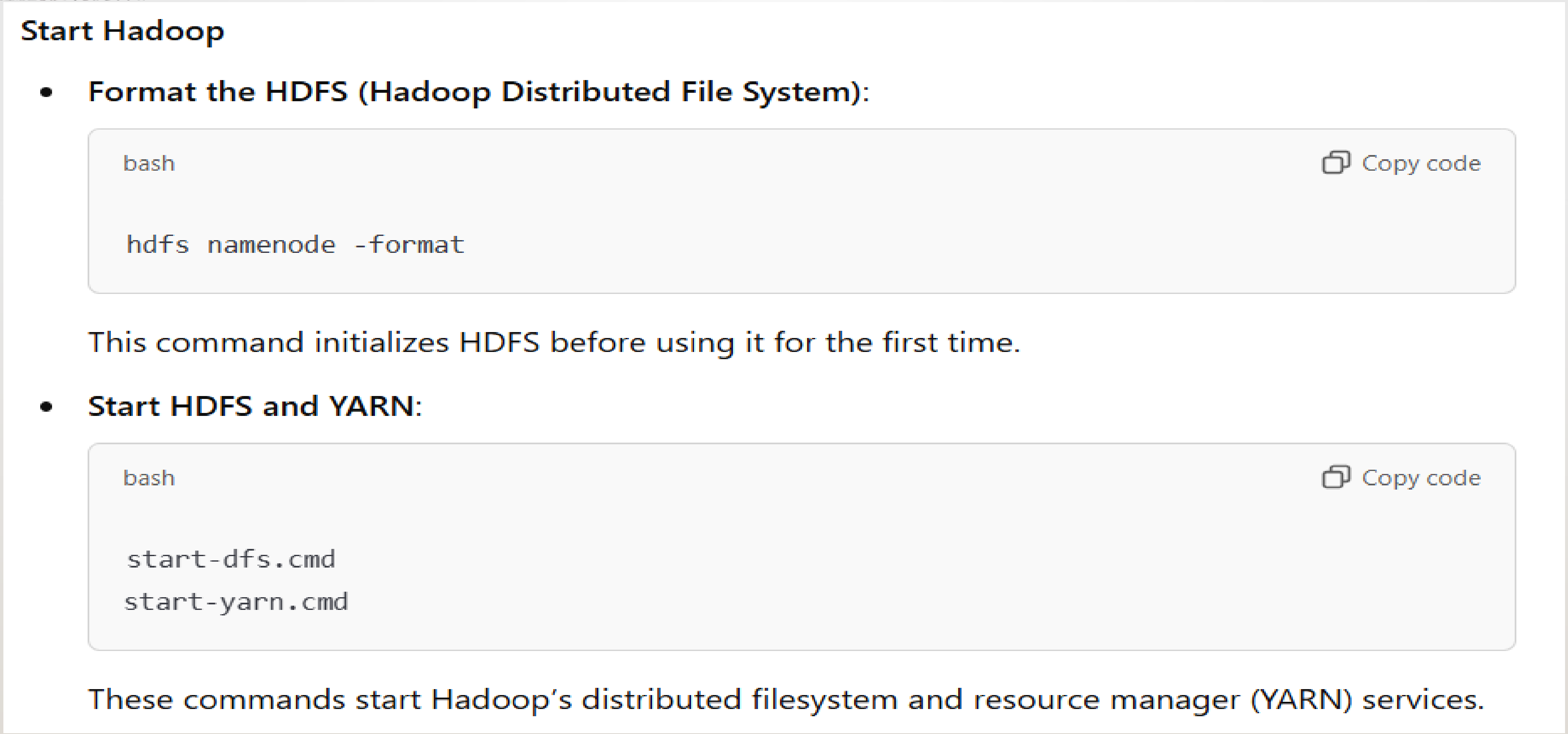
- Speed. Hadoop's concurrent processing, MapReduce model, and HDFS lets users run complex queries in just a few seconds.
- Diversity. Hadoop's HDFS can store different data formats, like structured, semi-structured, and unstructured.
- Cost-Effective. Hadoop is an open-source data framework.
- Resilient. Data stored in a node is replicated in other cluster nodes, ensuring fault tolerance.
- Scalable. Since Hadoop functions in a distributed environment, you can easily add more servers.

To run Hadoop framework in windows follow the steps



1. Software Requirements

- **Hadoop Binary Distribution**: Download a stable version of Hadoop (e.g., Hadoop 3.x) from the Apache Hadoop website.
- **Java Development Kit (JDK)**: Hadoop requires JDK 8 or JDK 11, which should be installed and added to the system's `PATH`.
- **Windows Subsystem for Linux (WSL)** or **Cygwin**: If you want to simulate a Linux environment, WSL or Cygwin can help, though Hadoop can still run with native Windows commands.
- **WinRAR or 7-Zip**: Used to extract `.tar.gz` Hadoop binaries.
- **Optional**: Docker or a Virtual Machine with Ubuntu if you want a full Linux environment for Hadoop without compatibility issues.



