AI VIETNAM
All-in-One Course
(TA Session)

Big Data

Extra

Dinh-Thang Duong – TA

Truong-Binh Duong – STA

Year

Outline

- Introduction
- Hadoop
- Spark
- Question

Getting Started

❖ Objectives

In this session, we will discuss about:

- Introduction to big data.
- Introduction to Hadoop.
- How to install virtual machine.
- How to install and use Hadoop on virtual machine.
- Introduction to spark and pyspark.

Introduction

Introduction

❖ Getting Started

UNIT	VALUE
bit	1 bit
byte (B)	8 bits
kilobyte (KB)	1024 bytes
megabyte (MB)	1024 kilobytes
gigabyte (GB)	1024 megabytes
terabyte (TB)	1024 gigabytes
petabyte (PB)	1024 terabytes
exabyte (EB)	1024 petabytes
zettabyte (ZB)	1024 exabytes
yottabyte (YB)	1024 zettabytes

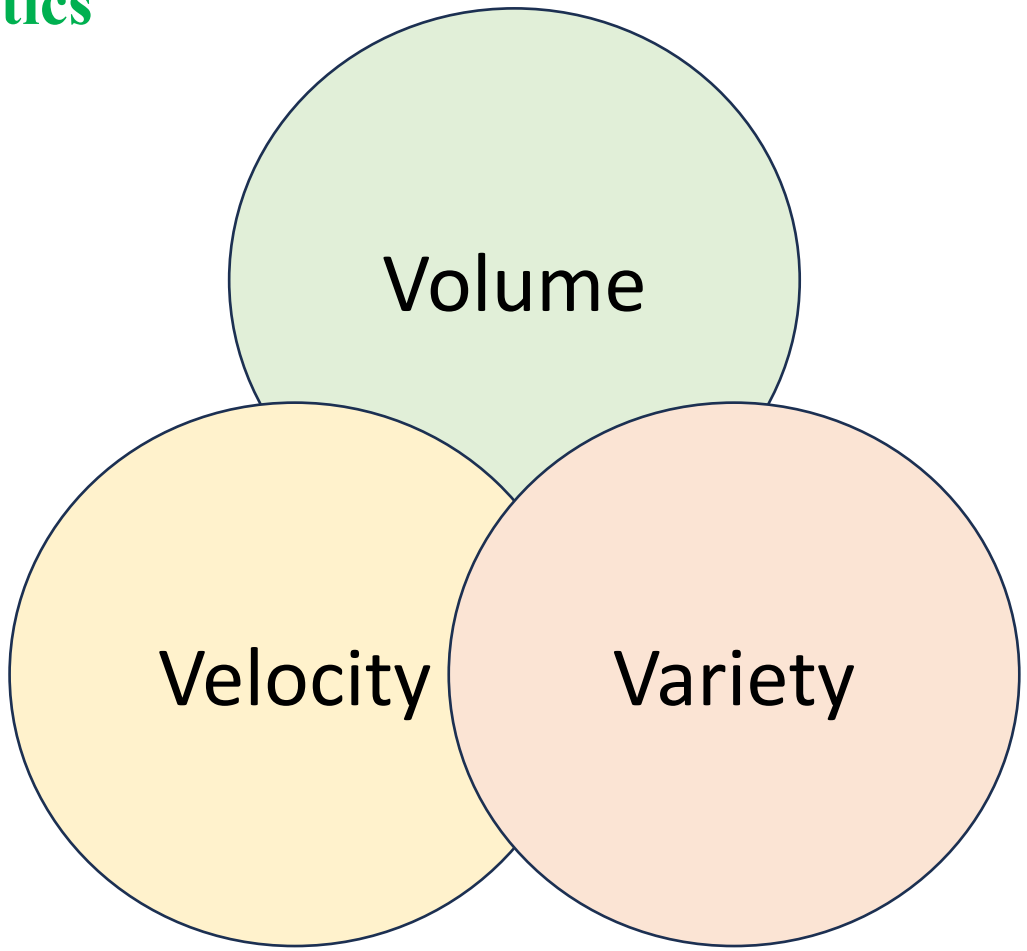
Introduction

❖ Big Data Definition

Big Data: A collection of datasets that is large, complex that make it very difficult to process using traditional data processing applications.

Introduction

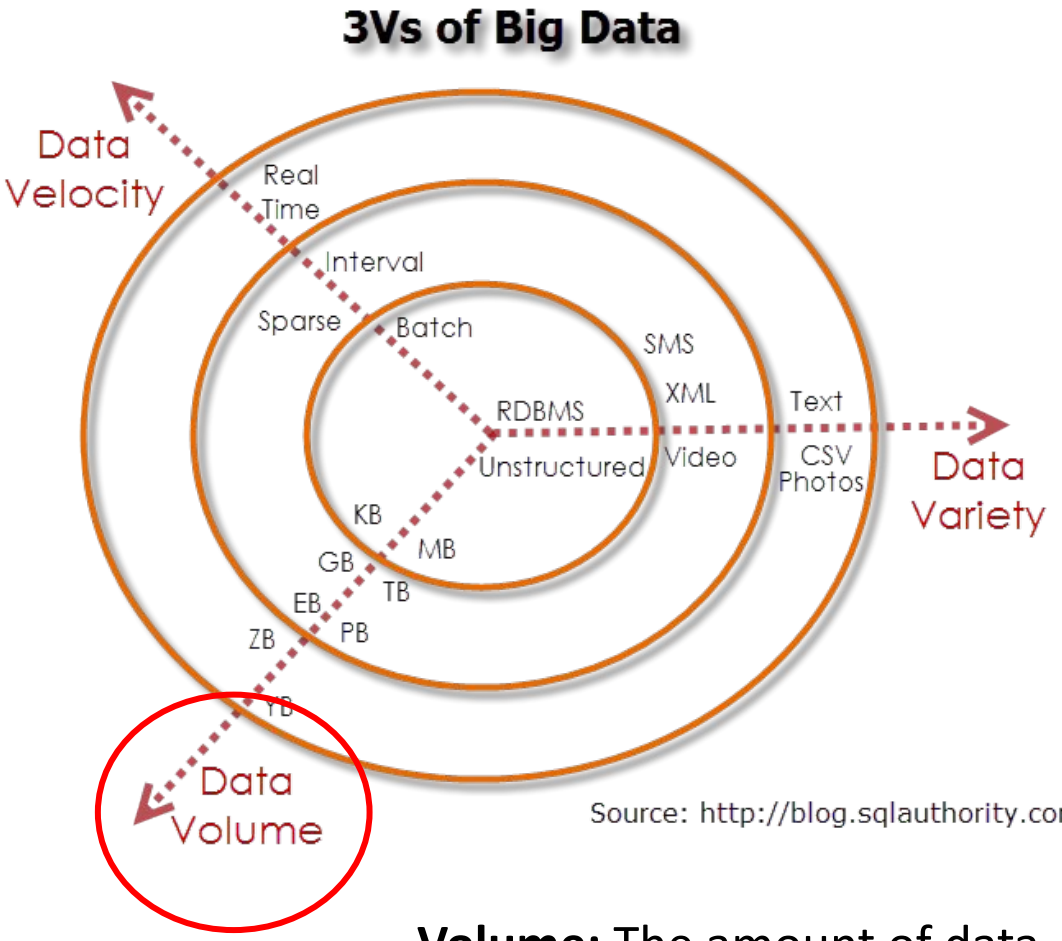
❖ Big Data Characteristics



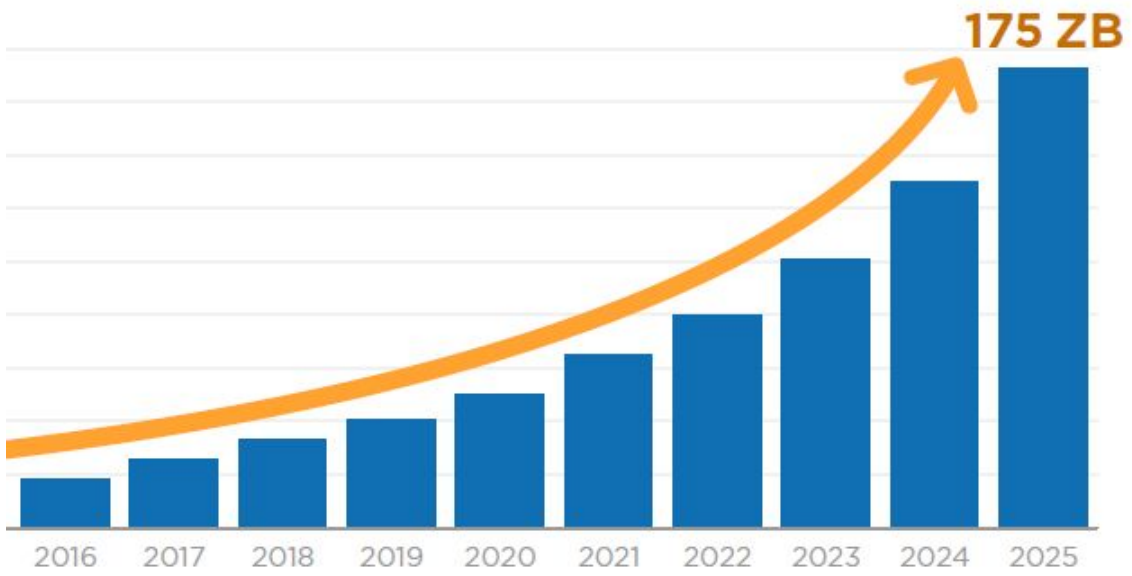
3V of Big Data

Introduction

❖ Big Data Characteristics



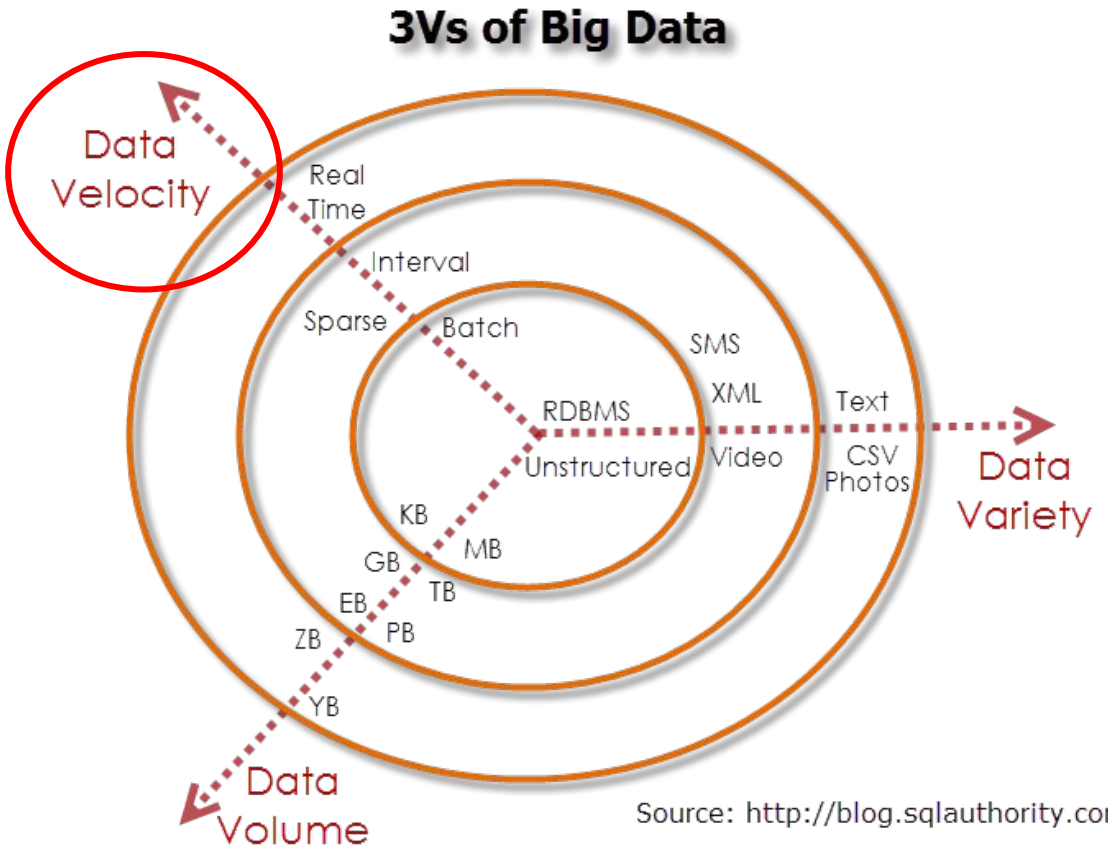
Volume: The amount of data



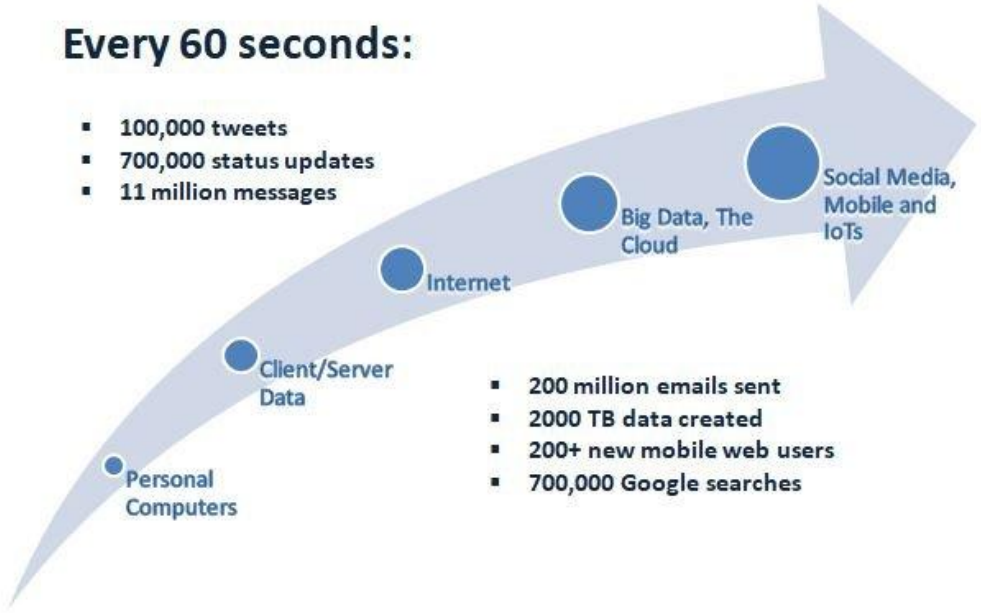
The amount of data generated on Internet each year

Introduction

❖ Big Data Characteristics



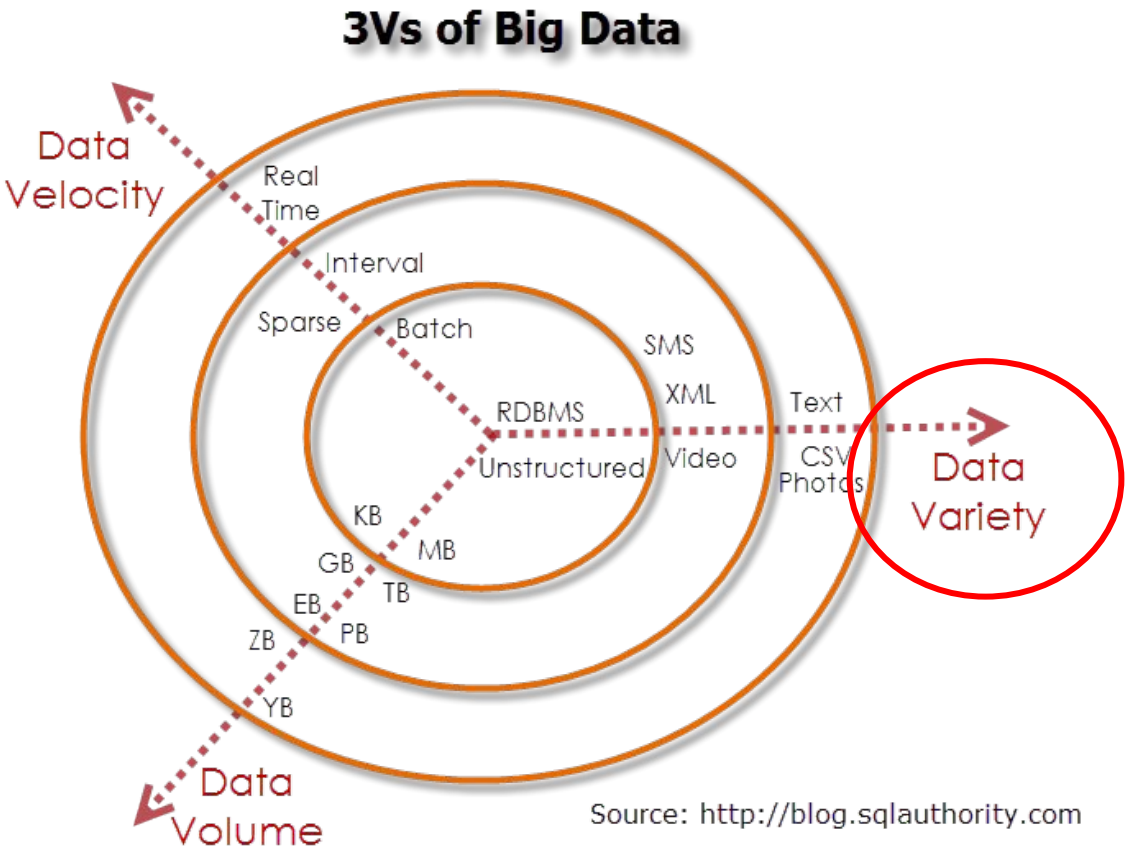
Velocity: The growth of data

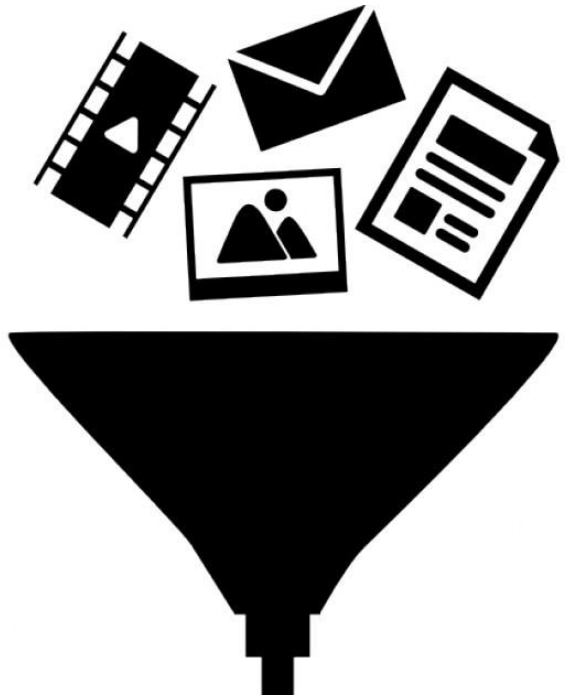


Data generated on Internet every 1 minute

Introduction

❖ Big Data Characteristics





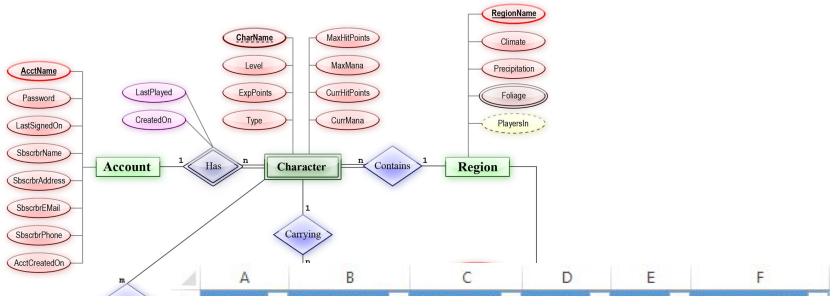
Lots of types of data to be processed

Variety: The diversity of data

Introduction

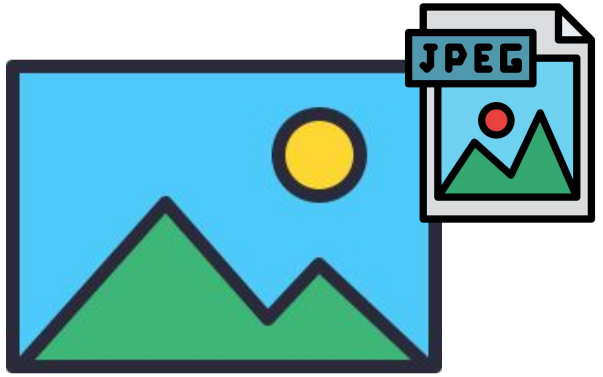
❖ Types of big data

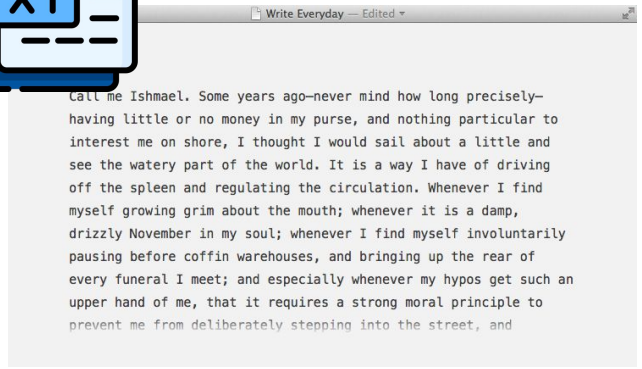
Structured Data



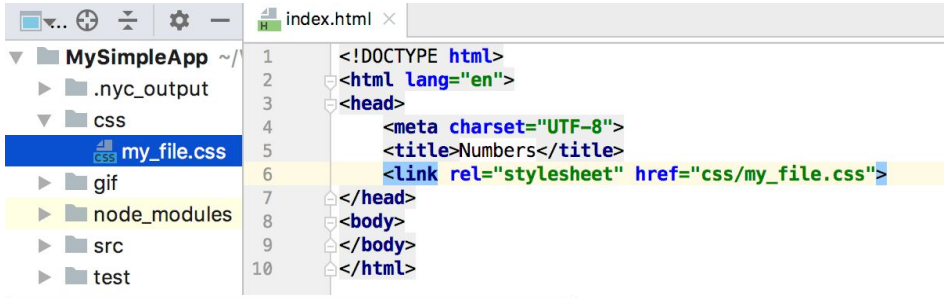
	A	B	C	D	E	F
1	Country	Salesperson	Order Date	OrderID	Units	Order Amount
2	USA	Fuller	1/01/2011	10392	13	1,440.00
3	UK	Gloucester	2/01/2011	10397	17	716.72
4	UK	Bromley	2/01/2011	10771	18	344.00
5	USA	Finchley	3/01/2011	10393	16	2,556.95
6	USA	Finchley	3/01/2011	10394	10	442.00
7	UK	Gillingham	3/01/2011	10395	9	2,122.92
8	USA	Finchley	6/01/2011	10396	7	1,903.80
9	USA	Callahan	8/01/2011	10399	17	1,765.60
10	USA	Fuller	8/01/2011	10404	7	1,591.25
11	USA	Fuller	9/01/2011	10398	11	2,505.60
12	USA	Coghill	9/01/2011	10403	18	855.01
13	USA	Finchley	10/01/2011	10401	7	3,868.60
14	USA	Callahan	10/01/2011	10402	11	2,713.50
15	UK	Rayleigh	13/01/2011	10406	15	1,830.78
16	USA	Callahan	14/01/2011	10408	10	1,622.40
17	USA	Farnham	14/01/2011	10409	19	319.20
18	USA	Farnham	15/01/2011	10410	16	802.00