Start Hadoop

- **Format the HDFS (Hadoop Distributed File System):**

  bash — Copy code

  ```bash
  hdfs namenode -format
  ```

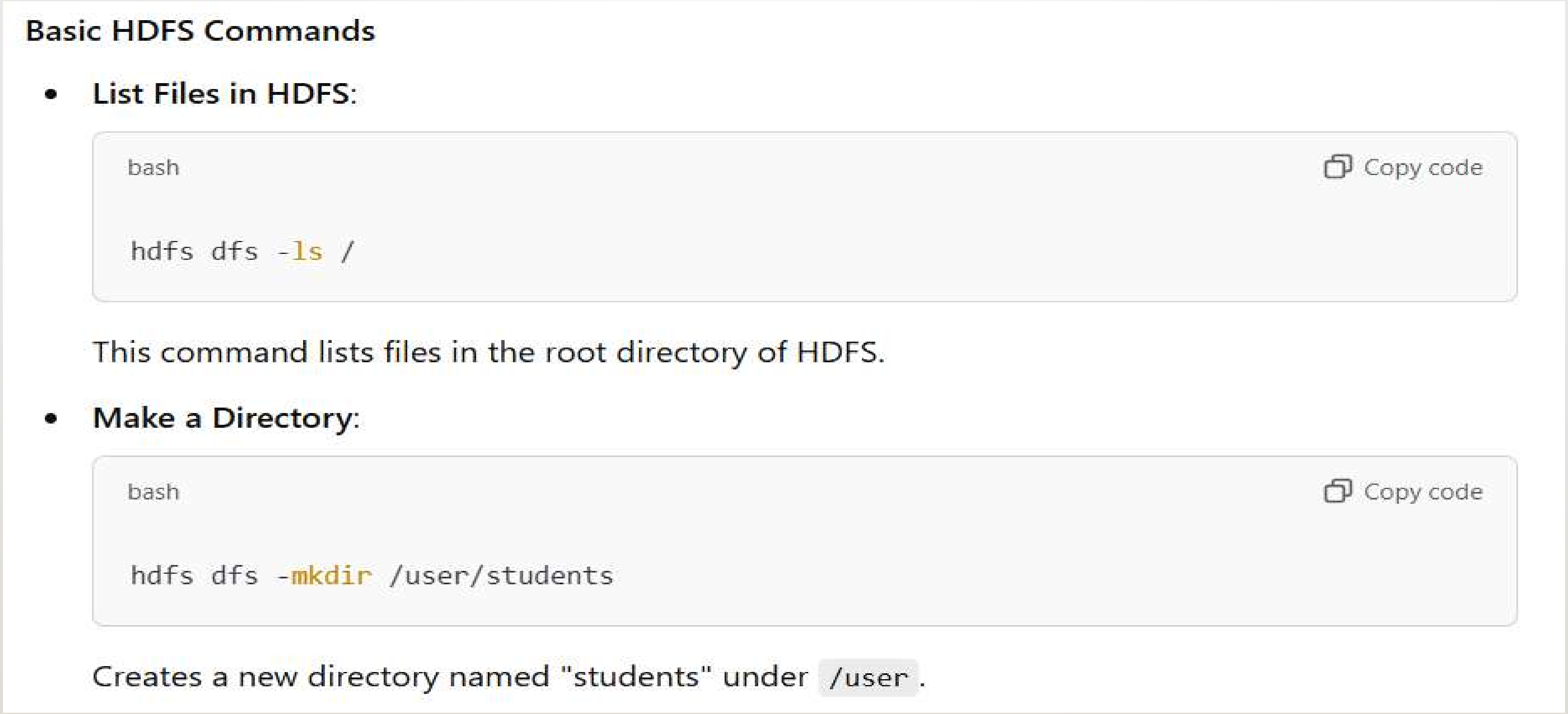
  This command initializes HDFS before using it for the first time.

- **Start HDFS and YARN:**

  bash — Copy code

  ```bash
  start-dfs.cmd
  start-yarn.cmd
  ```

  These commands start Hadoop's distributed filesystem and resource manager (YARN) services.


Basic HDFS Commands

- **List Files in HDFS**:

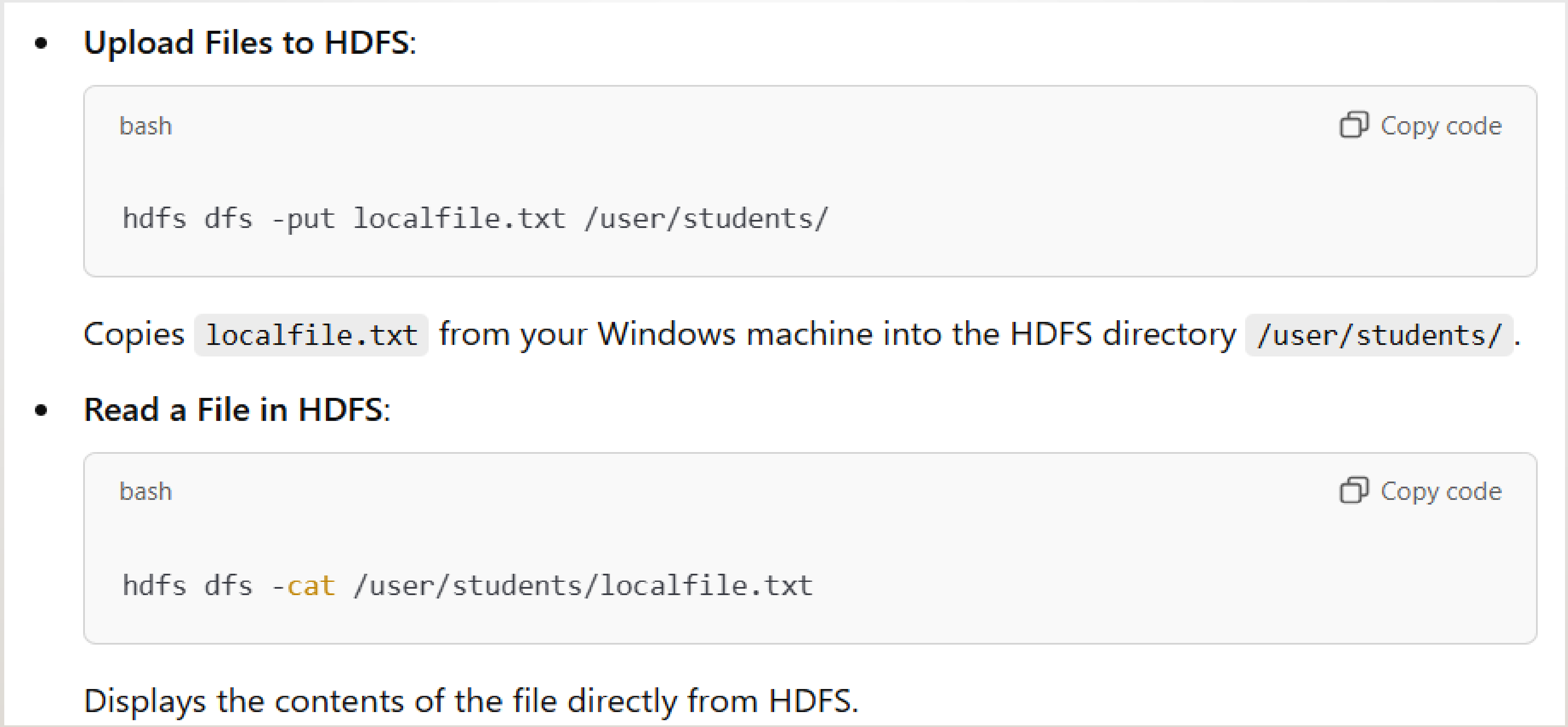
```bash
hdfs dfs -ls /
```

  This command lists files in the root directory of HDFS.

- **Make a Directory**:

```bash
hdfs dfs -mkdir /user/students
```

  Creates a new directory named "students" under `/user`.