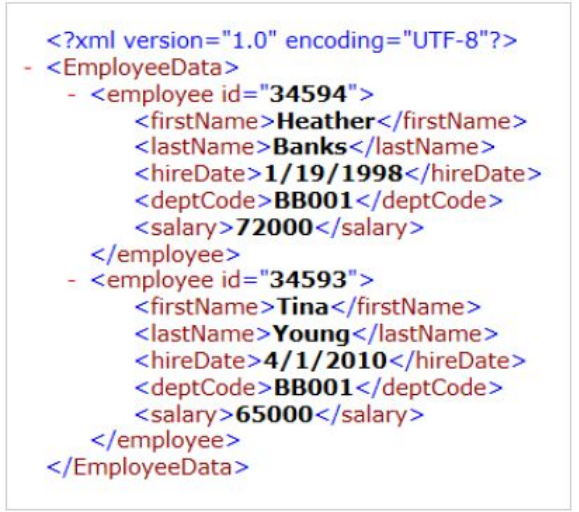
Unstructured Data

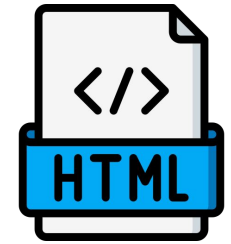




Semi-structured Data

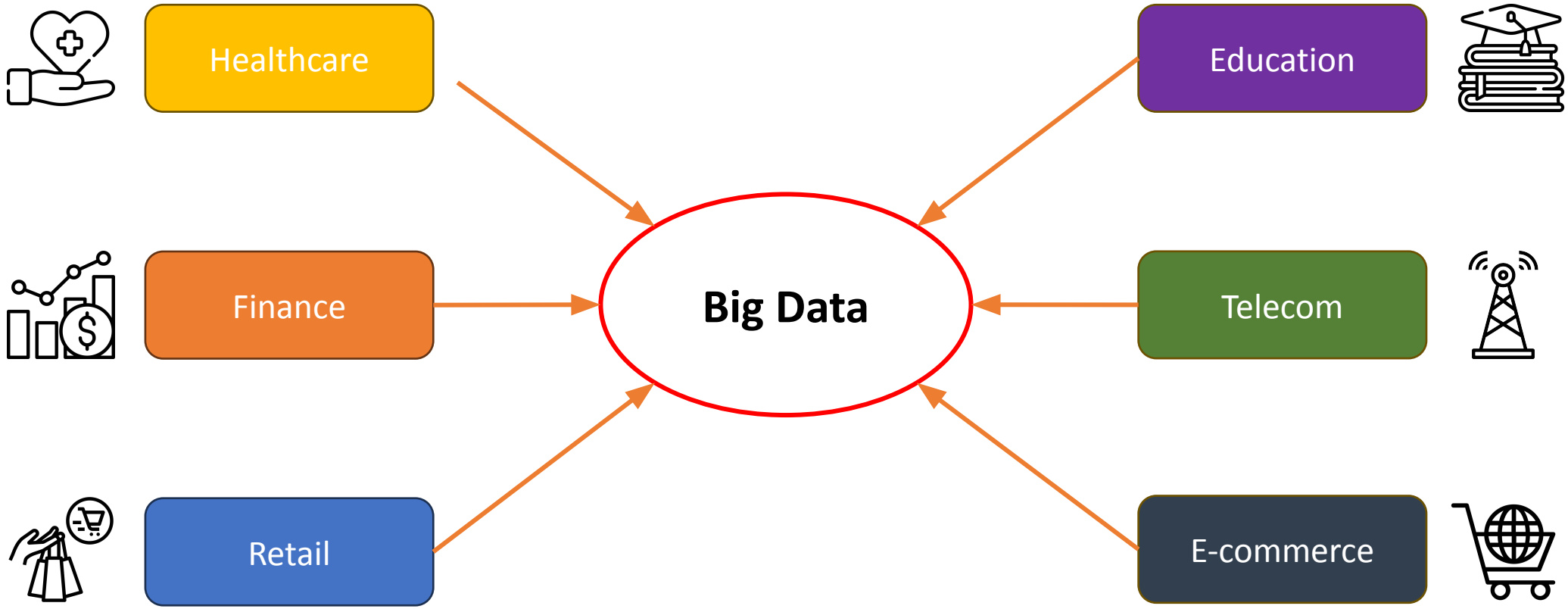






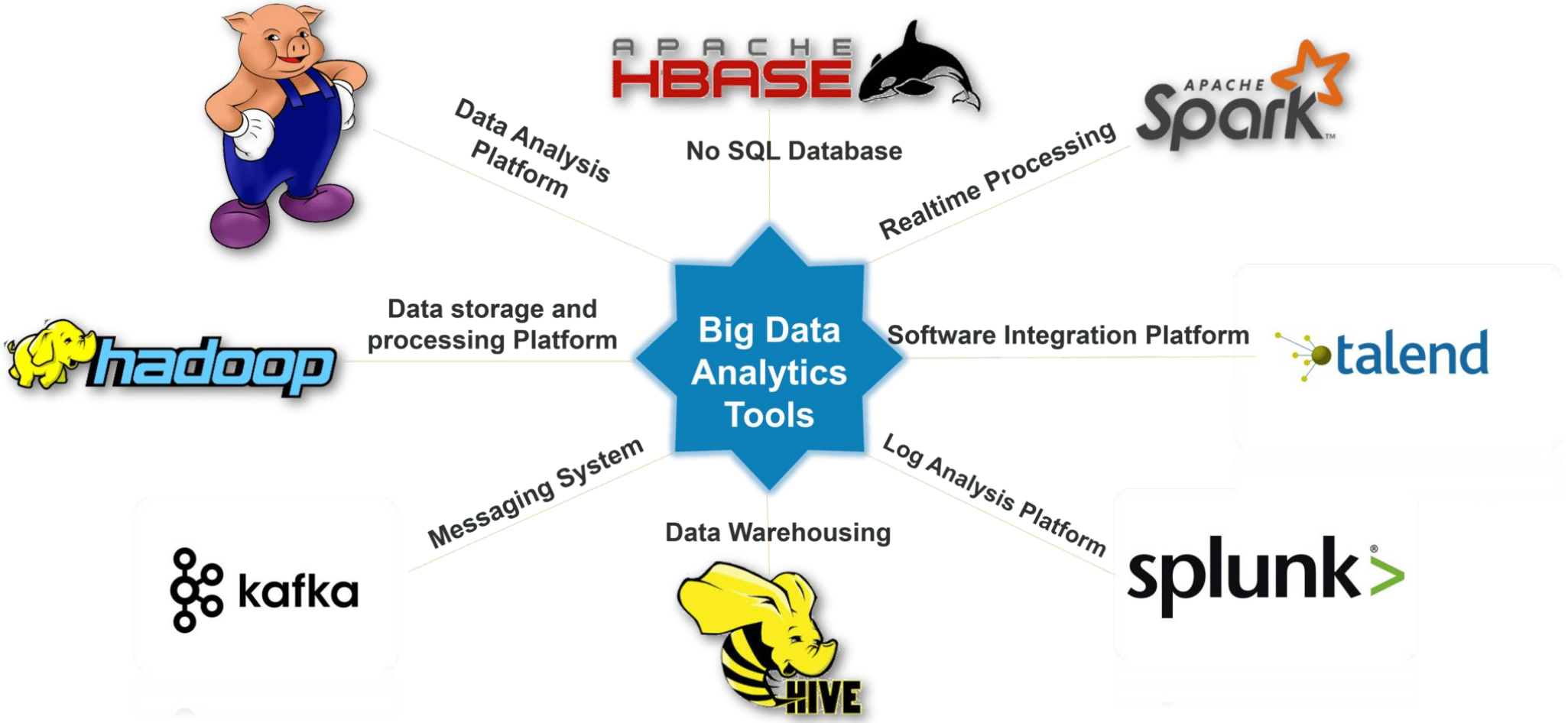
Introduction

❖ Big Data Applications



Introduction

❖ Tools for Big Data



Hadoop

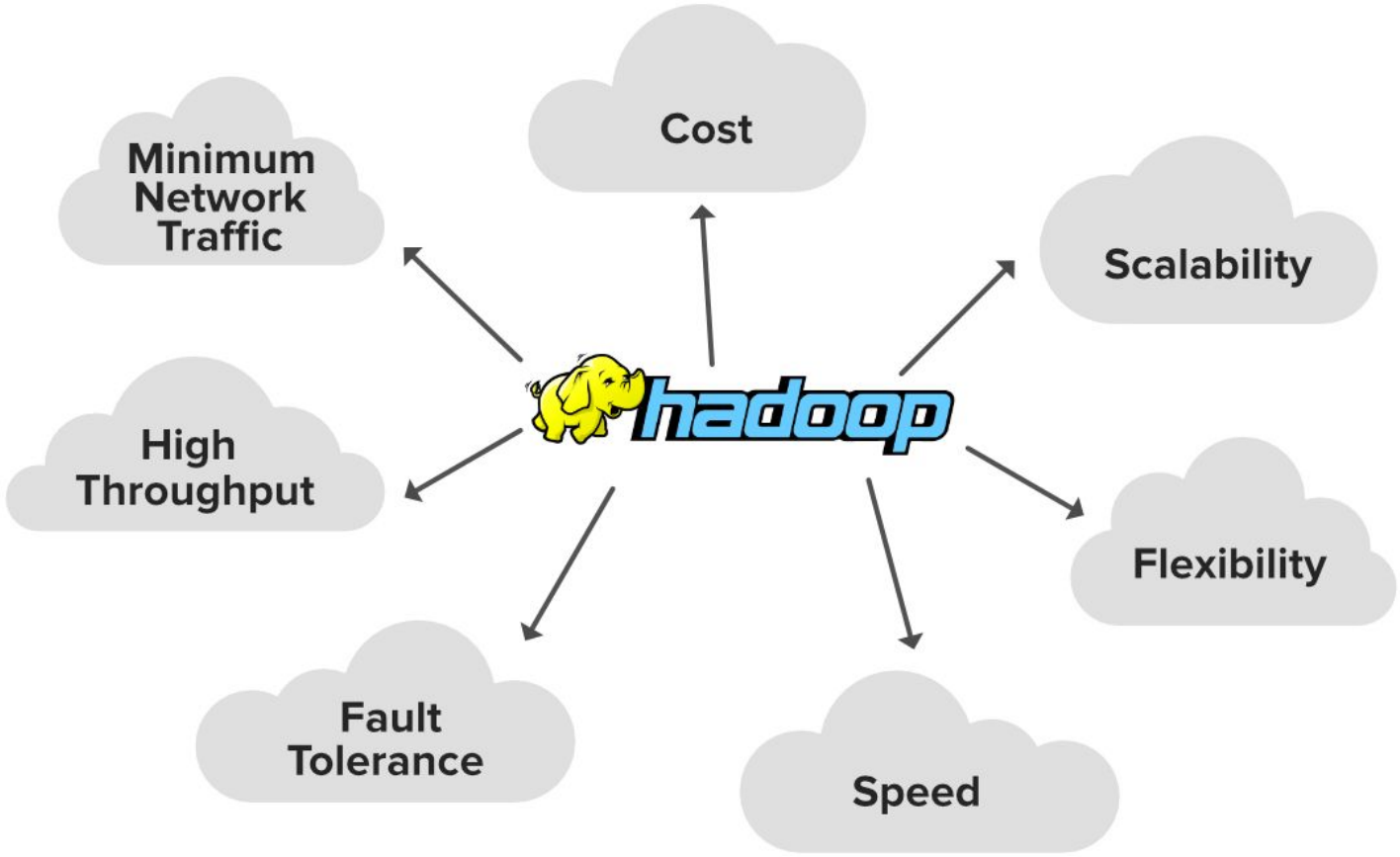
Hadoop

❖ Introduction

Apache Hadoop: an open-source framework that is used to **efficiently store and process large datasets** ranging in size from gigabytes to petabytes of data.

Hadoop

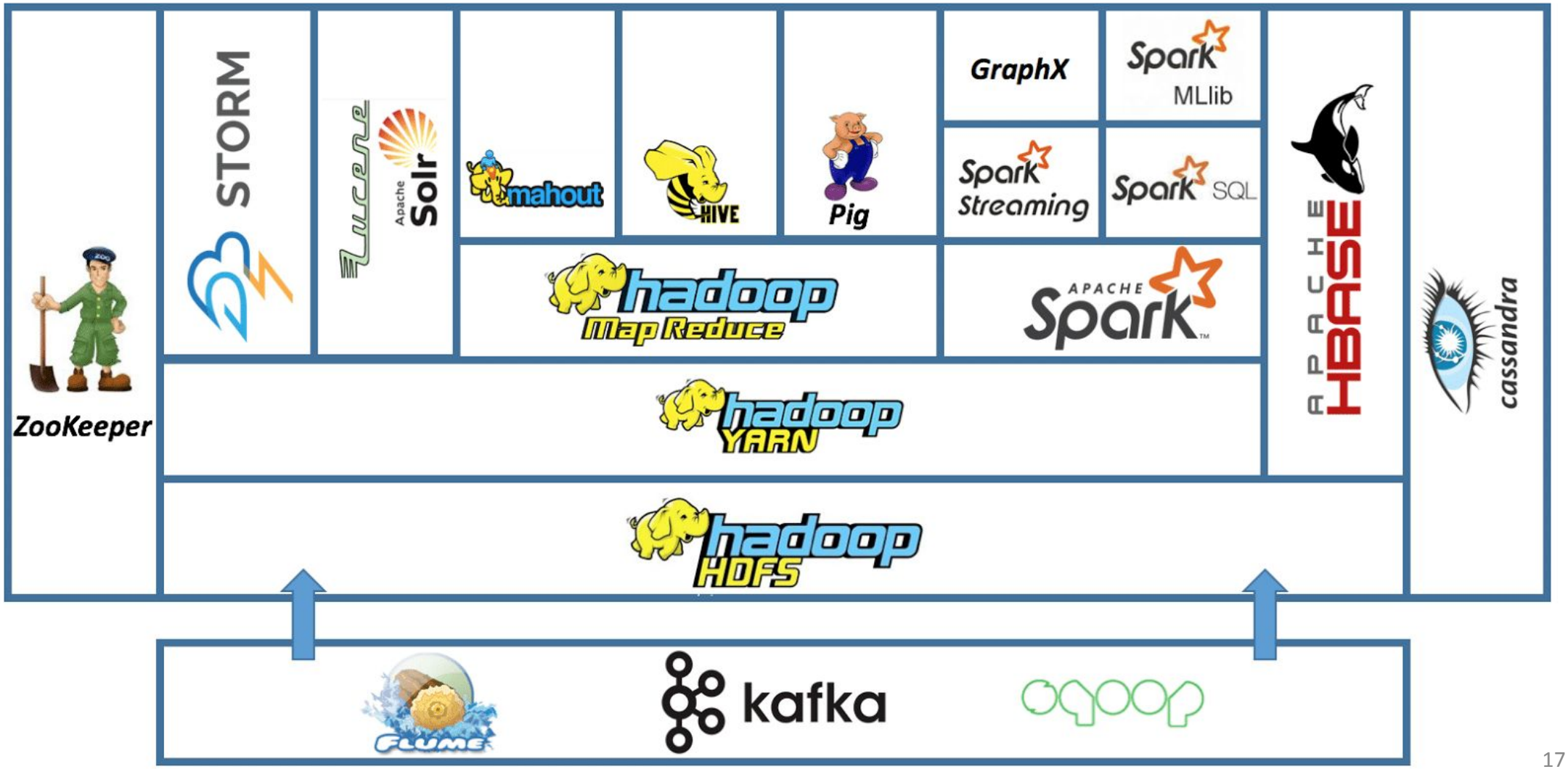
Introduction



Hadoop Advantages

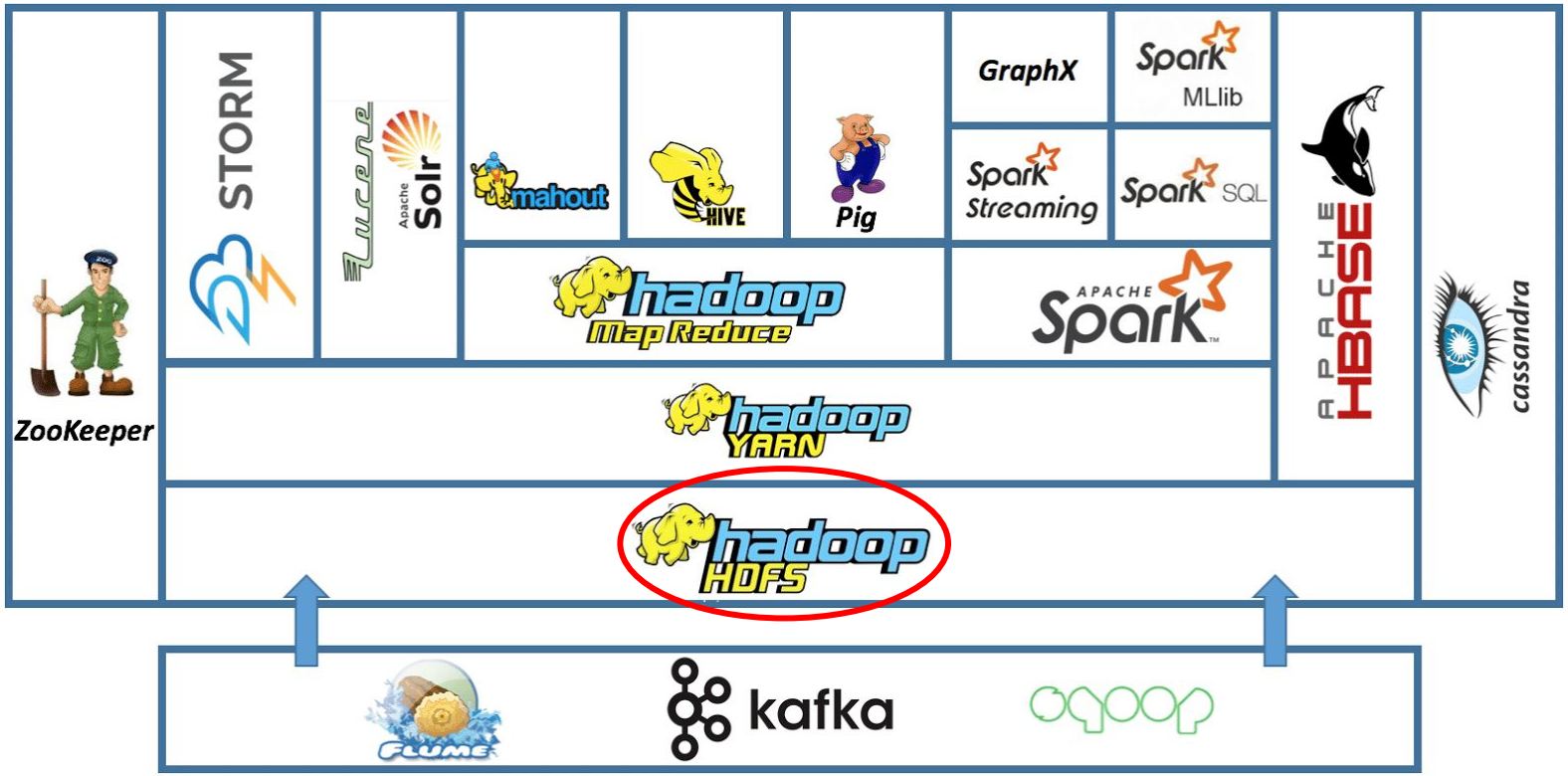
Hadoop

❖ Hadoop Ecosystem



Hadoop

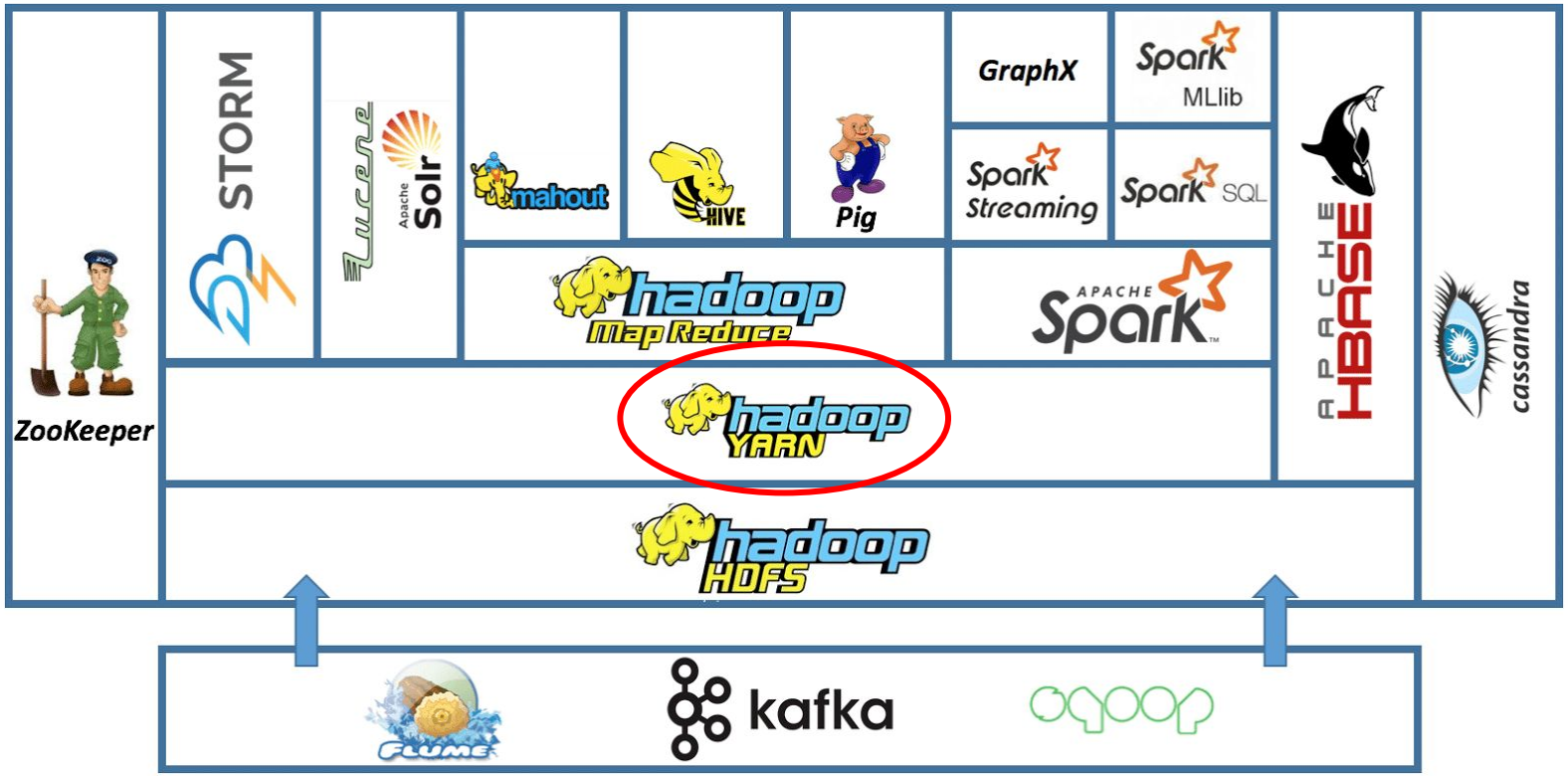
❖ Hadoop Ecosystem: Hadoop HDFS



Hadoop HDFS (Hadoop Distributed File System): A distributed file system that handles larget data sets running on commodity hardware.

Hadoop

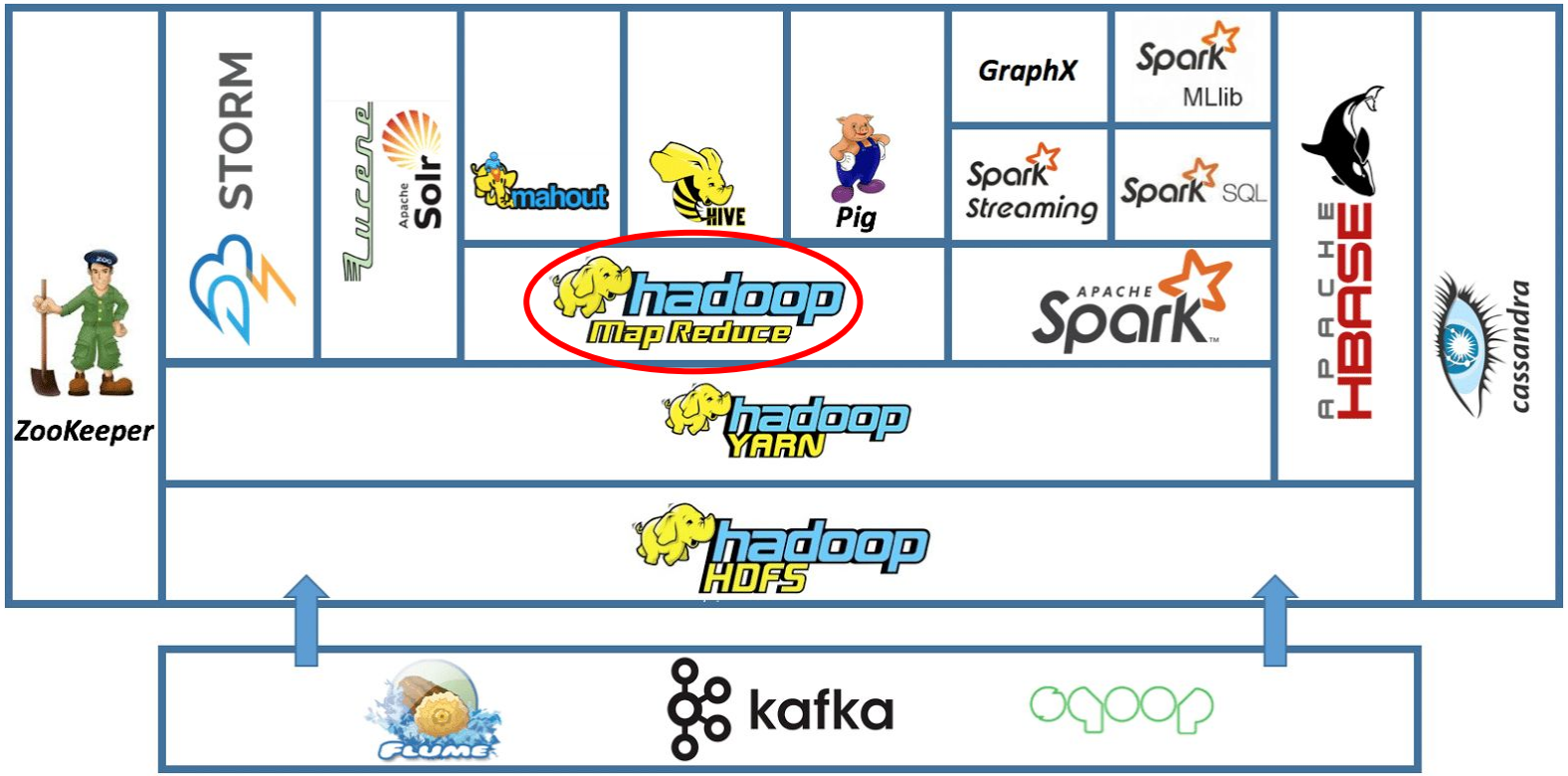
❖ Hadoop Ecosystem: Hadoop YARN



Hadoop YARN (Yet Another Resource Negotiator): the resources management and job scheduling technology.

Hadoop

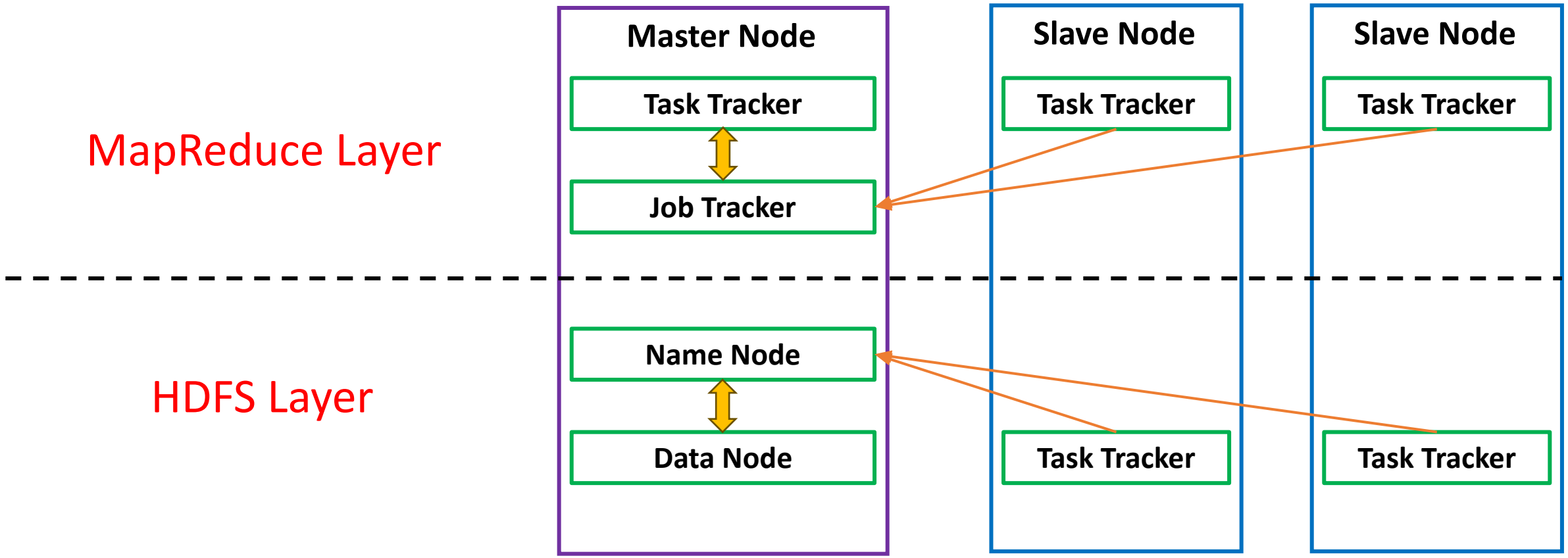
❖ Hadoop Ecosystem: Hadoop MapReduce



Hadoop MapReduce: A highly sufficient methodology for parallel processing of huge volumes of data.

Hadoop

❖ Hadoop Architecture

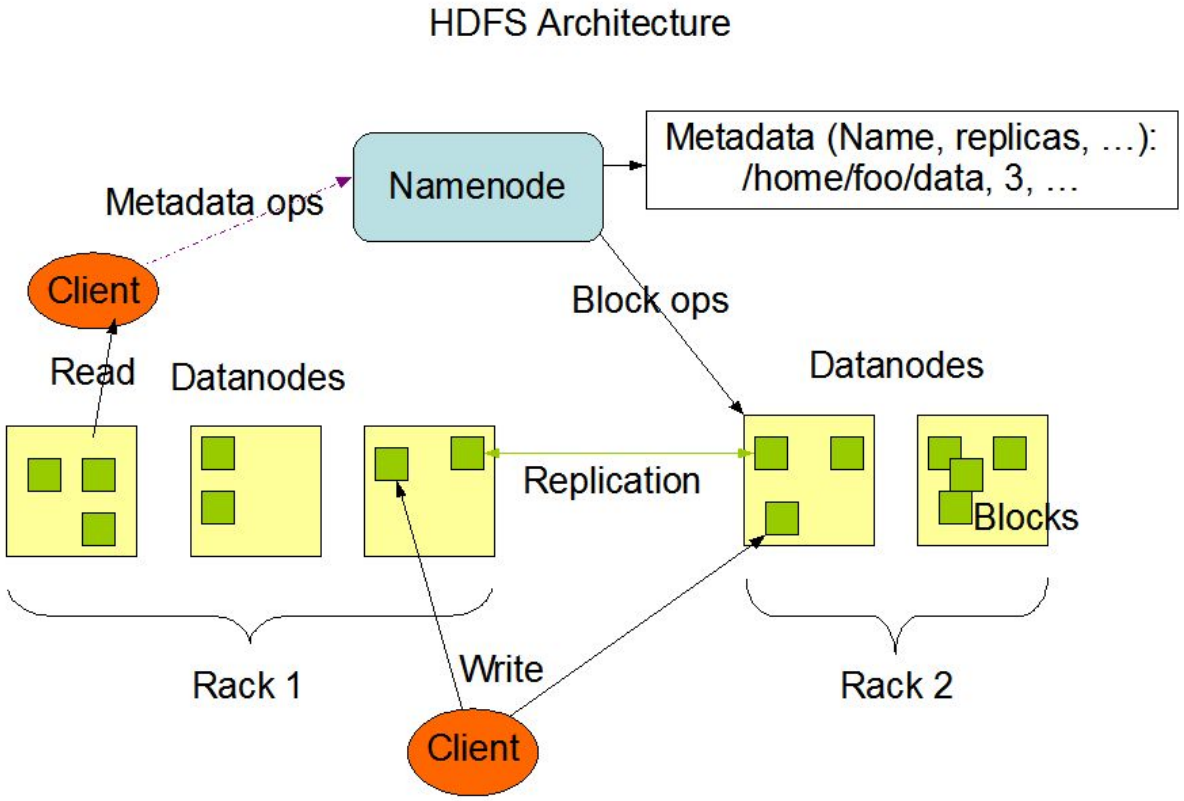


High-level Architecture of Hadoop

Hadoop

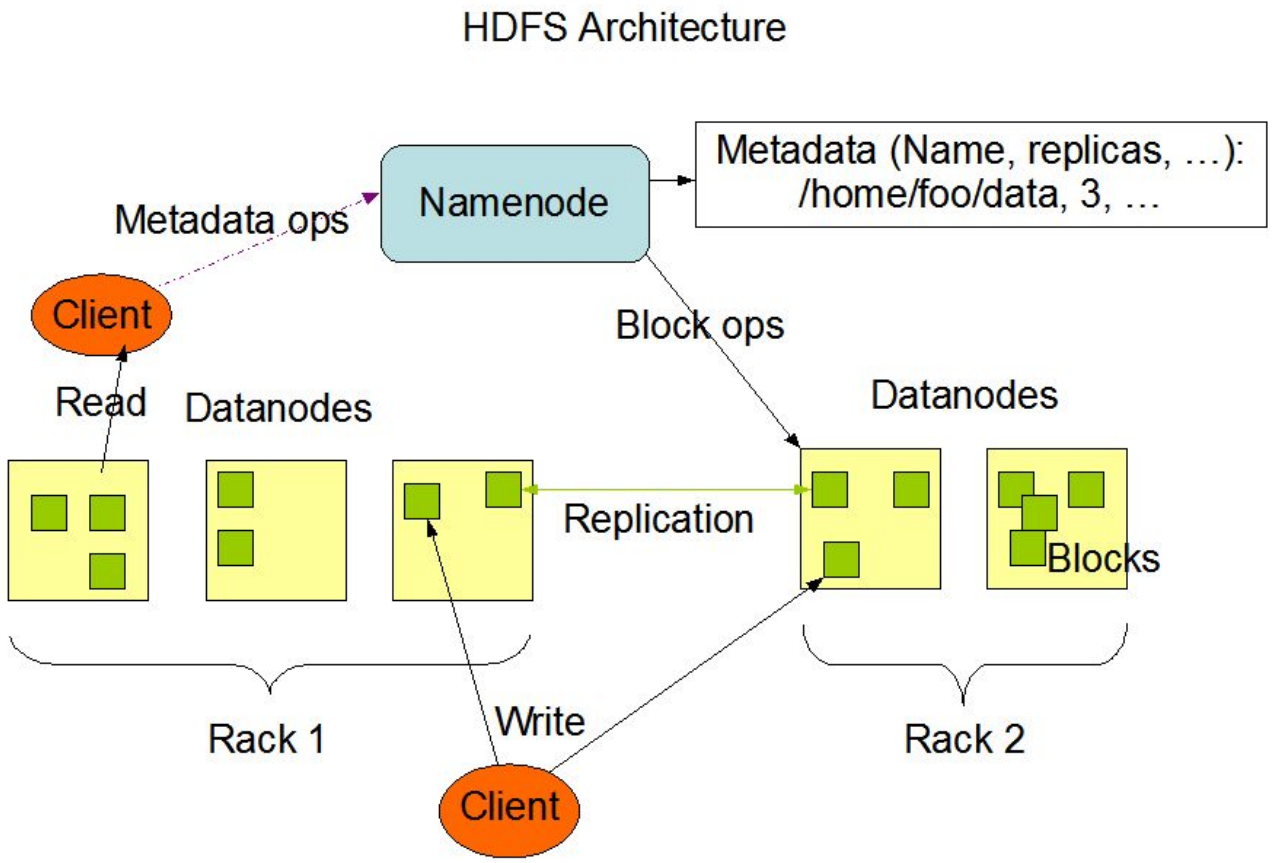
❖ Hadoop HDFS

HDFS (Hadoop Distributed File System): A distributed file system designed to store and process large amounts of data across multiple machines in a Hadoop cluster, providing high fault-tolerance and scalability.



Hadoop

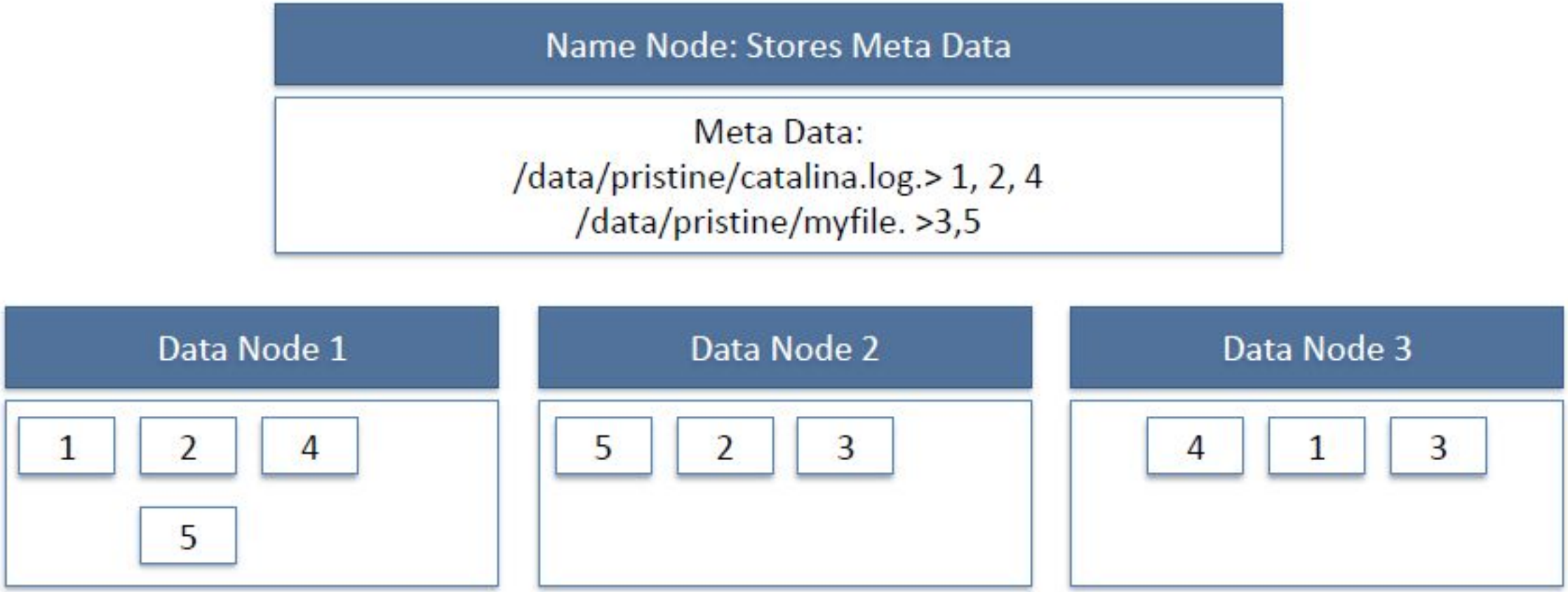
❖ Hadoop HDFS



- **Namenode:** Master node in a Hadoop cluster, managing file system's metadata.
- **Datanode:** Worker node in a Hadoop cluster, storing data blocks.
- **Blocks:** A fixed-size chunk of data. Default is 128MB (or 64MB) size.