- **Upload Files to HDFS:**

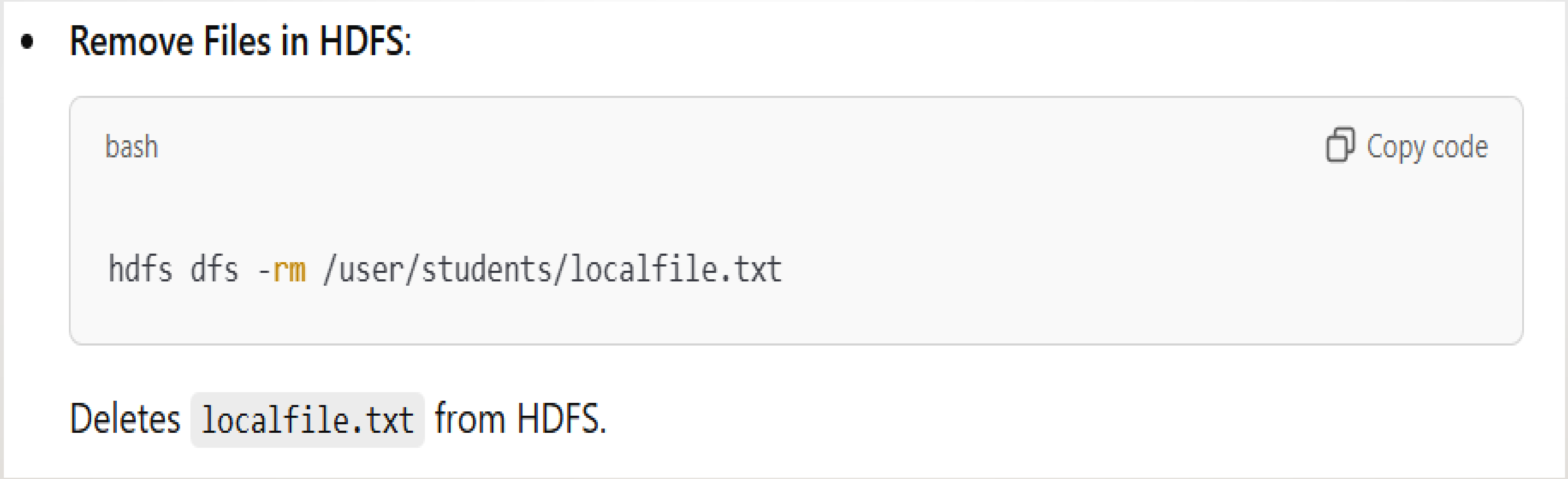
```bash
hdfs dfs -put localfile.txt /user/students/
```

Copies `localfile.txt` from your Windows machine into the HDFS directory `/user/students/`.

- **Read a File in HDFS:**

```bash
hdfs dfs -cat /user/students/localfile.txt
```

Displays the contents of the file directly from HDFS.



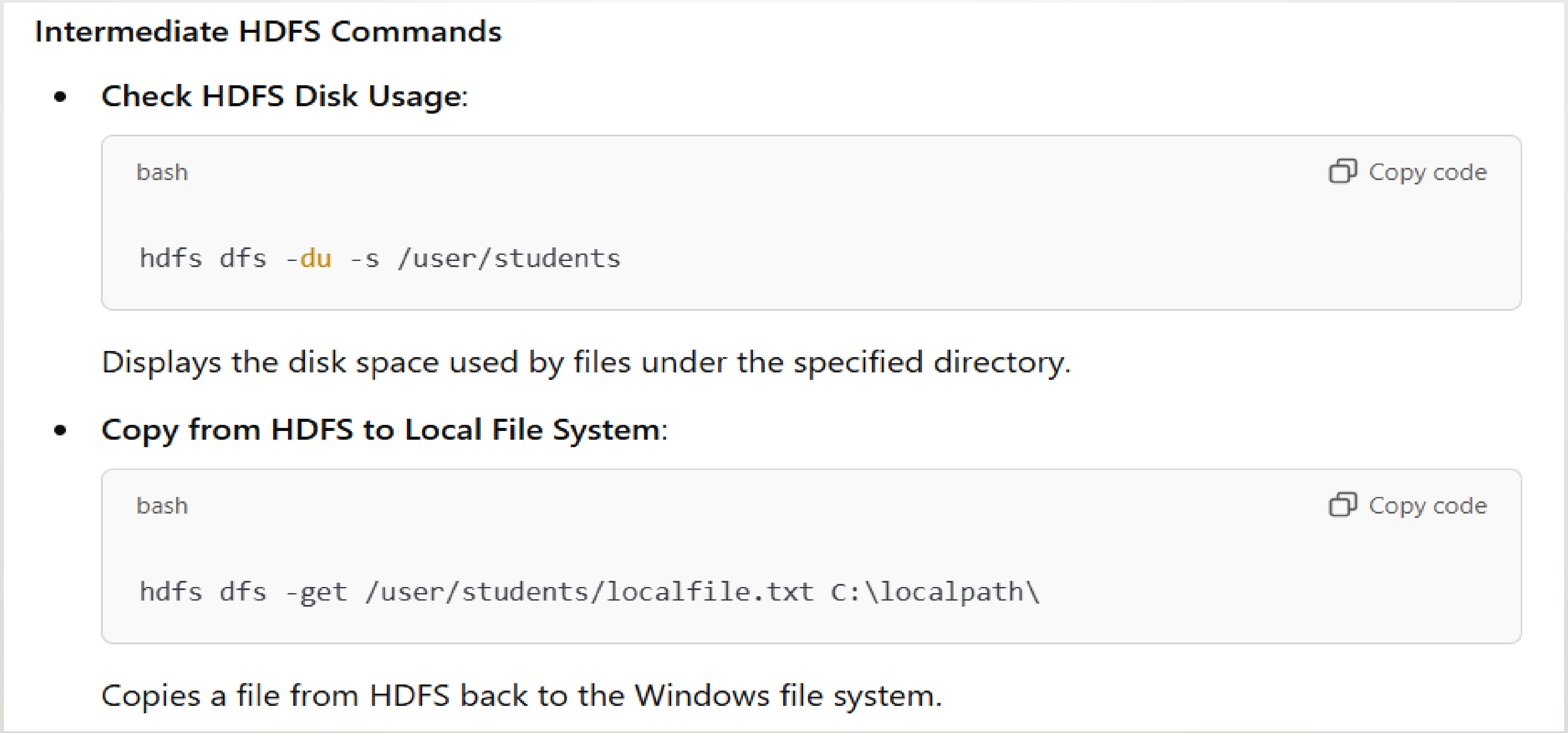
- Remove Files in HDFS:

bash

Copy code

```bash
hdfs dfs -rm /user/students/localfile.txt
```

Deletes `localfile.txt` from HDFS.



Intermediate HDFS Commands

- **Check HDFS Disk Usage:**

  bash   Copy code

  ```bash
  hdfs dfs -du -s /user/students
  ```

  Displays the disk space used by files under the specified directory.