Hadoop

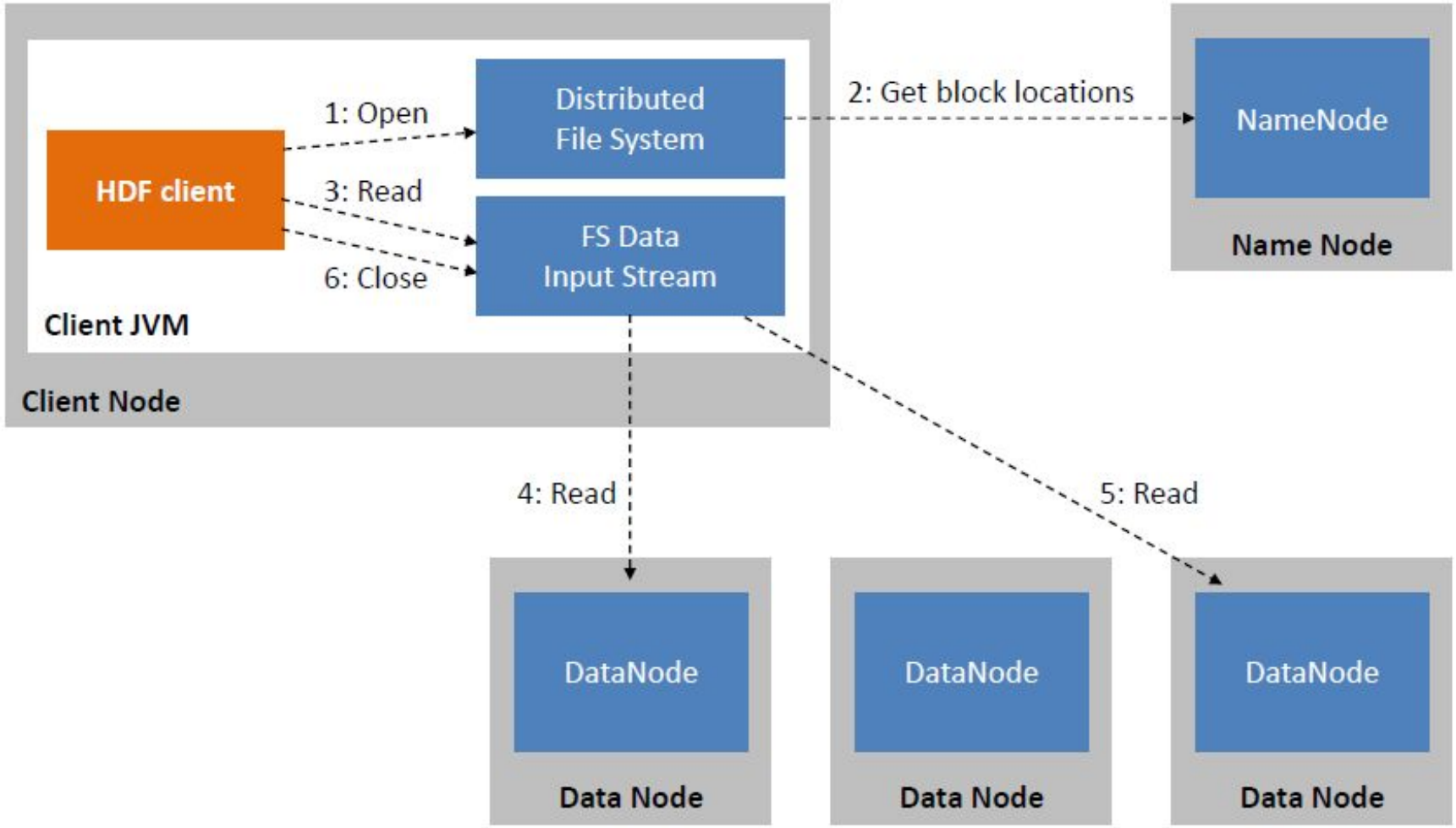
❖ Hadoop HDFS



https://www.javatpoint.com/hdfs

Hadoop

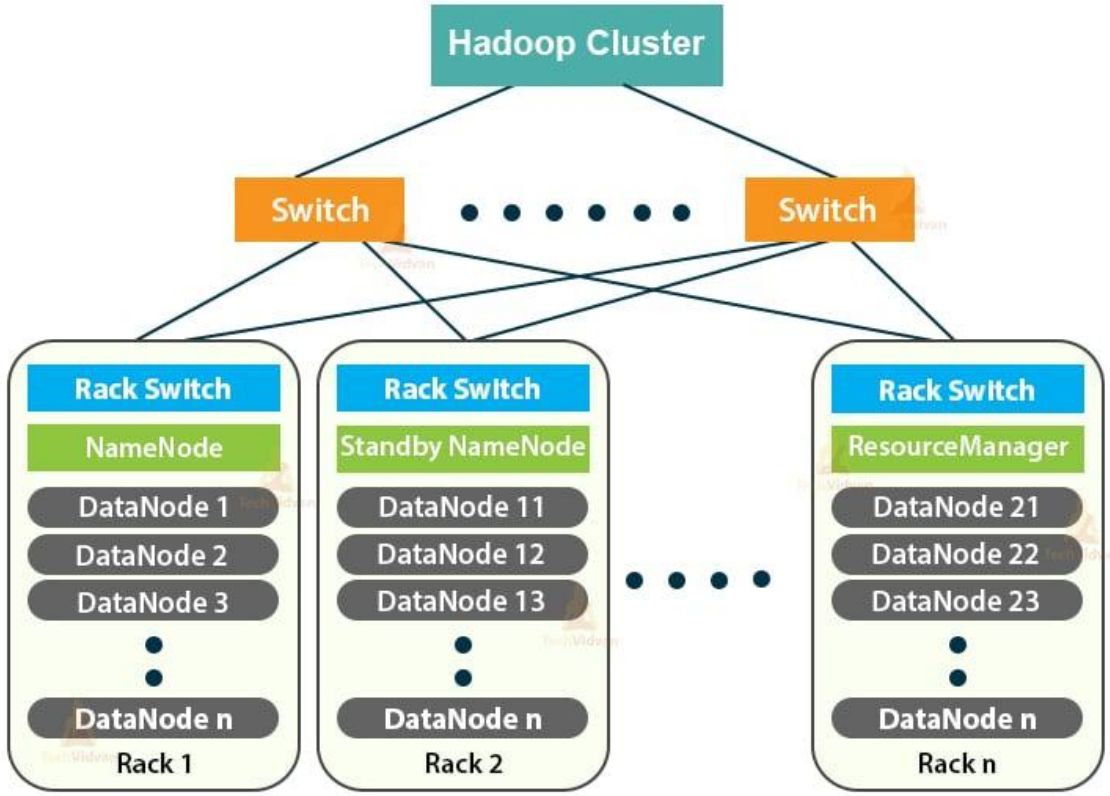
❖ Hadoop HDFS

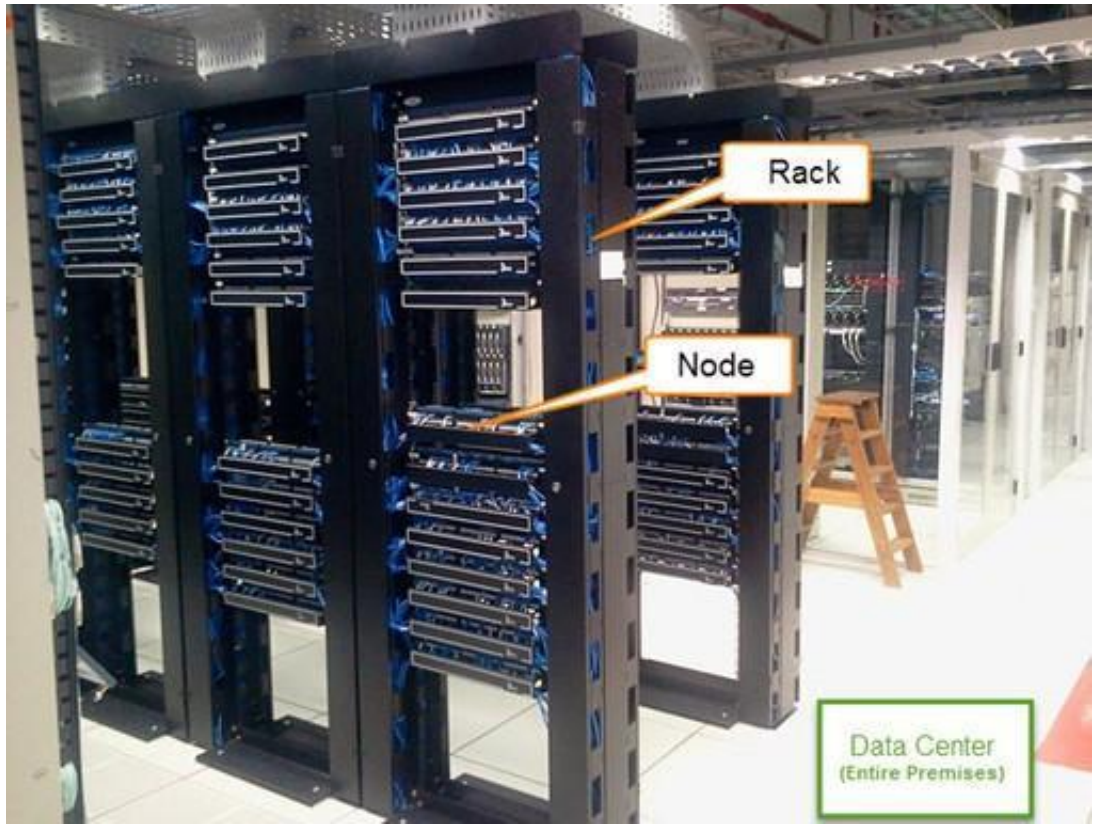


https://www.javatpoint.com/hdfs

Hadoop

❖ Hadoop HDFS



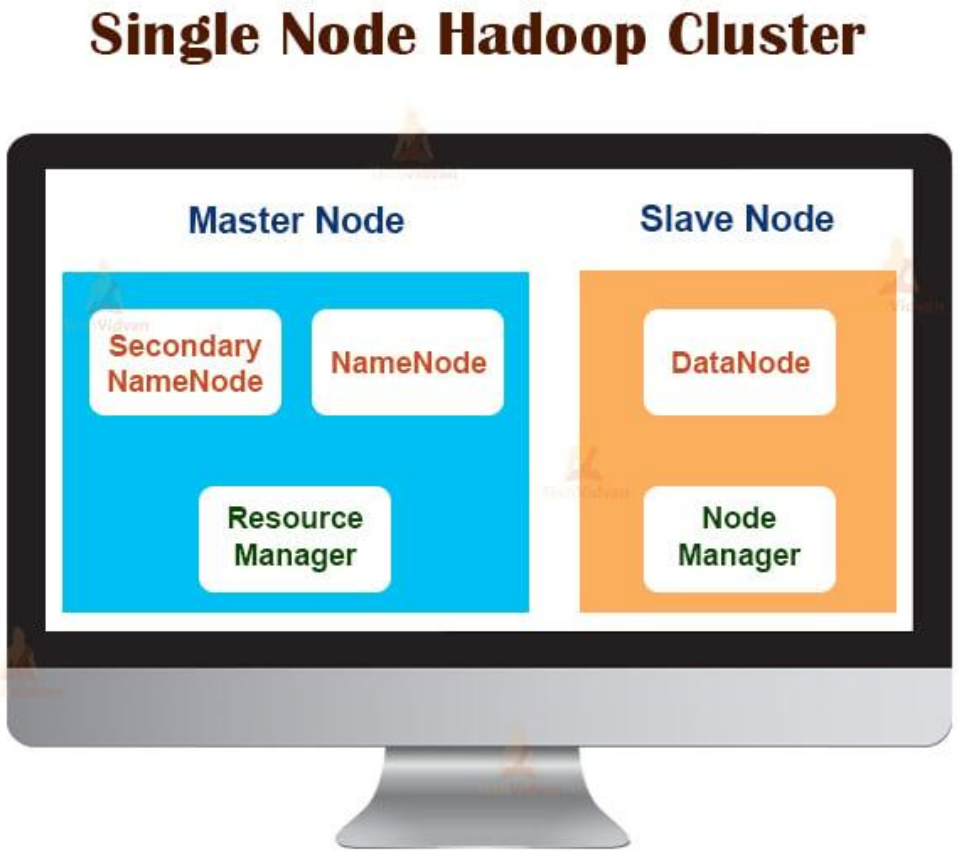


Hadoop Cluster Architecture

https://techvidvan.com/tutorials/hadoop-cluster/

Hadoop

❖ Hadoop HDFS



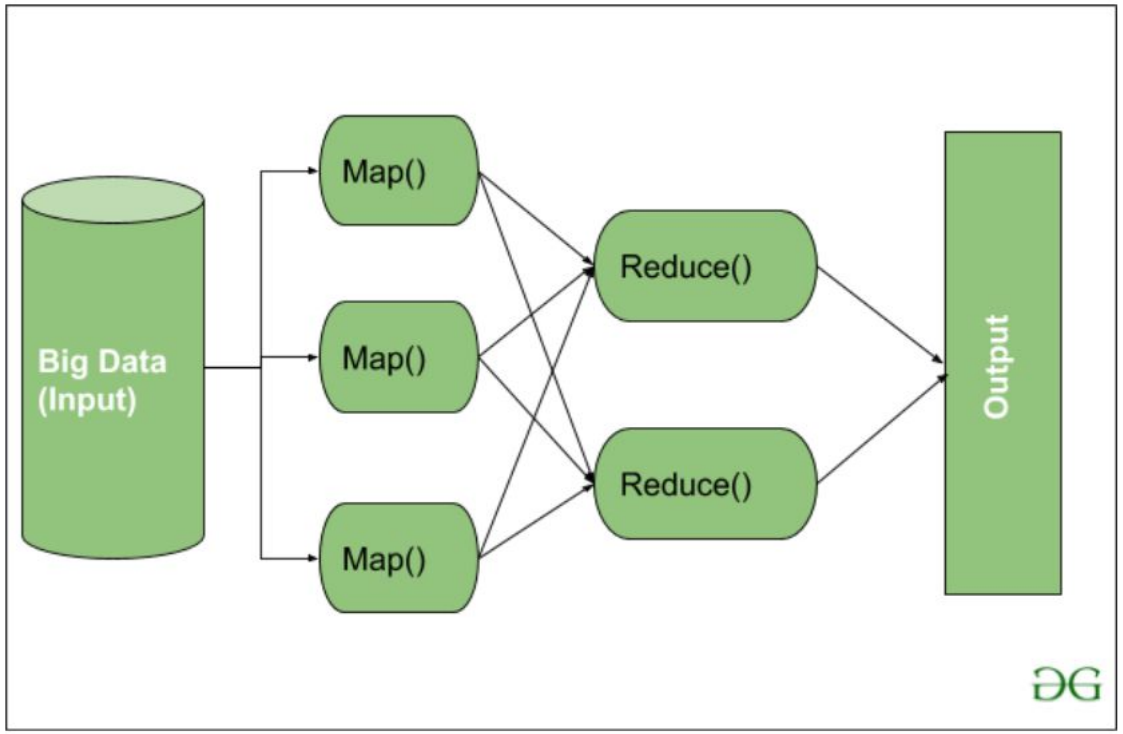
Hadoop Single Node Cluster Architecture

https://techvidvan.com/tutorials/hadoop-cluster/

Hadoop

❖ Hadoop MapReduce

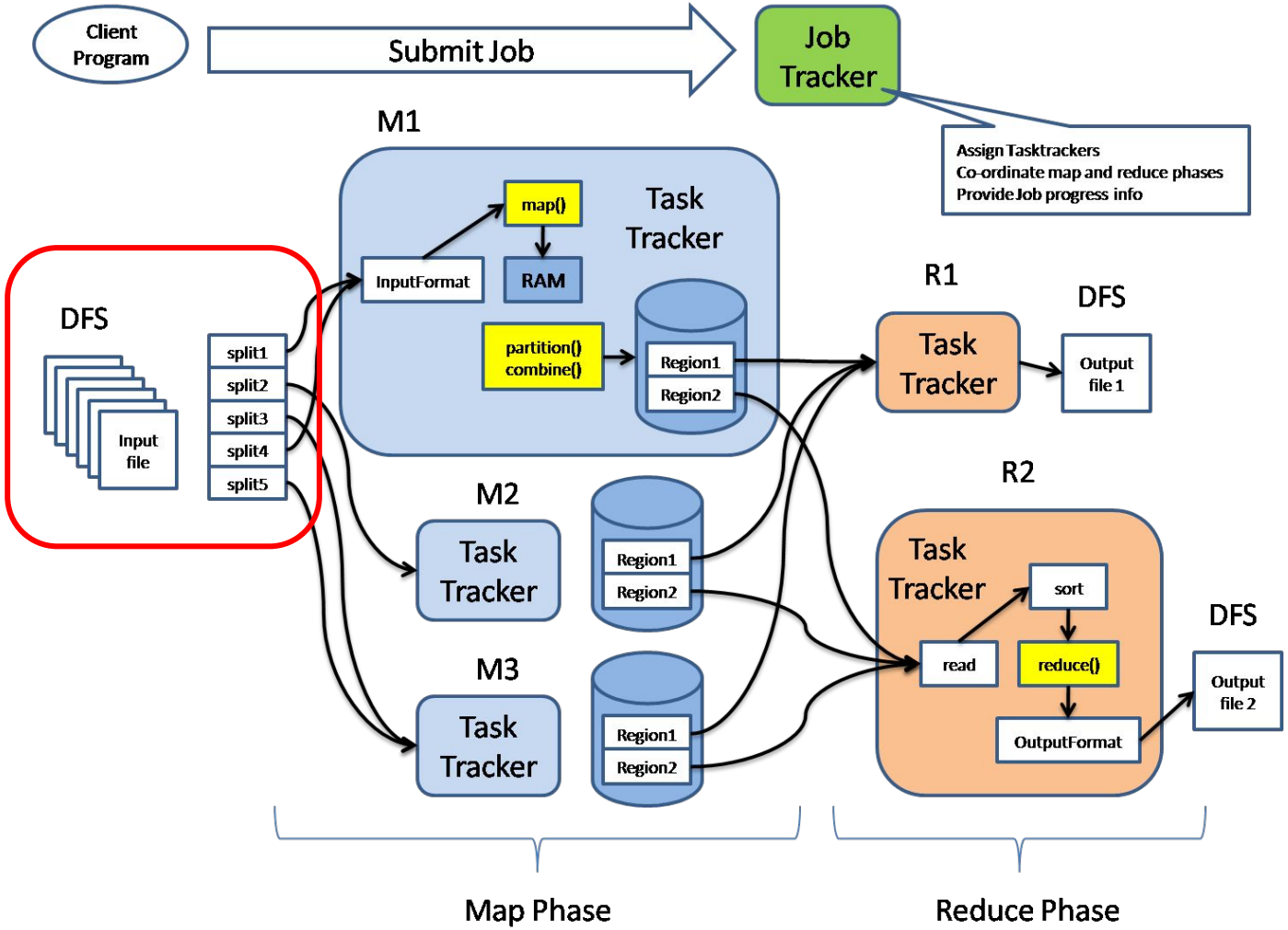
Hadoop MapReduce: A distributed programming model and framework that breaks down large-scale data processing tasks into smaller, parallelizable operations (map and reduce), allowing for efficient processing and analysis of big data across a cluster of machines.



https://www.geeksforgeeks.org/hadoop-architecture/

Hadoop

❖ Hadoop MapReduce

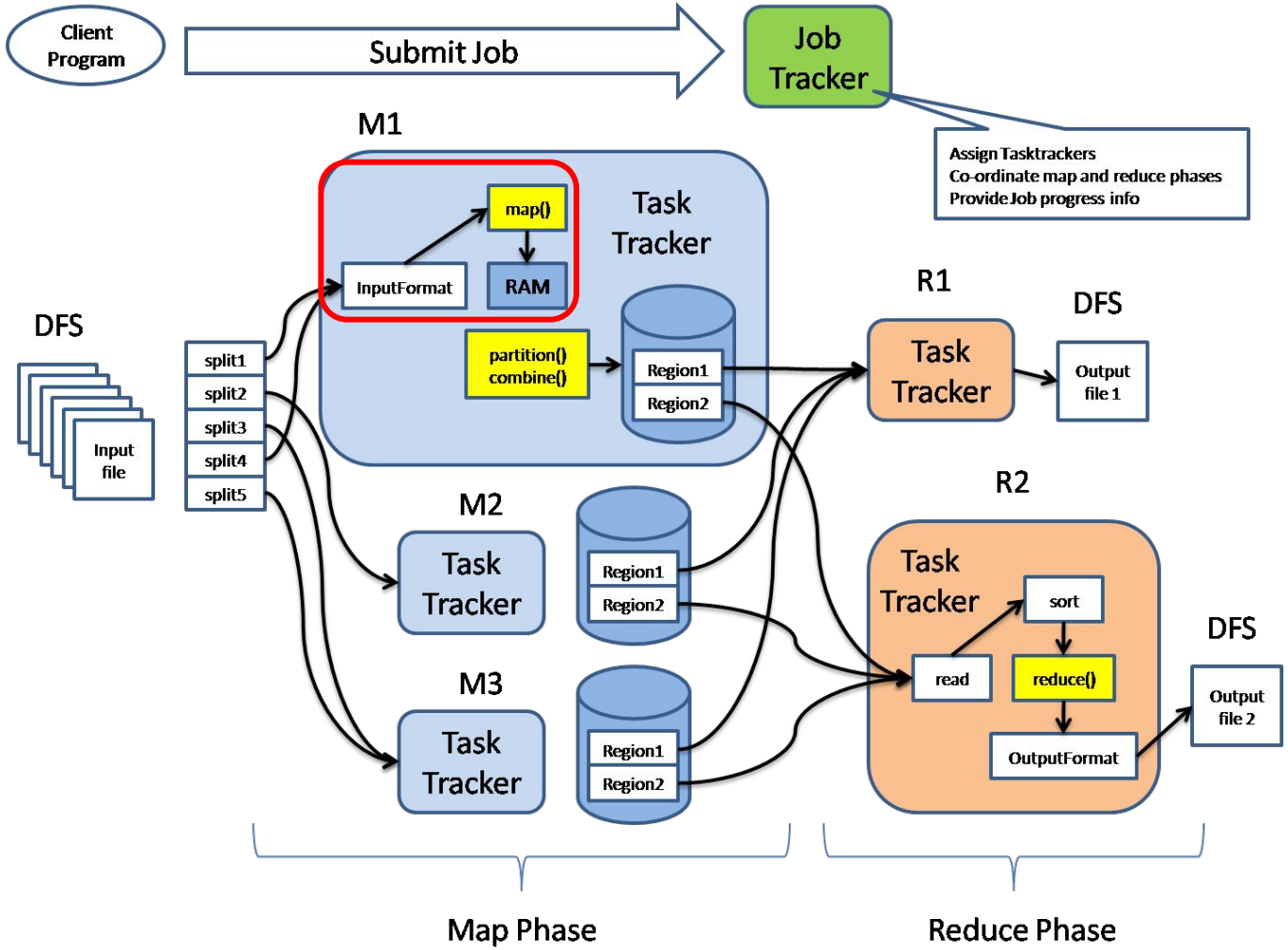


InputReader: Read the input data and split it into the data blocks.

https://www.analyticsvidhya.com/blog/2022/07/learn-everything-about-mapreduce-architecture-and-its-components/

Hadoop

❖ Hadoop MapReduce

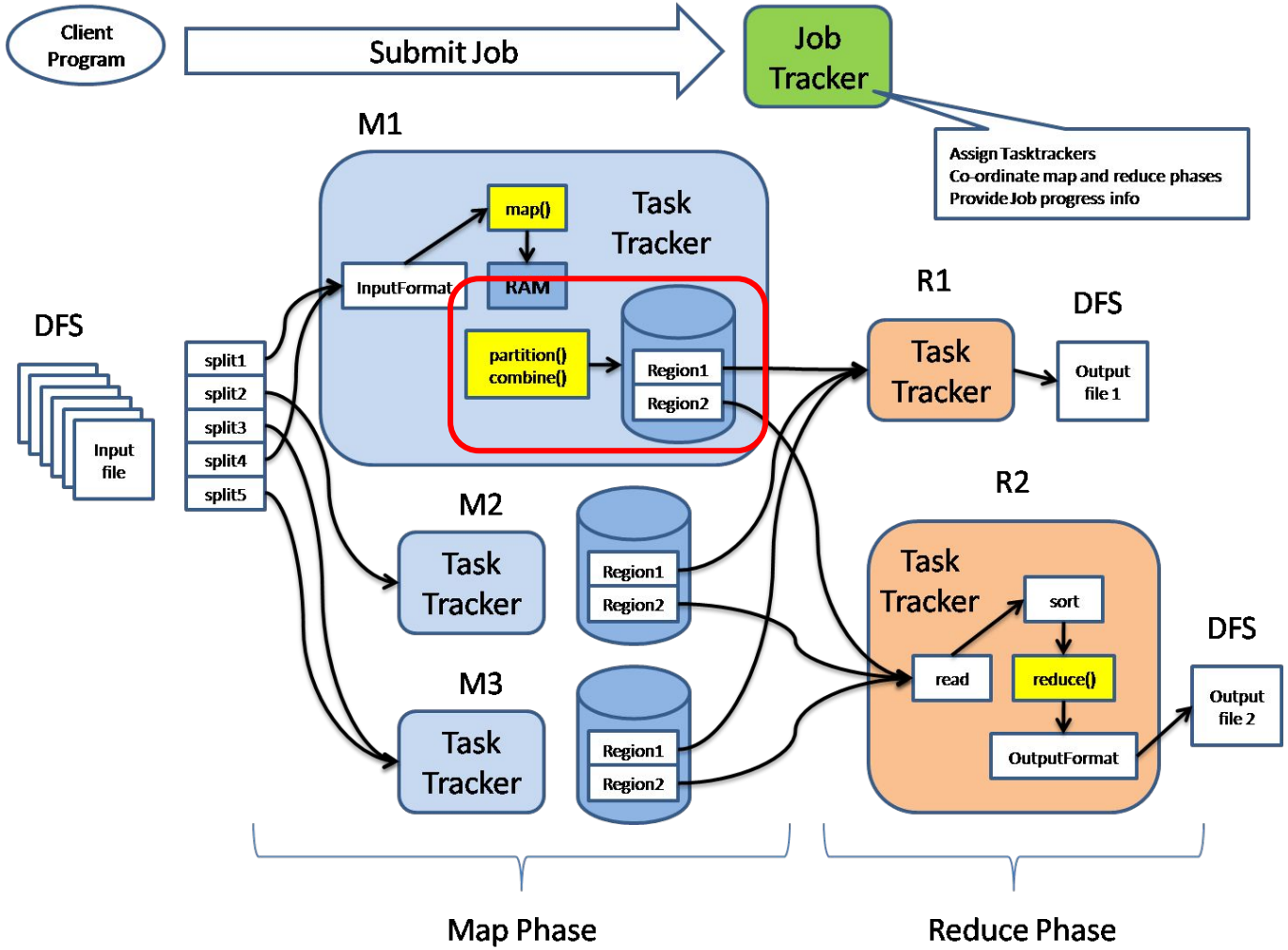


MapFunction: Process the key-value pairs and generate the corresponding output key-value pairs.

https://www.analyticsvidhya.com/blog/2022/07/learn-everything-about-mapreduce-architecture-and-its-components/

Hadoop

❖ Hadoop MapReduce

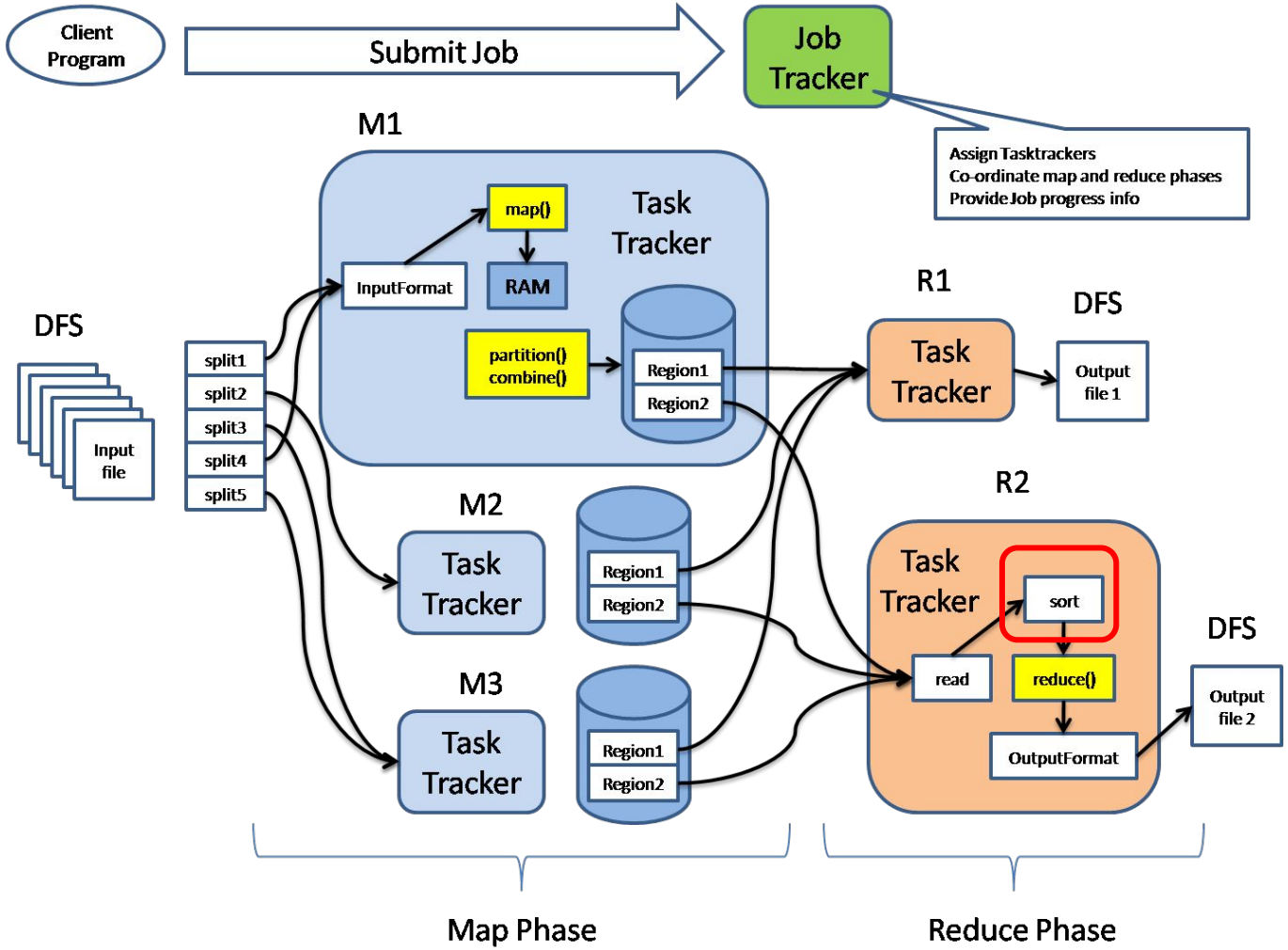


PartitionFunction: Assign the output of Mapping to the appropriate Reducer.

https://www.analyticsvidhya.com/blog/2022/07/learn-everything-about-mapreduce-architecture-and-its-components/

Hadoop

❖ Hadoop MapReduce

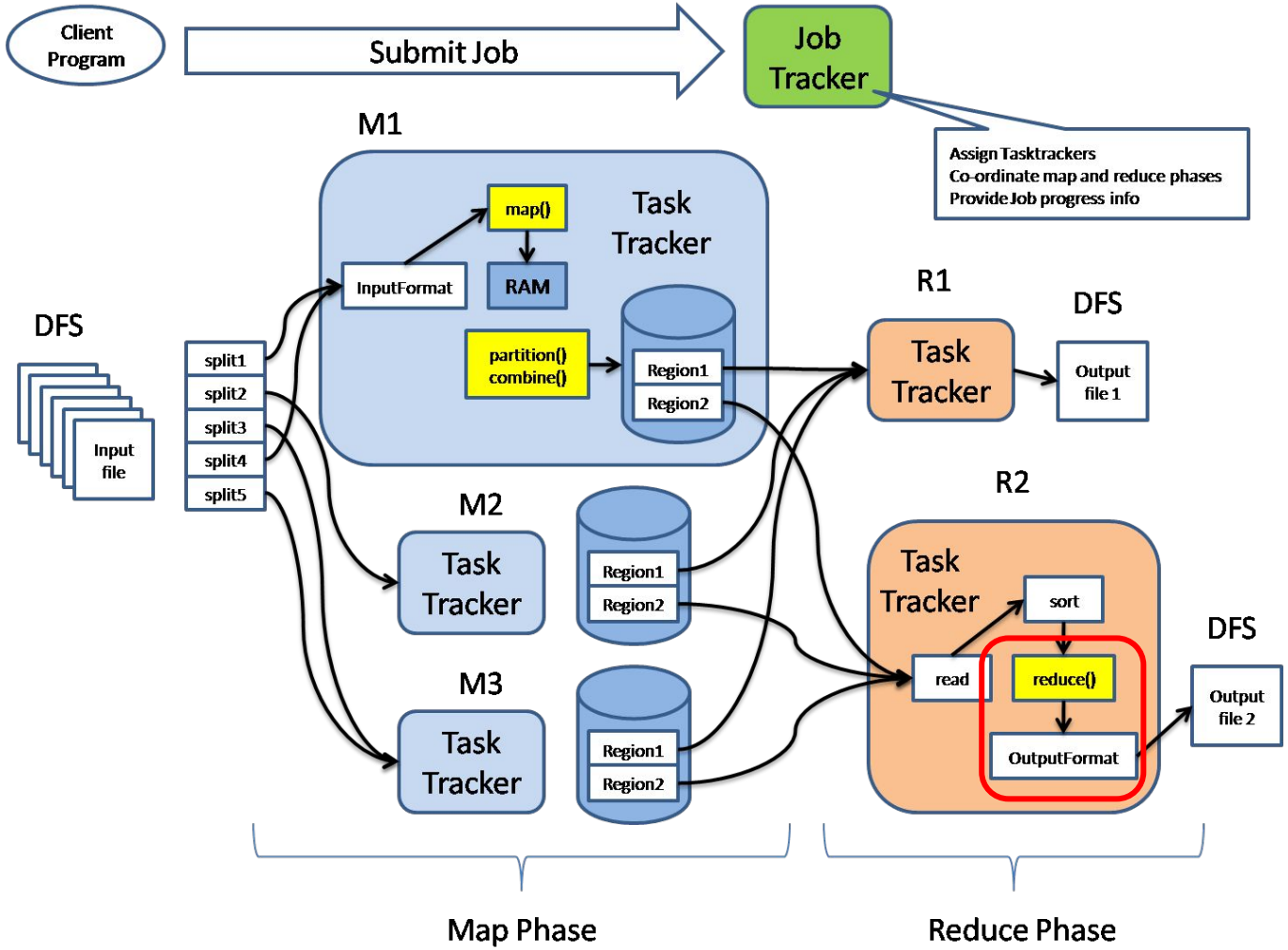


ShufflingAndSorting: Get the results of mapping and sorting

https://www.analyticsvidhya.com/blog/2022/07/learn-everything-about-mapreduce-architecture-and-its-components/

Hadoop

❖ Hadoop MapReduce

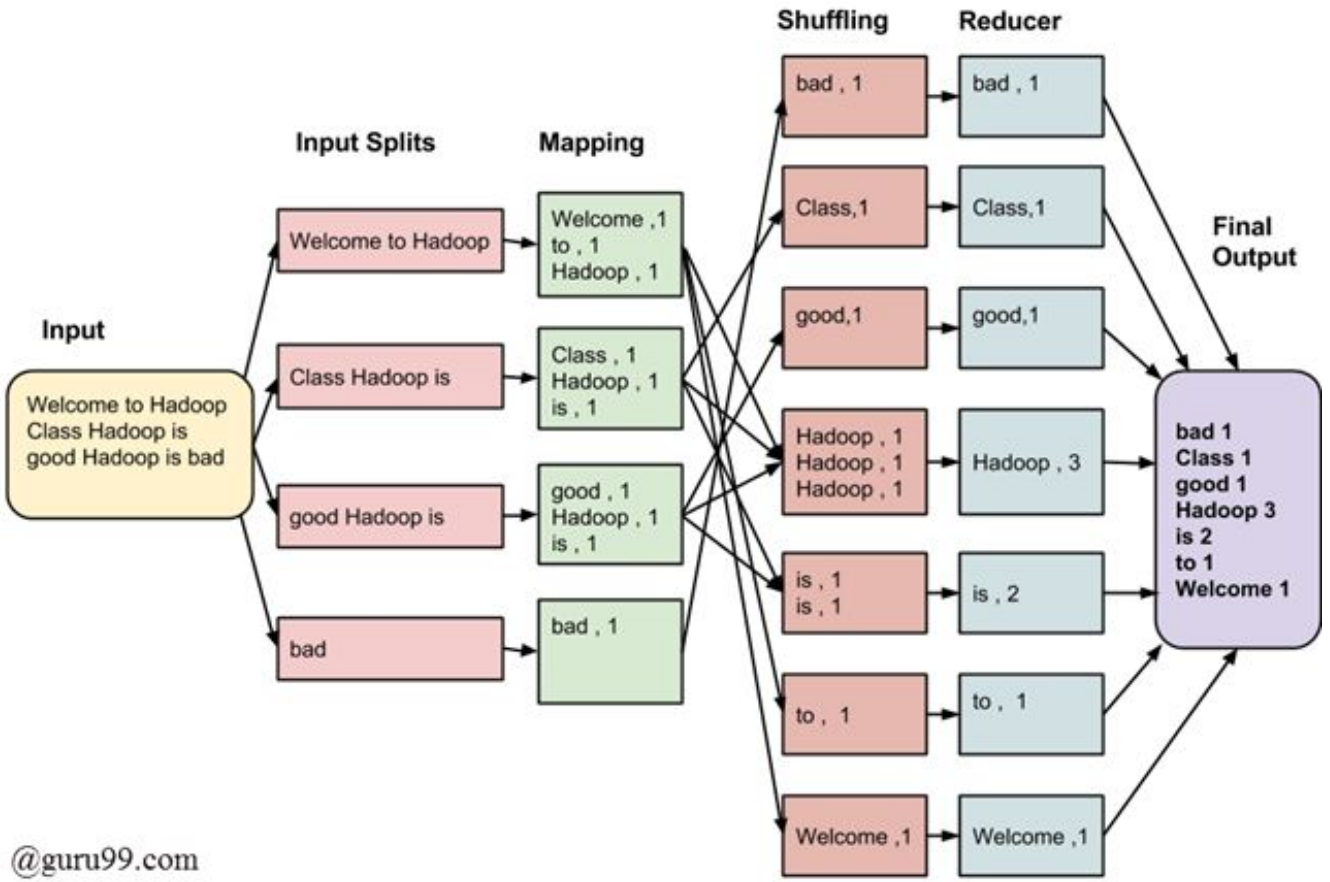


ReduceFunction: Grouping and processing the intermediate key-value pairs produced by the map phase.

https://www.analyticsvidhya.com/blog/2022/07/learn-everything-about-mapreduce-architecture-and-its-components/