- **Copy from HDFS to Local File System:**

  bash   Copy code

  ```bash
  hdfs dfs -get /user/students/localfile.txt C:\localpath\
  ```

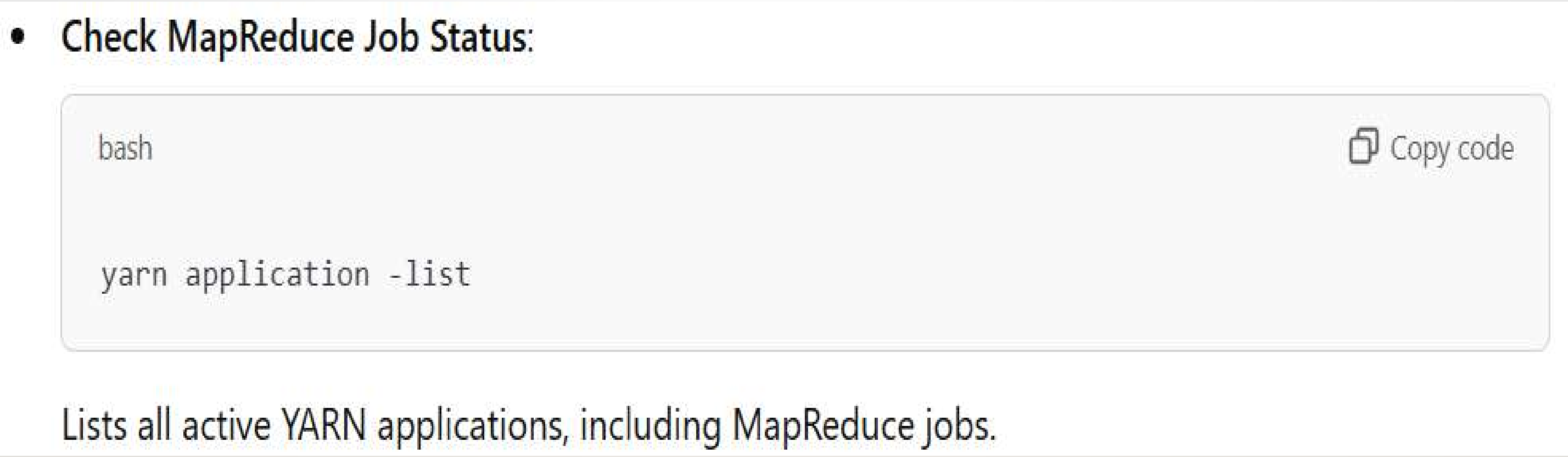
  Copies a file from HDFS back to the Windows file system.

MapReduce Commands

- Run a WordCount Example:

```
yarn jar $HADOOP_HOME/share/hadoop/mapreduce/hadoop-mapreduce-examples-*.jar wordcount /input /output
```

This example job takes an HDFS `/input` directory and processes it, saving the output to `/output`.



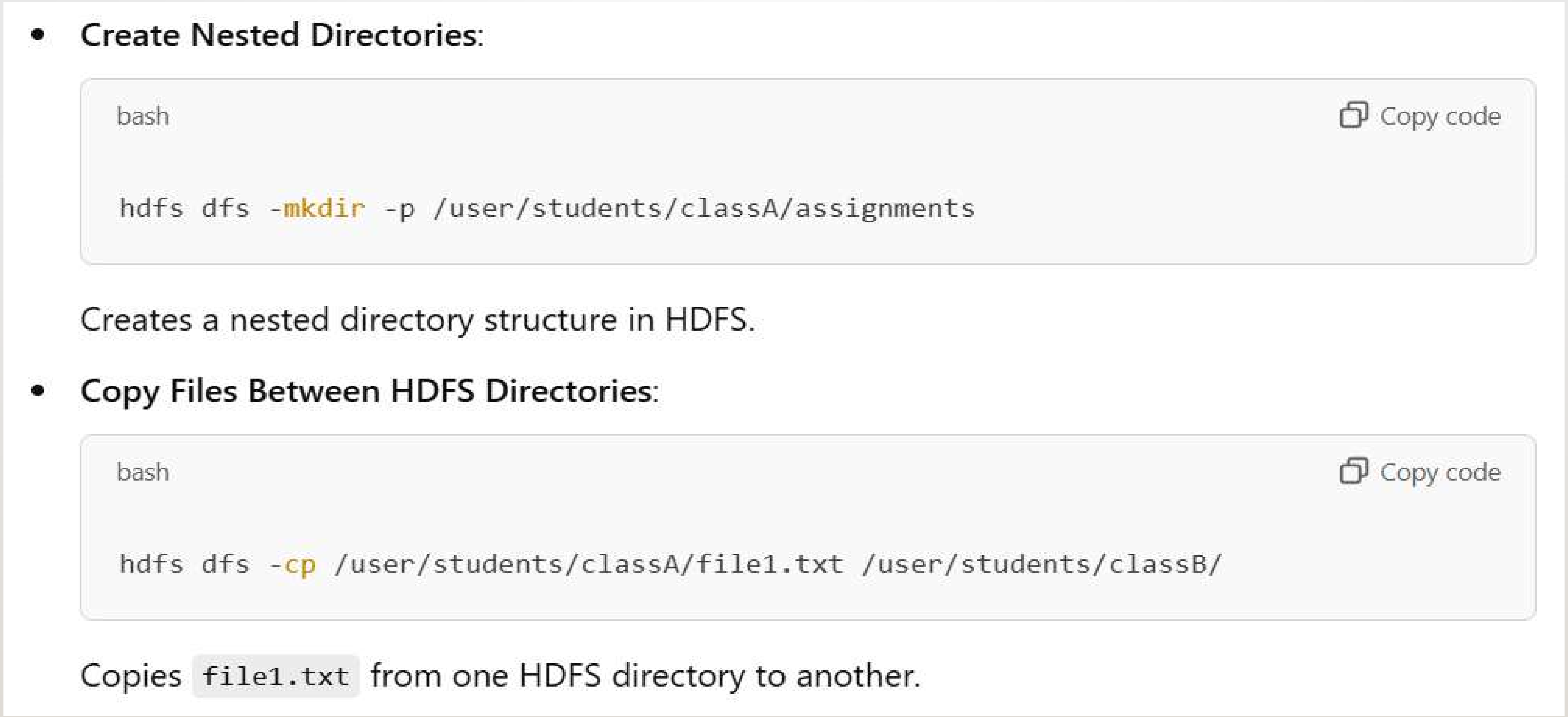
- Check MapReduce Job Status:

bash

Copy code

```bash
yarn application -list
```

Lists all active YARN applications, including MapReduce jobs.



- **Create Nested Directories**:

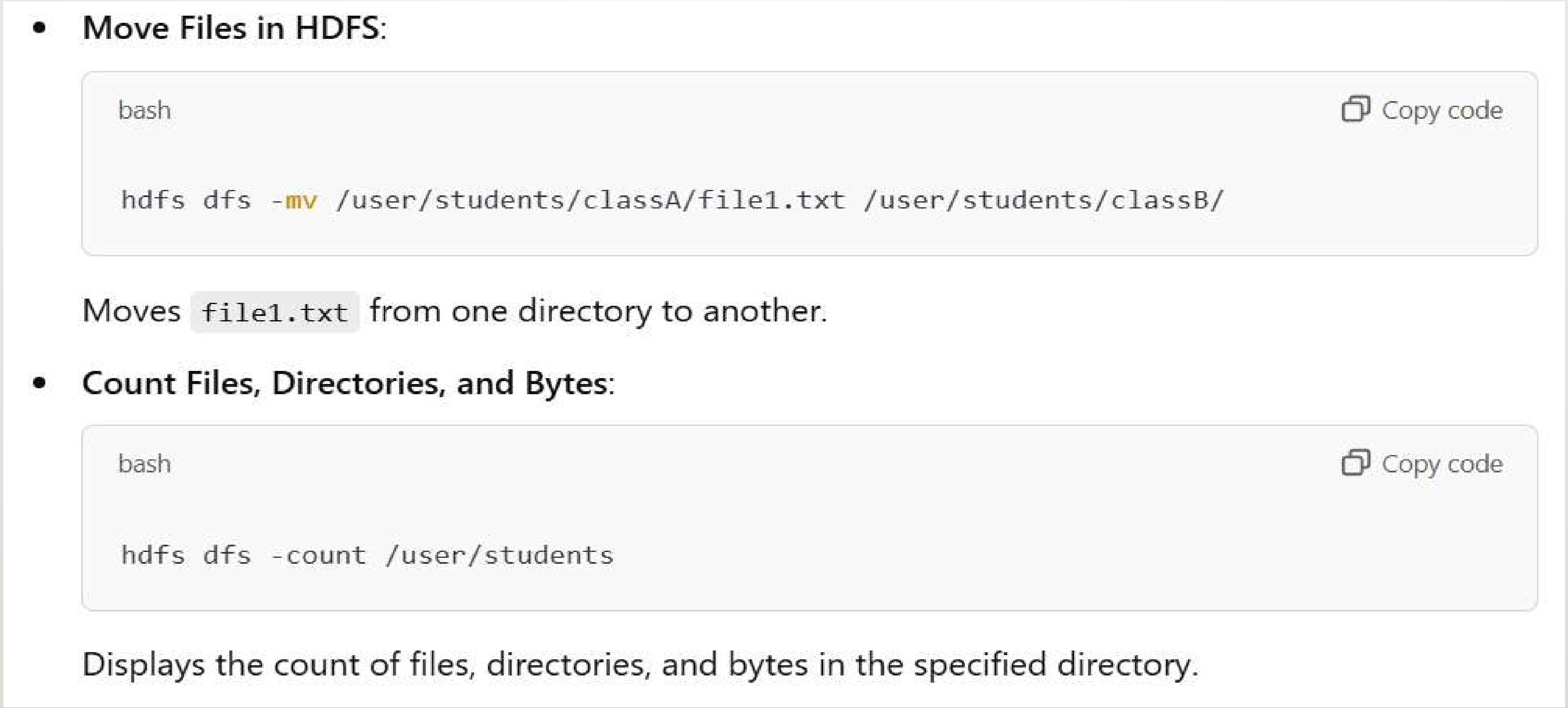
```bash
hdfs dfs -mkdir -p /user/students/classA/assignments
```

Creates a nested directory structure in HDFS.

- **Copy Files Between HDFS Directories**:

```bash
hdfs dfs -cp /user/students/classA/file1.txt /user/students/classB/
```

Copies `file1.txt` from one HDFS directory to another.



- **Move Files in HDFS**:

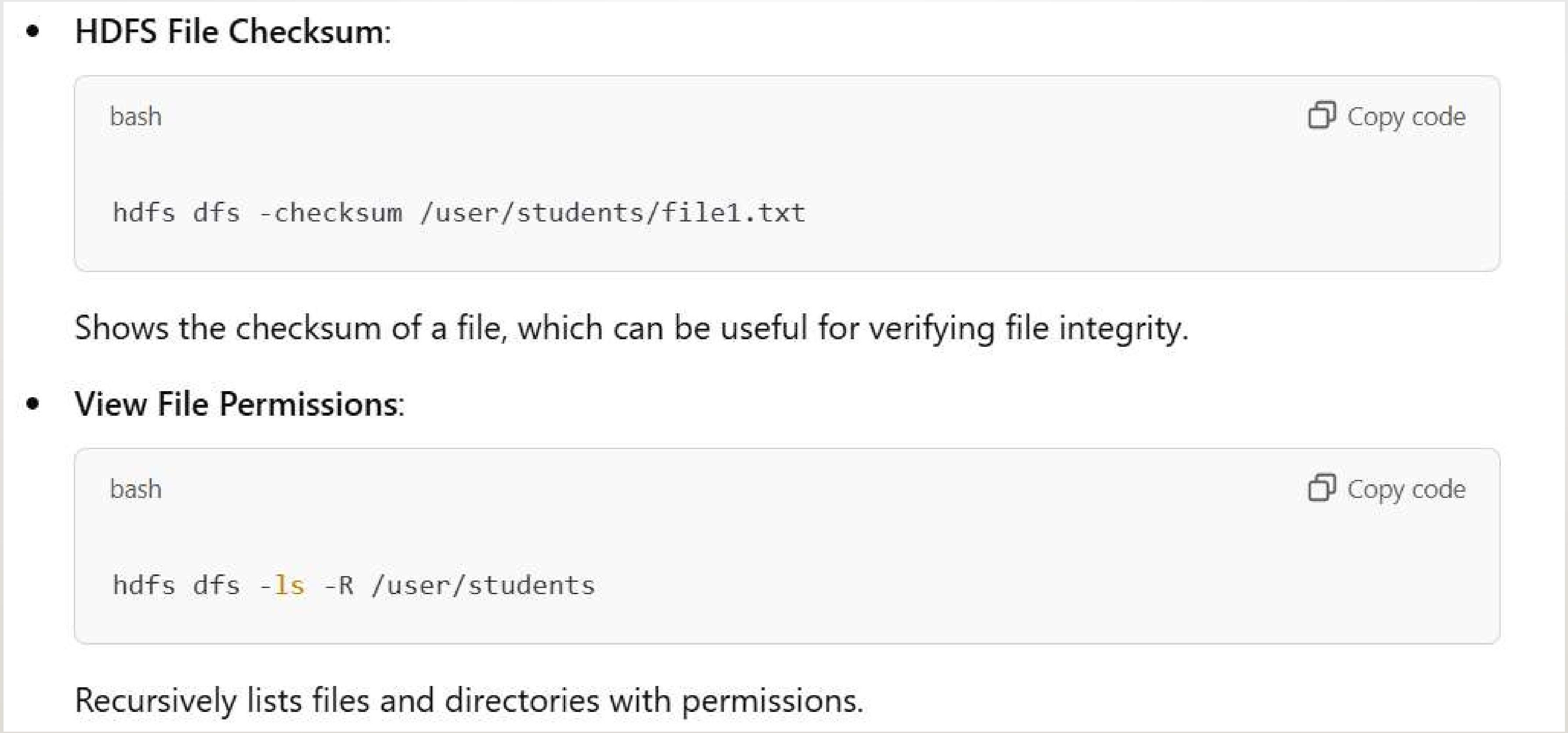
```bash
hdfs dfs -mv /user/students/classA/file1.txt /user/students/classB/
```

Moves `file1.txt` from one directory to another.