Hadoop

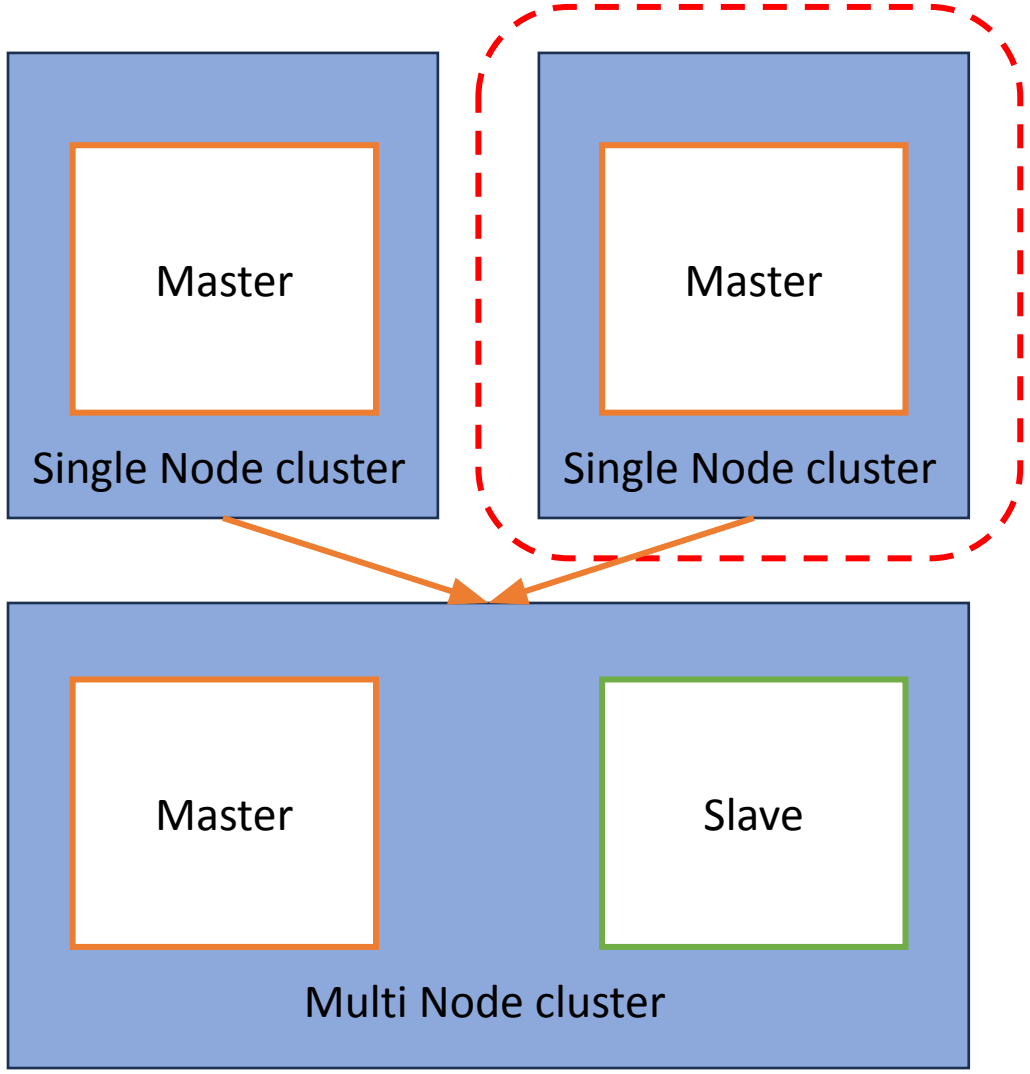
❖ Hadoop MapReduce: WordCount Example



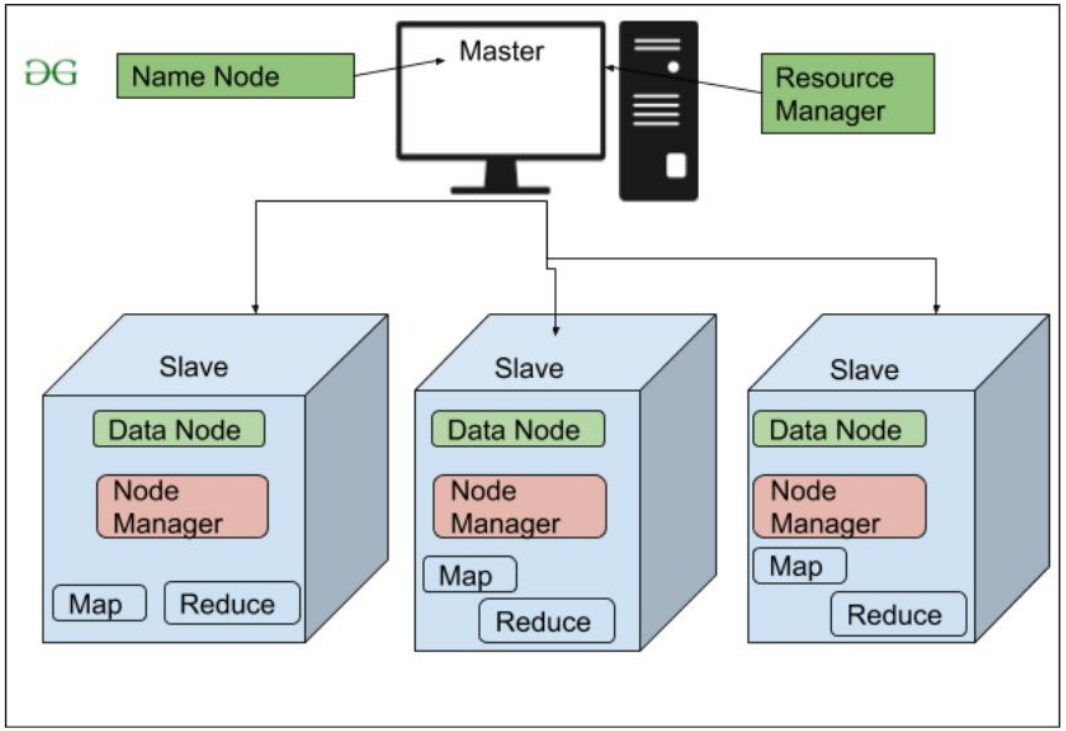
https://www.guru99.com/introduction-to-mapreduce.html

Hadoop

Installation



Hadoop Single Node (Hadoop pseudo-distributed mode): A configuration option in Hadoop that allows us to run Hadoop on a single machine.



https://www.geeksforgeeks.org/hadoop-architecture/

Hadoop

❖ Installation: Requirements

1. Virtual Machine

VirtualBox

VMWare

Cloudera

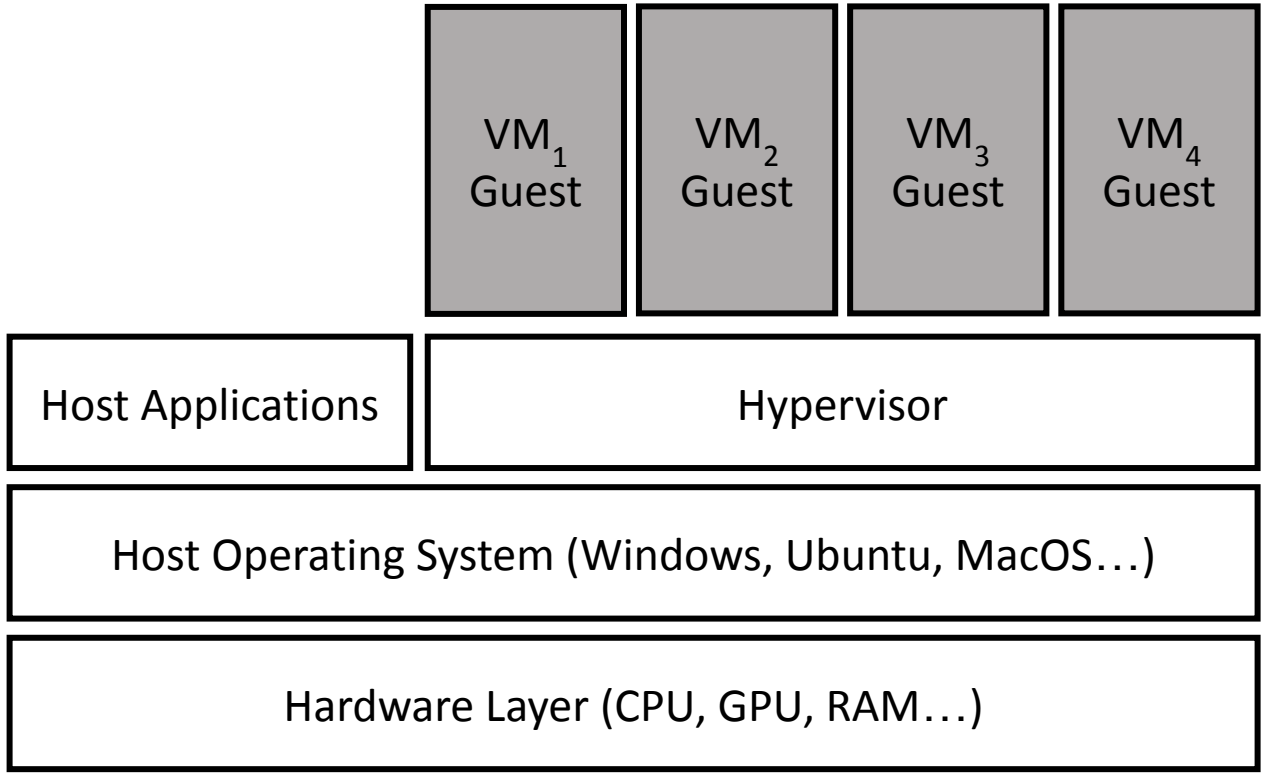
2. CentOS

3. Hadoop

Note: The following installation demo is on Mac M1. You need to choose proper version for your computer.

Hadoop

❖ Virtual Machine



Virtual Machines (VMs): An emulation of a computer system, where these machines use computer architectures to provide the functionality of a physical computer.

Example: A MacOS computer running two Windows VMs

Hadoop

❖ Installation: VMware

VMware: A software providing machine virtualization

Download VMware Workstation Pro

VMware Workstation Pro is the industry standard desktop hypervisor for running virtual machines on Linux or Windows PCs. Start your free, fully functional 30-day trial today.

BUY ONLINE

For Windows/Linux: Use VMware Workstation

Run Windows and More on Mac

VMware Fusion

Harness the full power of your Mac when you use VMware Fusion to run Windows, Linux, containers, Kubernetes and more in virtual machines (VMs) without rebooting.

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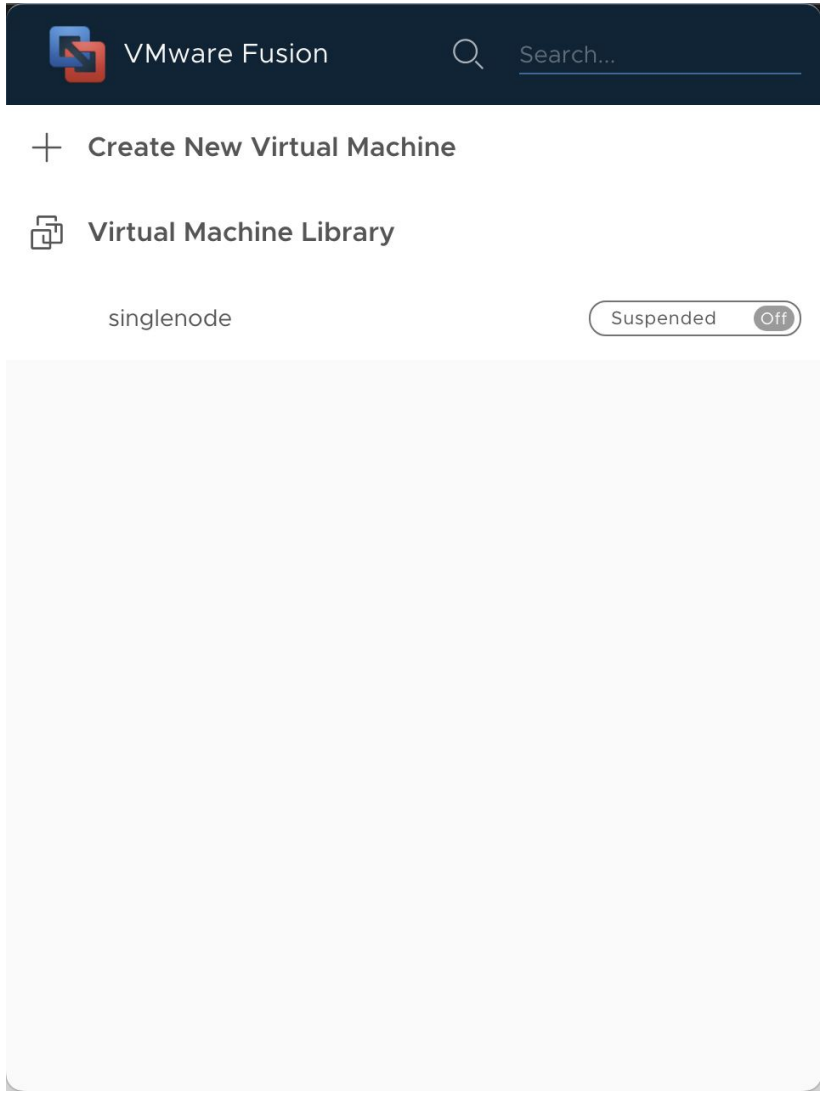
Hadoop

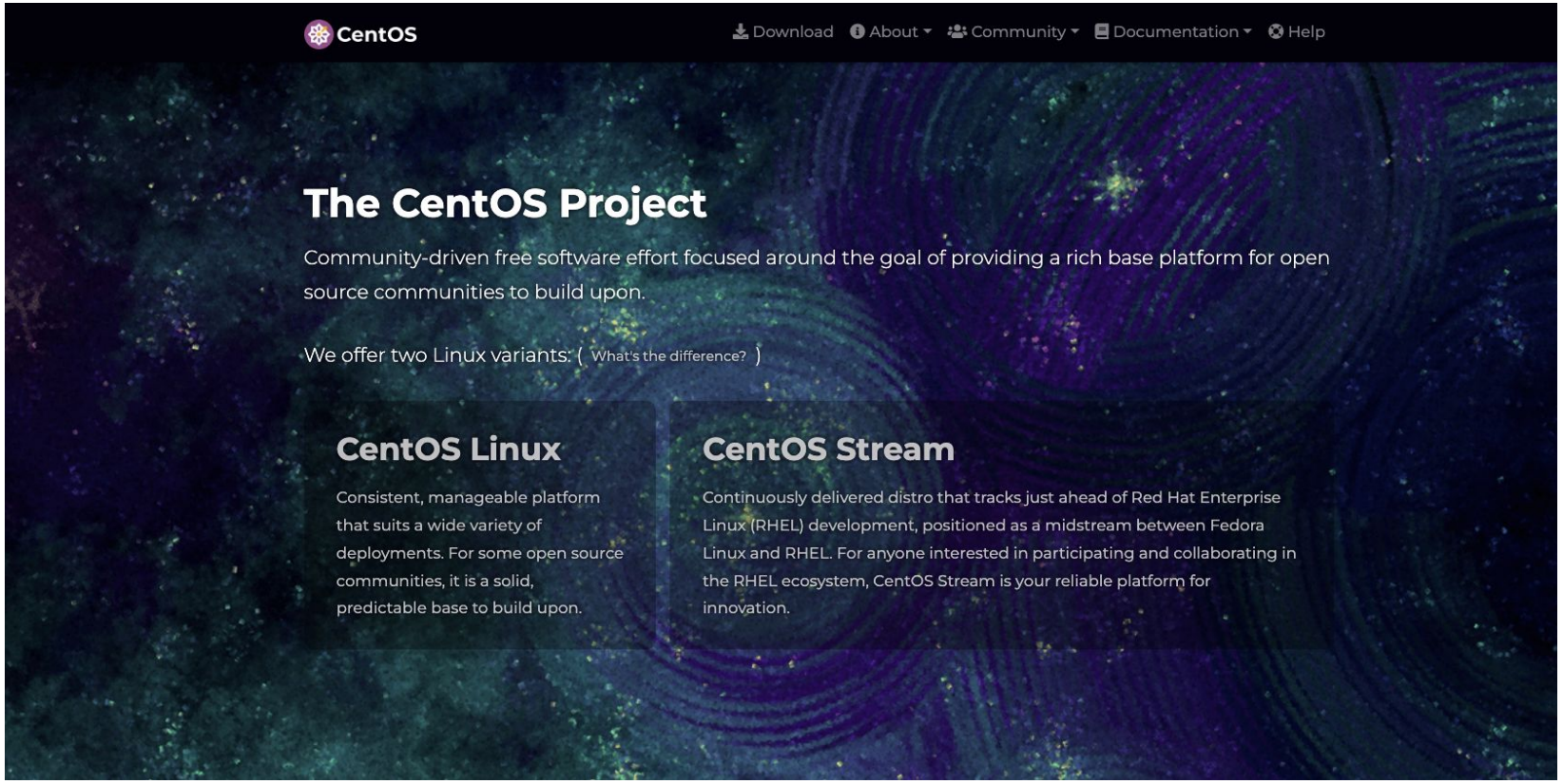
❖ Installation: VMware

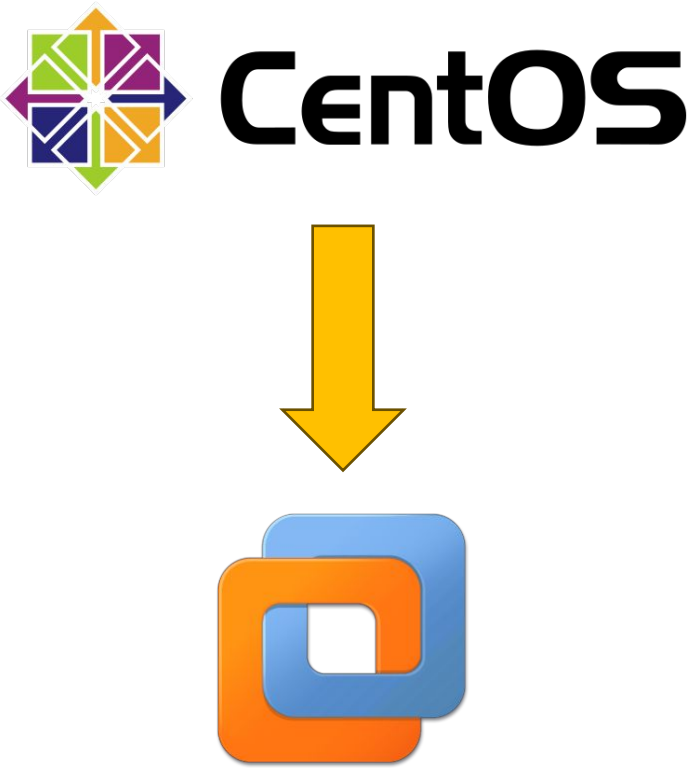


VM Fusion Interface

Hadoop

❖ Installation: CentOS





CentOS: Community-driven free software effort focused around the goal of providing a rich base platform for open source communities to build upon.

Hadoop

❖ Installation: CentOS

Download

CentOS Stream

9 | 8

Architectures	Packages	Others
x86_64	RPMs	Cloud | Containers | Vagrant
ARM64 (aarch64)	RPMs	Cloud | Containers | Vagrant
IBM Power (ppc64le)	RPMs	Cloud | Containers | Vagrant
IBM Z (s390x)	RPMs	Cloud | Containers | Vagrant

Documentation

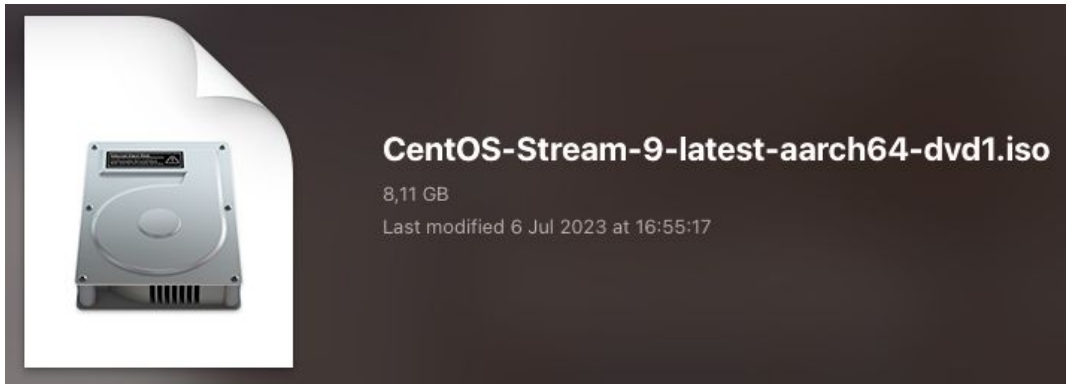
Release Notes | Release Email | Website

End-of-life

End of RHEL9 full support phase.