- **Count Files, Directories, and Bytes**:

```bash
hdfs dfs -count /user/students
```

Displays the count of files, directories, and bytes in the specified directory.



- **HDFS File Checksum**:

bash Copy code

```bash
hdfs dfs -checksum /user/students/file1.txt
```

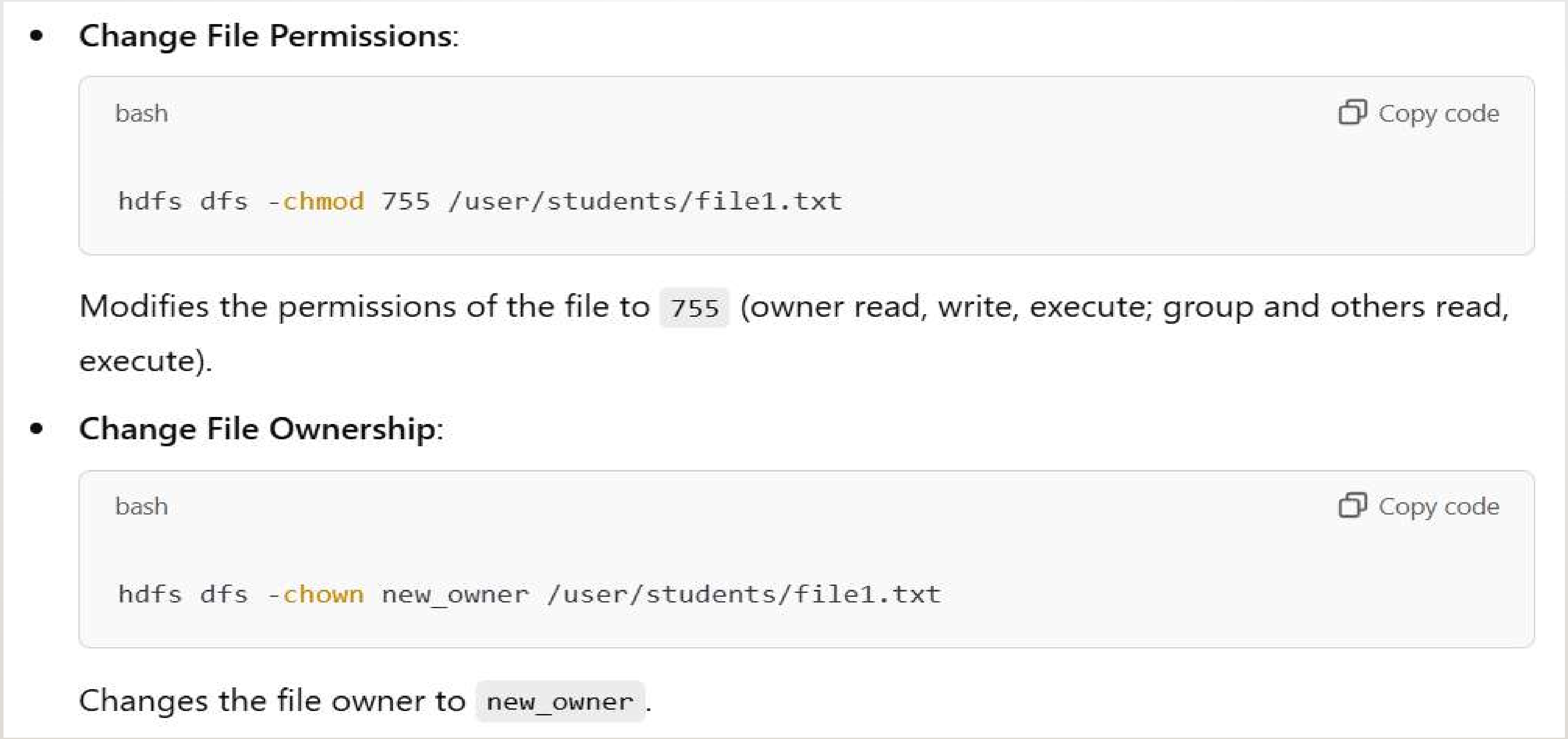
Shows the checksum of a file, which can be useful for verifying file integrity.

- **View File Permissions**:

bash Copy code

```bash
hdfs dfs -ls -R /user/students
```

Recursively lists files and directories with permissions.



- **Change File Permissions**:

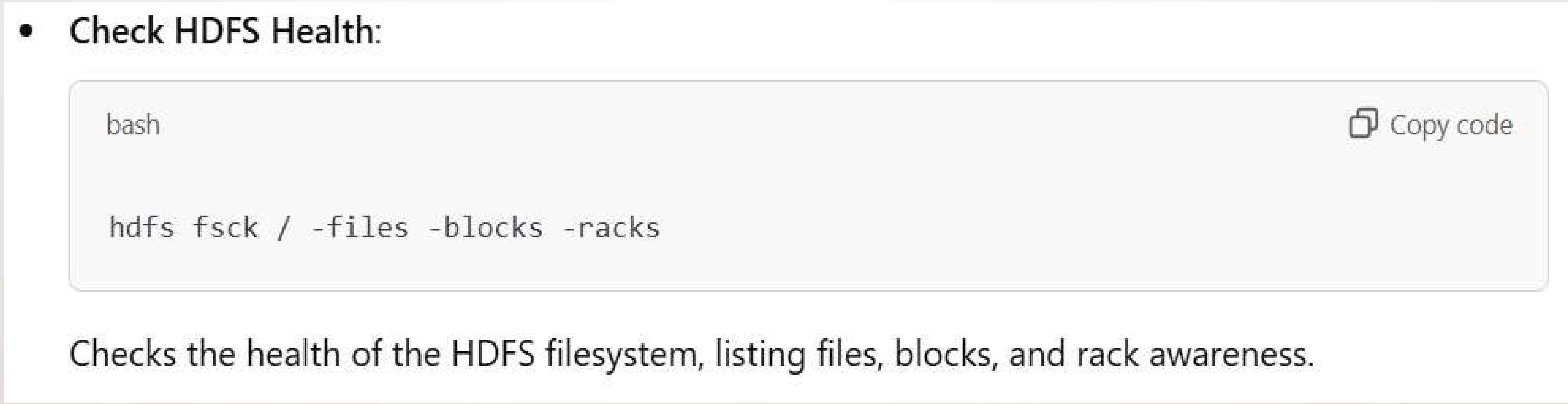
```bash
hdfs dfs -chmod 755 /user/students/file1.txt
```

Modifies the permissions of the file to `755` (owner read, write, execute; group and others read, execute).

- **Change File Ownership**:

```bash
hdfs dfs -chown new_owner /user/students/file1.txt
```

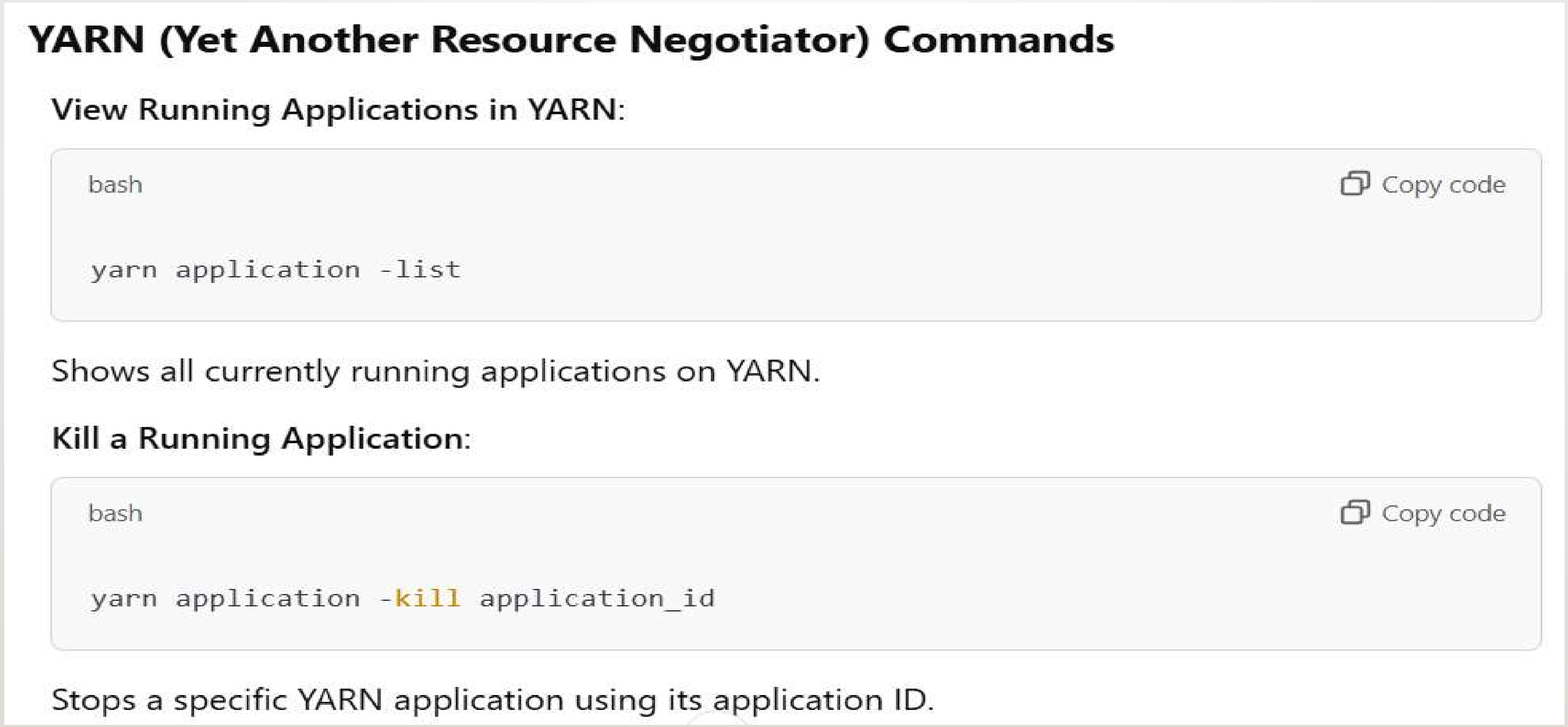
Changes the file owner to `new_owner`.



- **Check HDFS Health:**

```bash
hdfs fsck / -files -blocks -racks
```

Checks the health of the HDFS filesystem, listing files, blocks, and rack awareness.



YARN (Yet Another Resource Negotiator) Commands

View Running Applications in YARN:

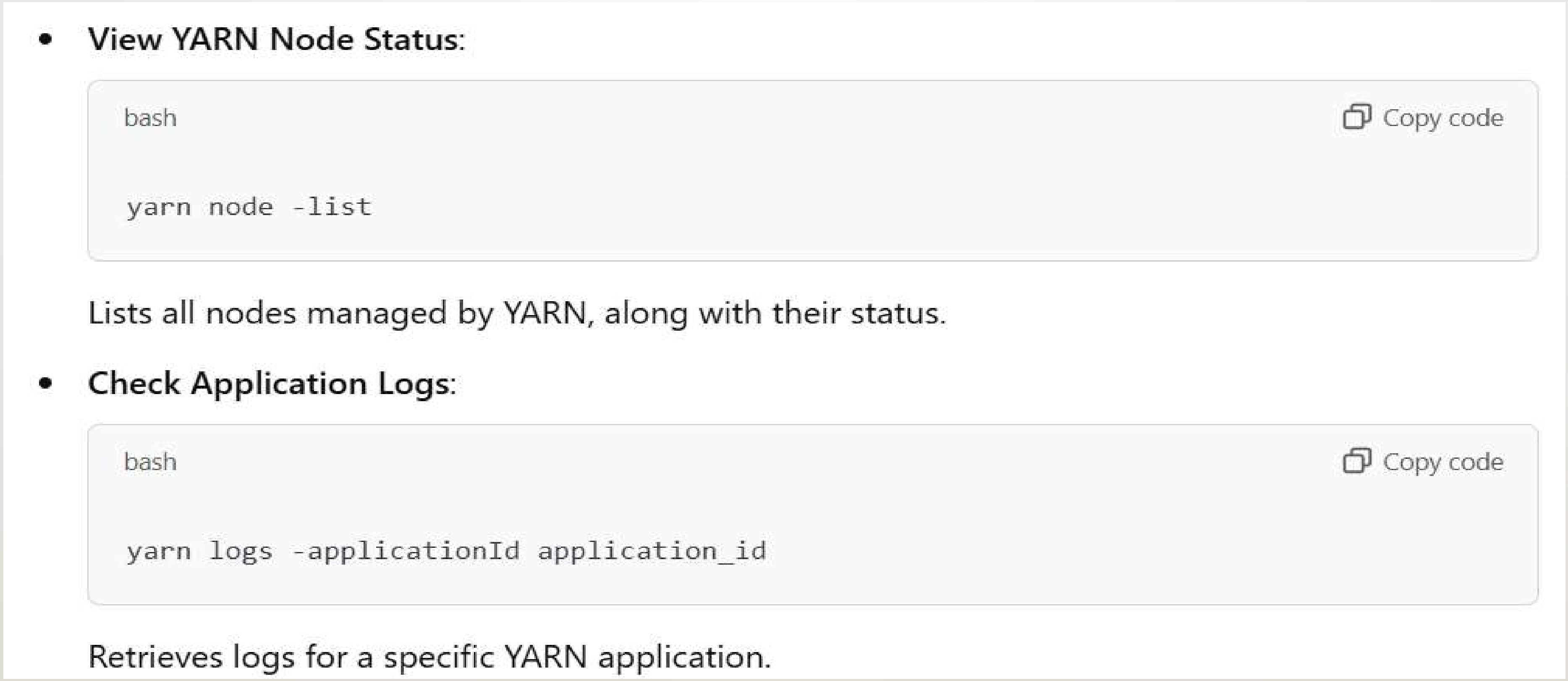
```bash
yarn application -list
```

Shows all currently running applications on YARN.