Choose version:

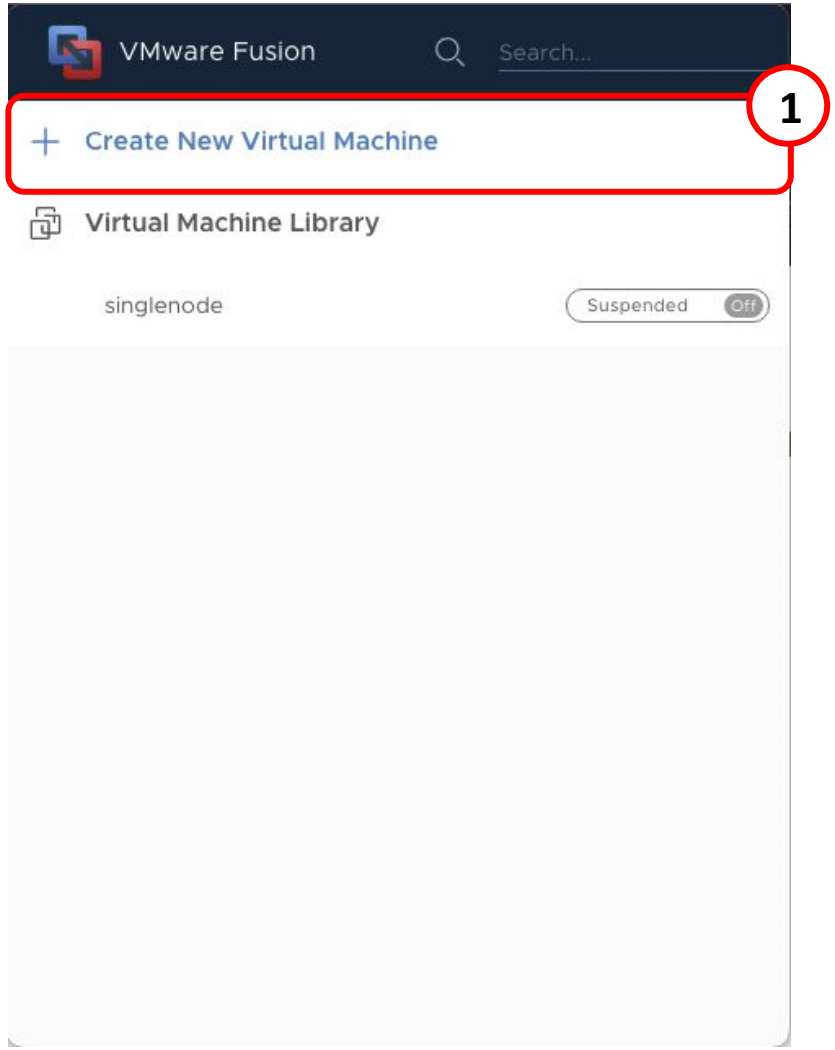
- **x86_64:** For Windows/Ubuntu/Mac Intel
- **ARM64 (aarch64):** For Mac M1/M2