Kill a Running Application:

```bash
yarn application -kill application_id
```

Stops a specific YARN application using its application ID.



- **View YARN Node Status:**

```bash
yarn node -list
```

  Lists all nodes managed by YARN, along with their status.

- **Check Application Logs:**

```bash
yarn logs -applicationId application_id
```

  Retrieves logs for a specific YARN application.

Administrative Hadoop Commands

View HDFS Cluster Summary:

```bash
hdfs dfsadmin -report
```

Provides an overview of the HDFS cluster, including disk capacity and utilization.

Apache Pig and Apache Hive

- **Apache Pig** and **Apache Hive** provide high-level frameworks for processing and analyzing large datasets stored in HDFS.
- Each has distinct strengths and use cases, designed to simplify working with big data by abstracting away from **Java-based MapReduce programming**.

1. Apache Pig

- **Purpose**: Apache Pig is a high-level data flow scripting language that provides a simple way to process and analyze large data sets.
- **Language**: Uses **Pig Latin**, a procedural language designed to simplify the creation of data processing workflows.
- **Advantages**:
  - **Flexible Data Model**: Pig can handle structured, semi-structured, and unstructured data, making it suitable for diverse datasets.
  - **Simplified Processing**: Pig Latin scripts break down data flows into multiple steps, which Hadoop translates into a series of MapReduce jobs automatically.
- **Common Use Cases**:
  - Data transformations (filtering, grouping, joining, sorting)
  - Extract, Transform, Load (ETL) processes
  - Iterative data processing tasks

- Basic Pig Commands:
  - Load Data:

```pig
data = LOAD 'data.txt' USING PigStorage(',');
```

  - Filter Data:

```pig
filtered_data = FILTER data BY $0 == 'specific_value';
```

  - Group Data:

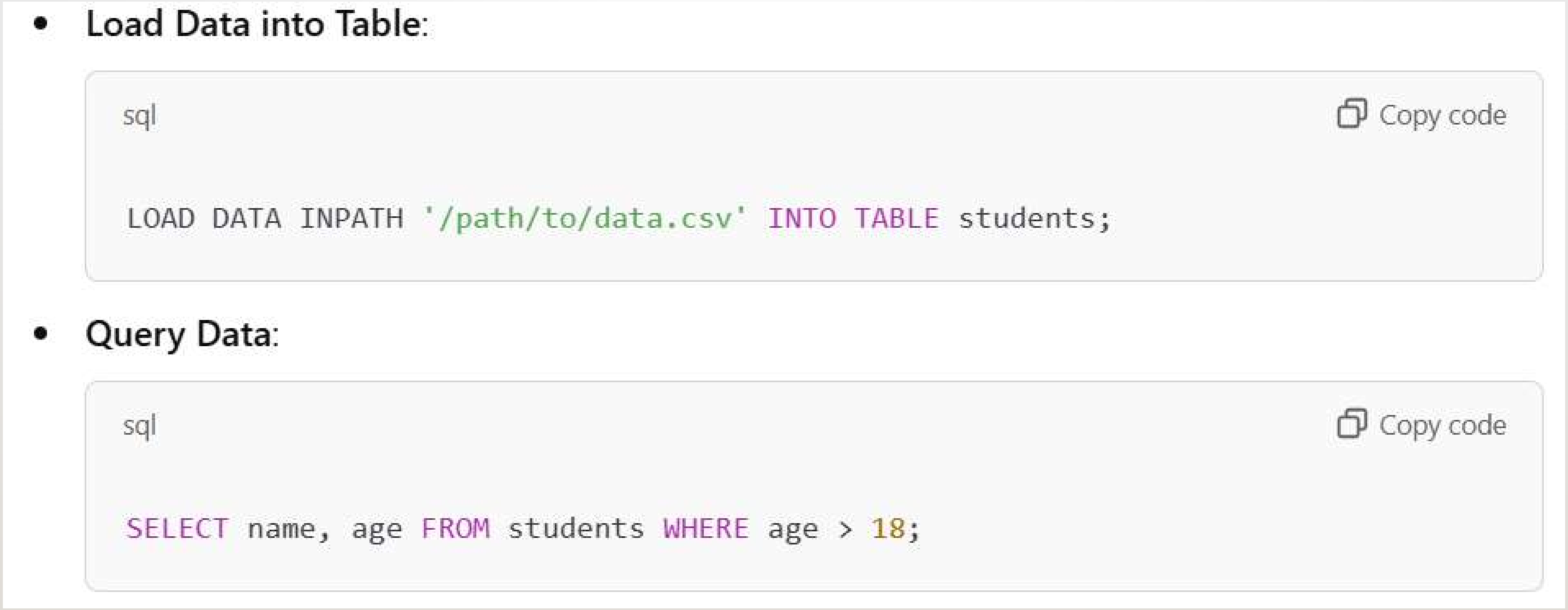
```pig
grouped_data = GROUP data BY $0;
```

2. Apache Hive

- **Purpose**: Apache Hive is a data warehousing and SQL-like framework that enables querying and managing large datasets.
- **Language**: Uses **HiveQL (HQL)**, an SQL-like query language optimized for batch processing in Hadoop.
- **Advantages**:
  - **SQL Compatibility**: Familiar to users with SQL experience, allowing them to perform queries without needing to write MapReduce code.
  - **Schema on Read**: Hive applies schema when querying data, making it versatile and suitable for both structured and semi-structured data.
  - **Integration with BI Tools**: Hive's structure is compatible with Business Intelligence (BI) tools for data analytics and reporting.
- **Common Use Cases**:
  - Data summarization and analysis
  - Data mining tasks
  - Batch data processing for reporting

- Basic Hive Commands:
    - Create Database and Table:

```
CREATE DATABASE student_db;
USE student_db;
CREATE TABLE students (id INT, name STRING, age INT) ROW FORMAT
DELIMITED FIELDS TERMINATED BY ',';
```



- **Load Data into Table:**

sql Copy code

```sql
LOAD DATA INPATH '/path/to/data.csv' INTO TABLE students;
```

- **Query Data:**

sql Copy code

```sql
SELECT name, age FROM students WHERE age > 18;
```

Comparison of Pig and Hive

Feature	Apache Pig	Apache Hive
Language	Pig Latin (procedural)	HiveQL (declarative SQL-like)
Ideal User	Data engineers familiar with scripting	Analysts familiar with SQL
Data Type Compatibility	Structured, semi-structured, unstructured	Mostly structured and semi-structured
Execution	MapReduce jobs	MapReduce, Spark, or Tez
Primary Use Cases	Data transformation, ETL, batch processing	Data warehousing, batch analytics, reporting