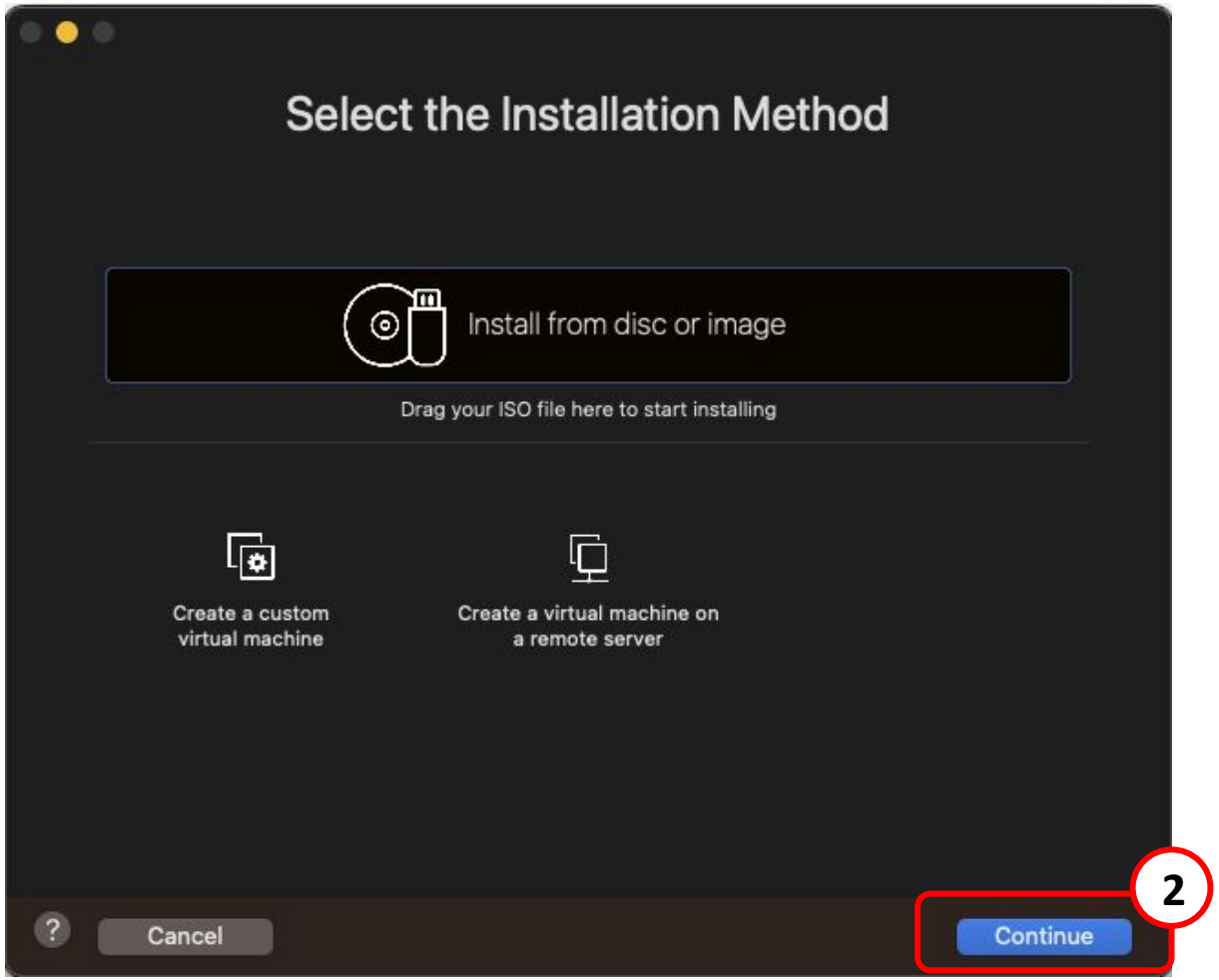


Download file .iso of CentOS: Link

Hadoop

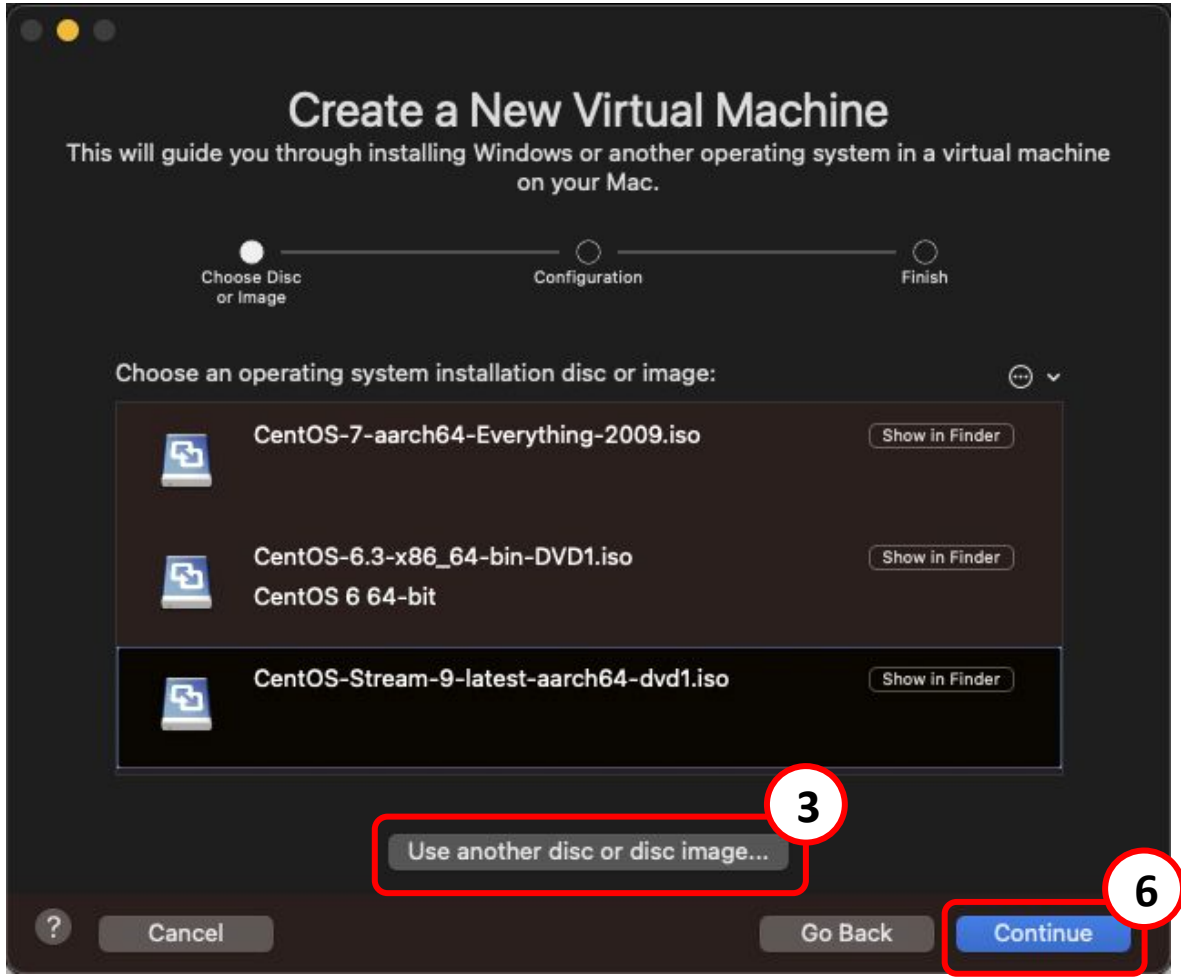
❖ Installation: Run CentOS in VMware

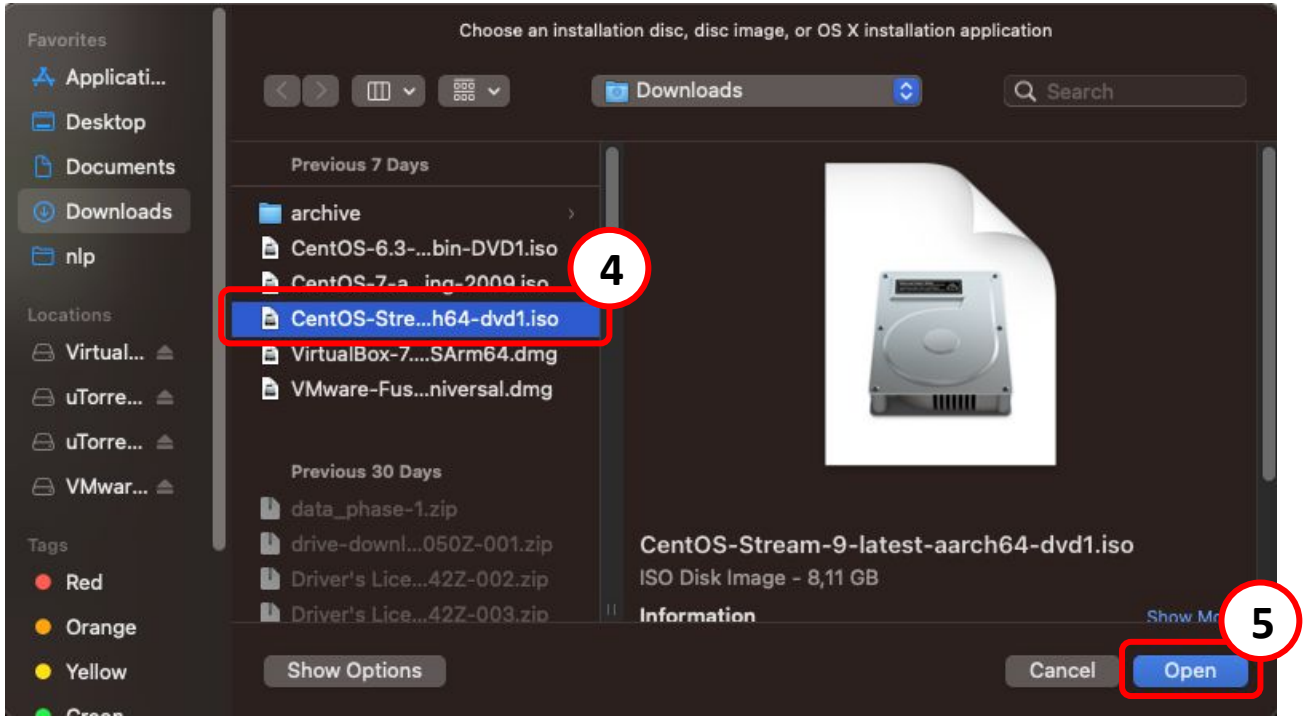




Hadoop

❖ Installation: Run CentOS in VMware

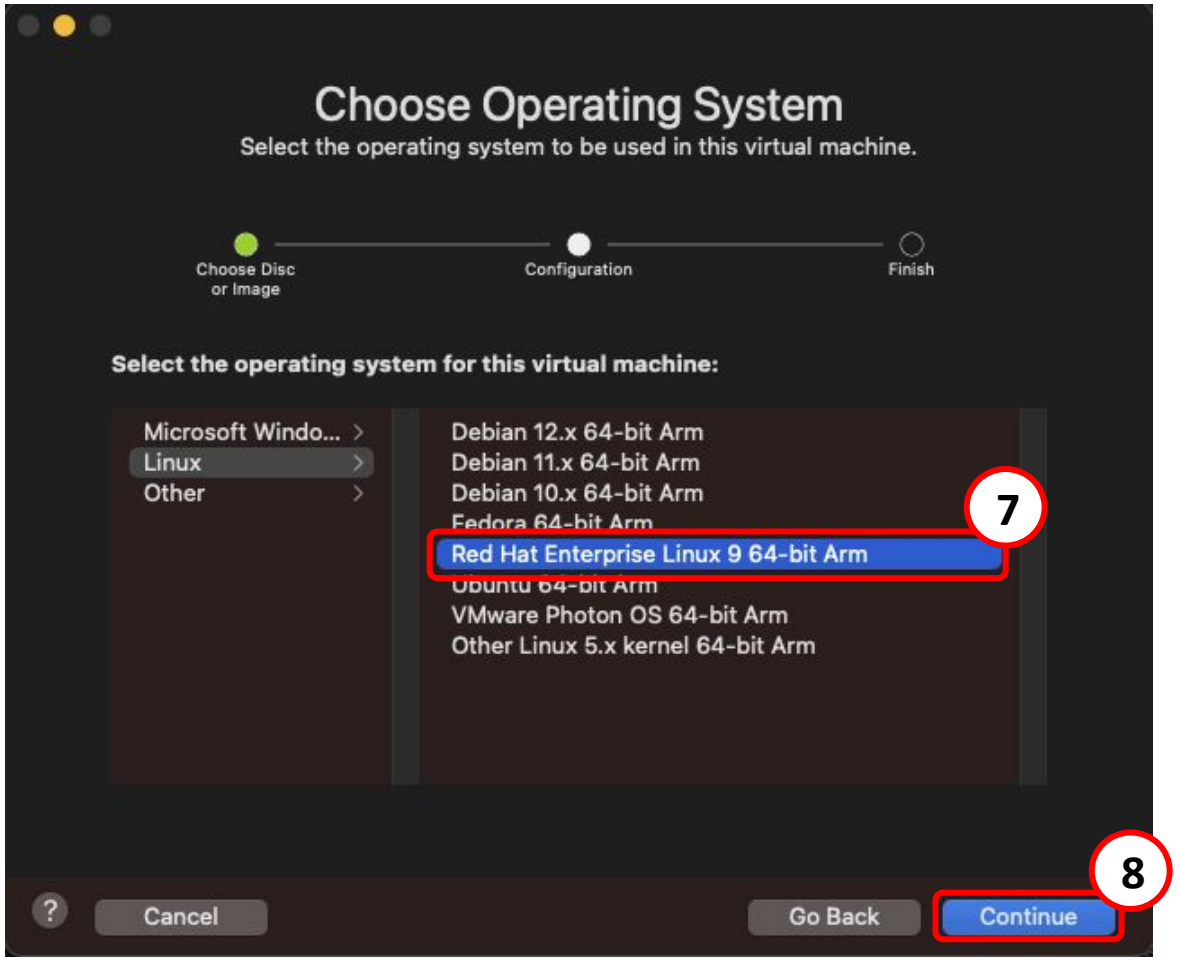




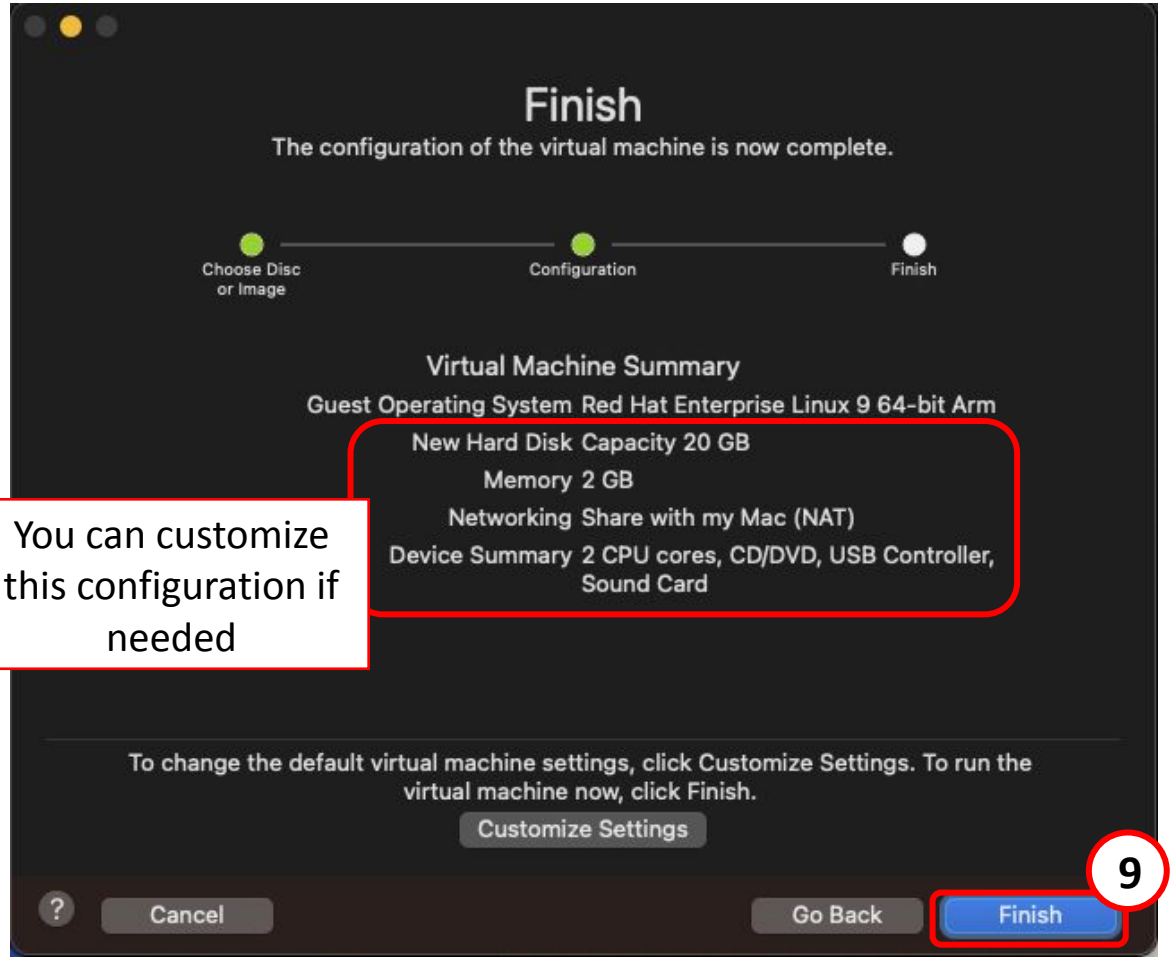
Choose CentOS .iso file

Hadoop

❖ Installation: Run CentOS in VMware

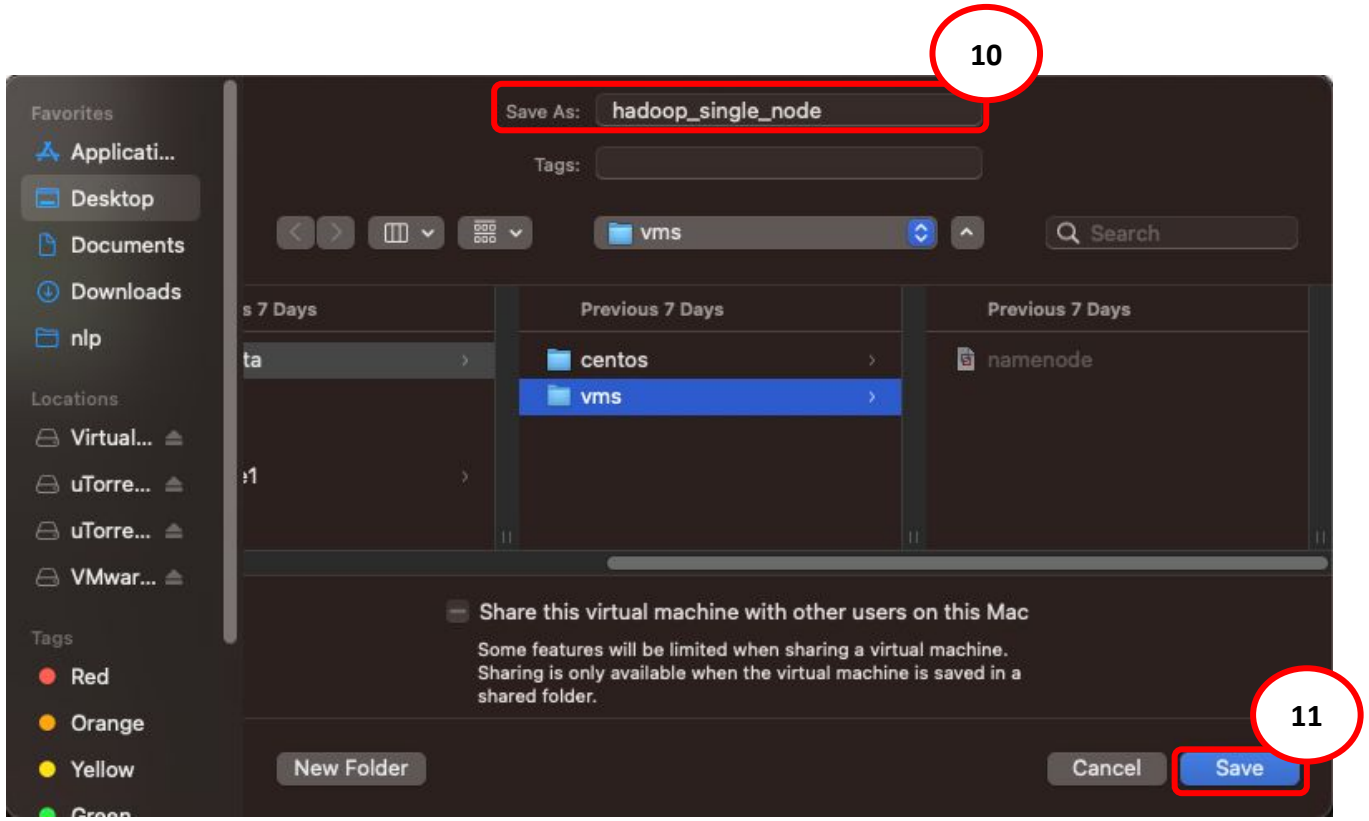


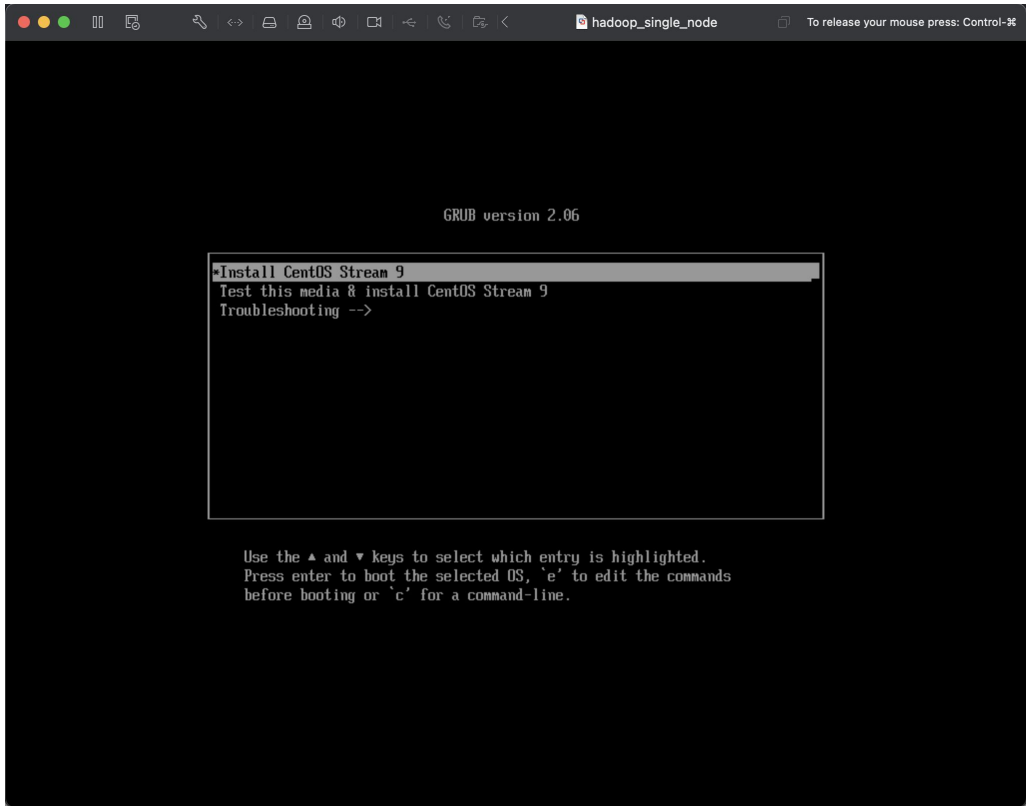
You can customize this configuration if needed



Hadoop

❖ Installation: Run CentOS in VMware

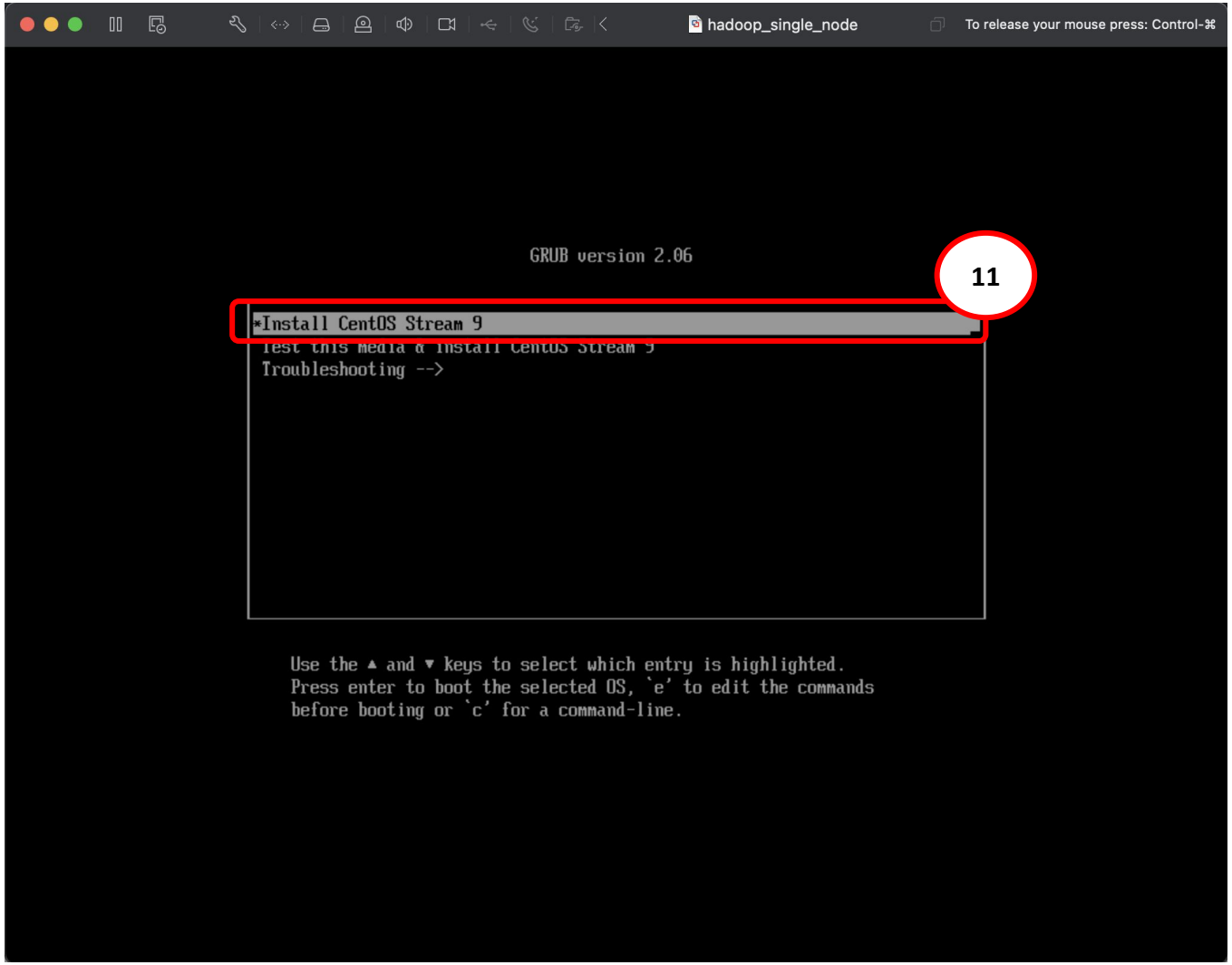




Choose where to save the new virtual machine

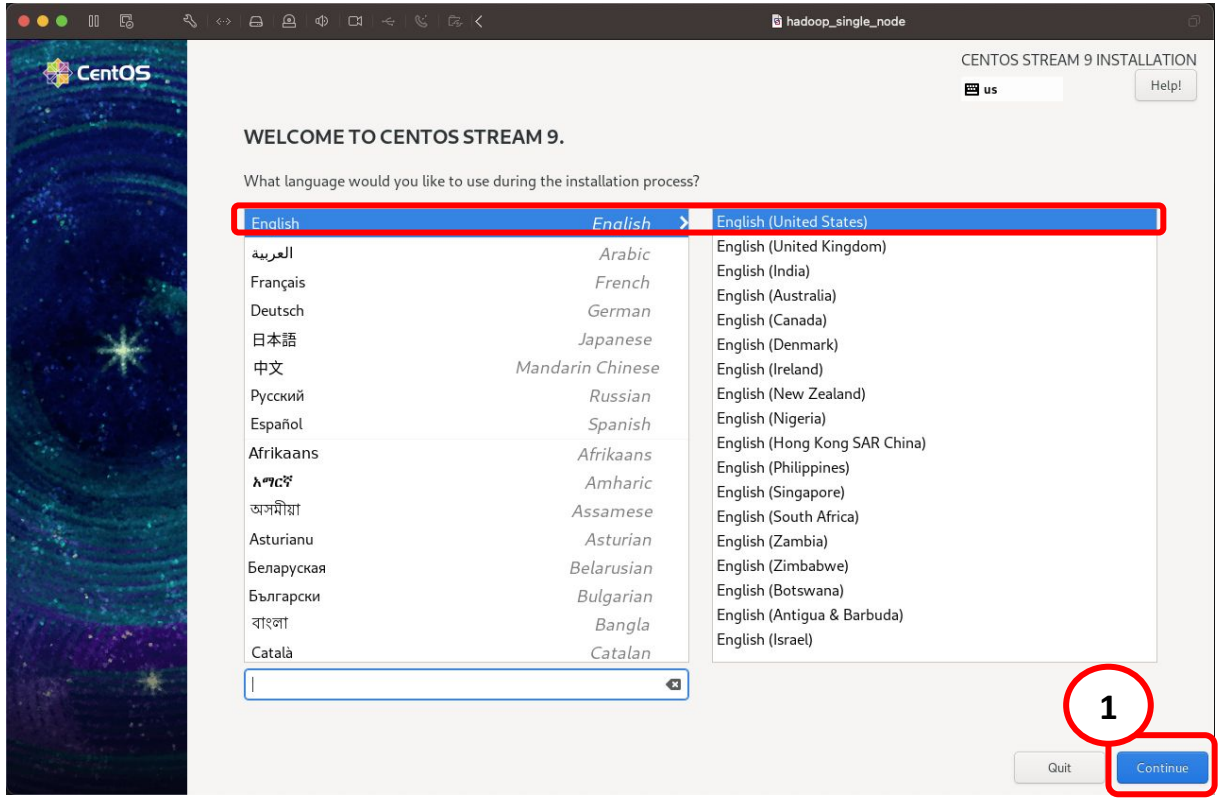
Hadoop

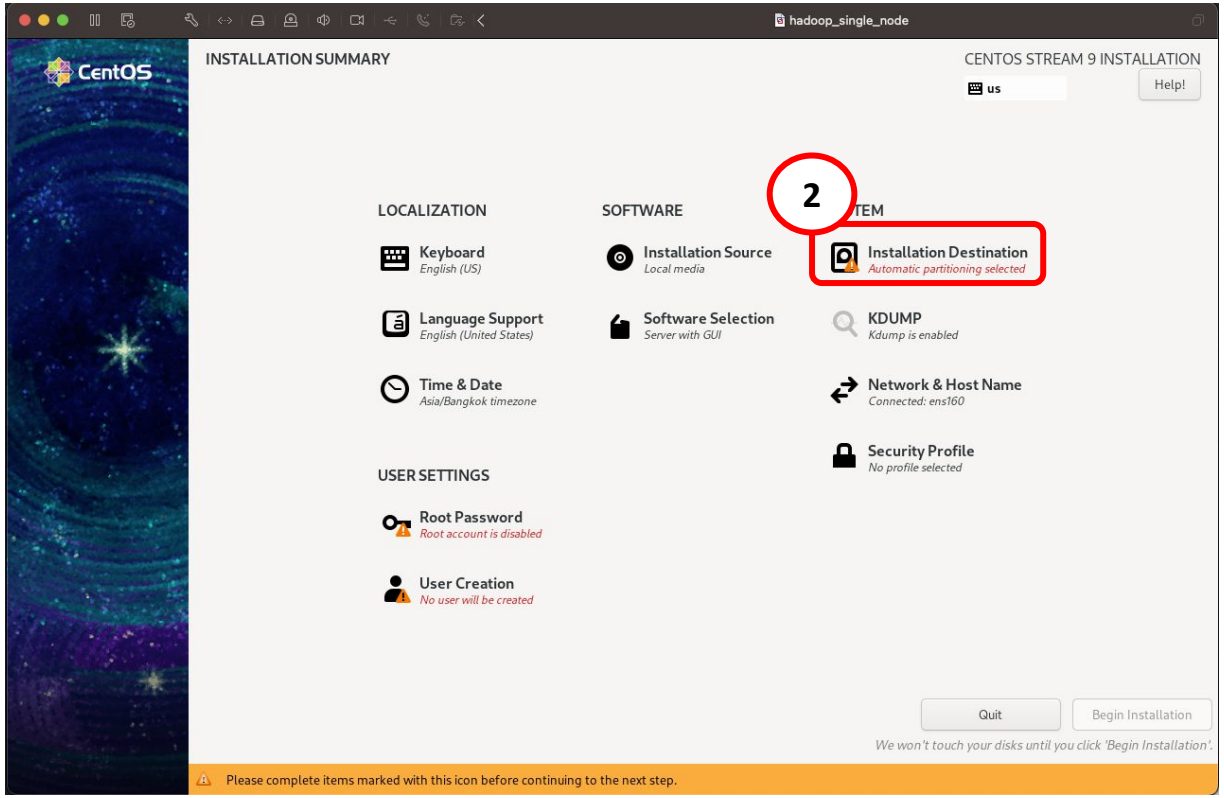
❖ Installation: Run CentOS in VMware



Hadoop

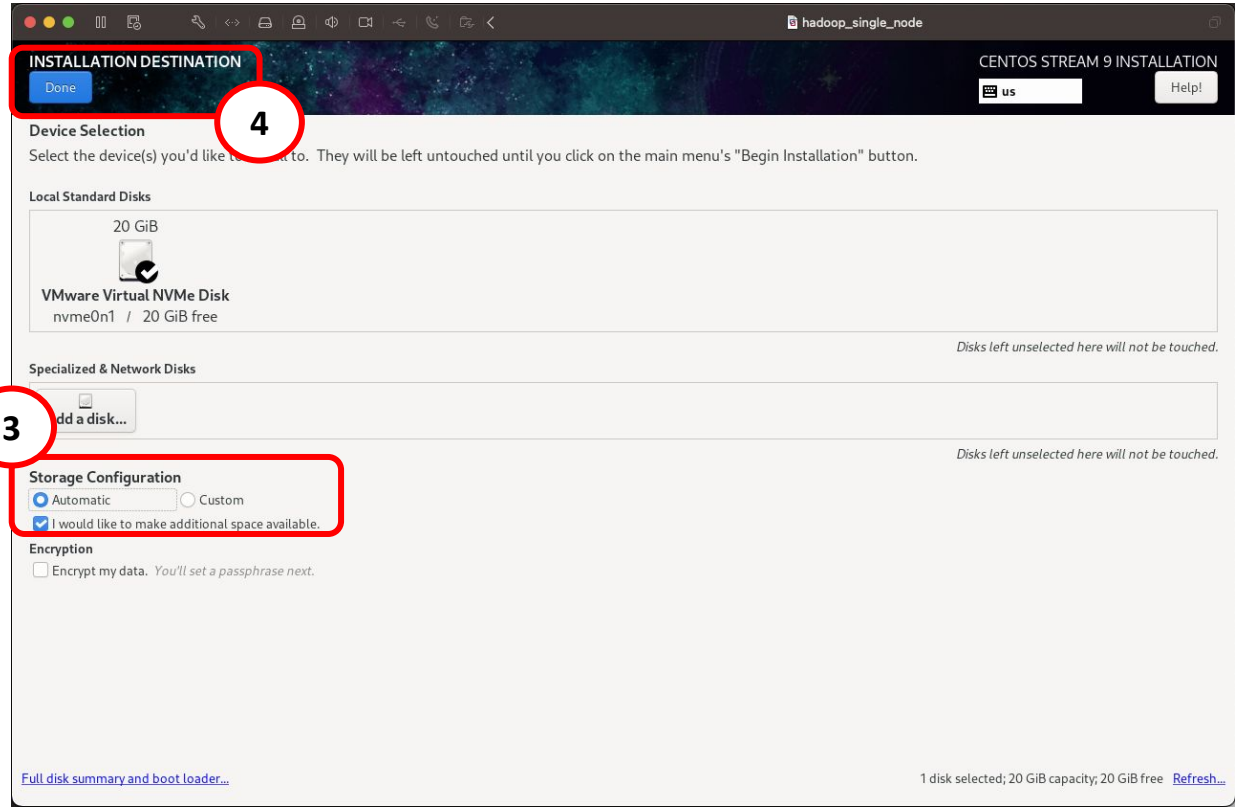
❖ Installation: Setup CentOS

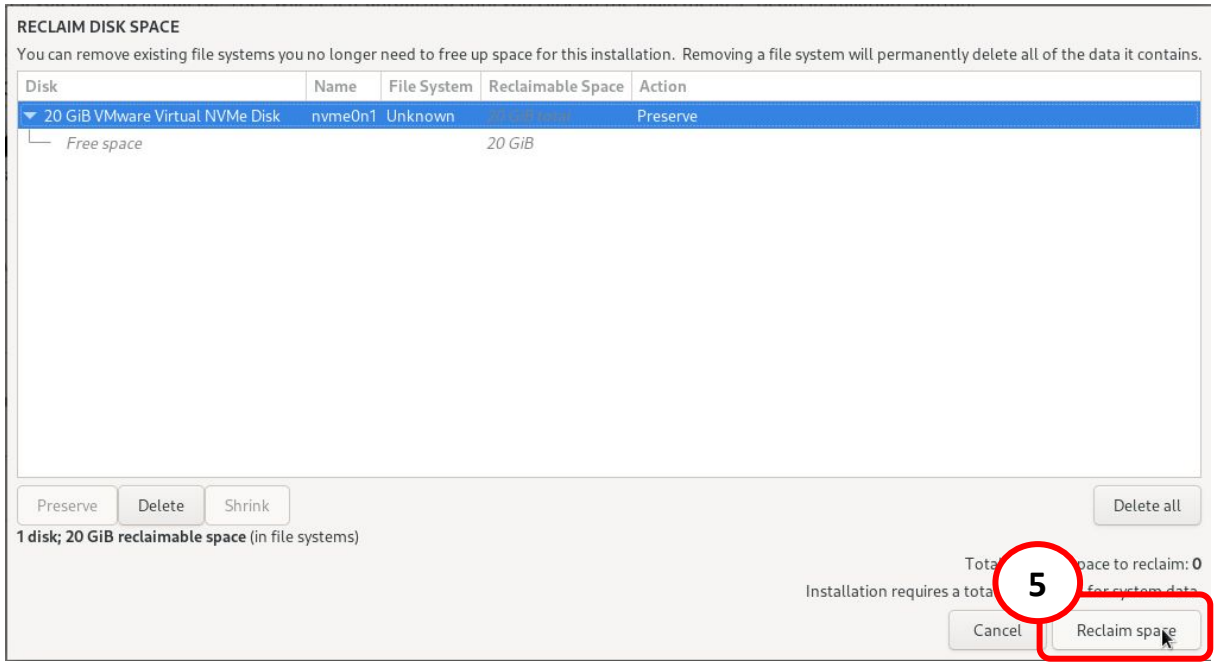




Hadoop

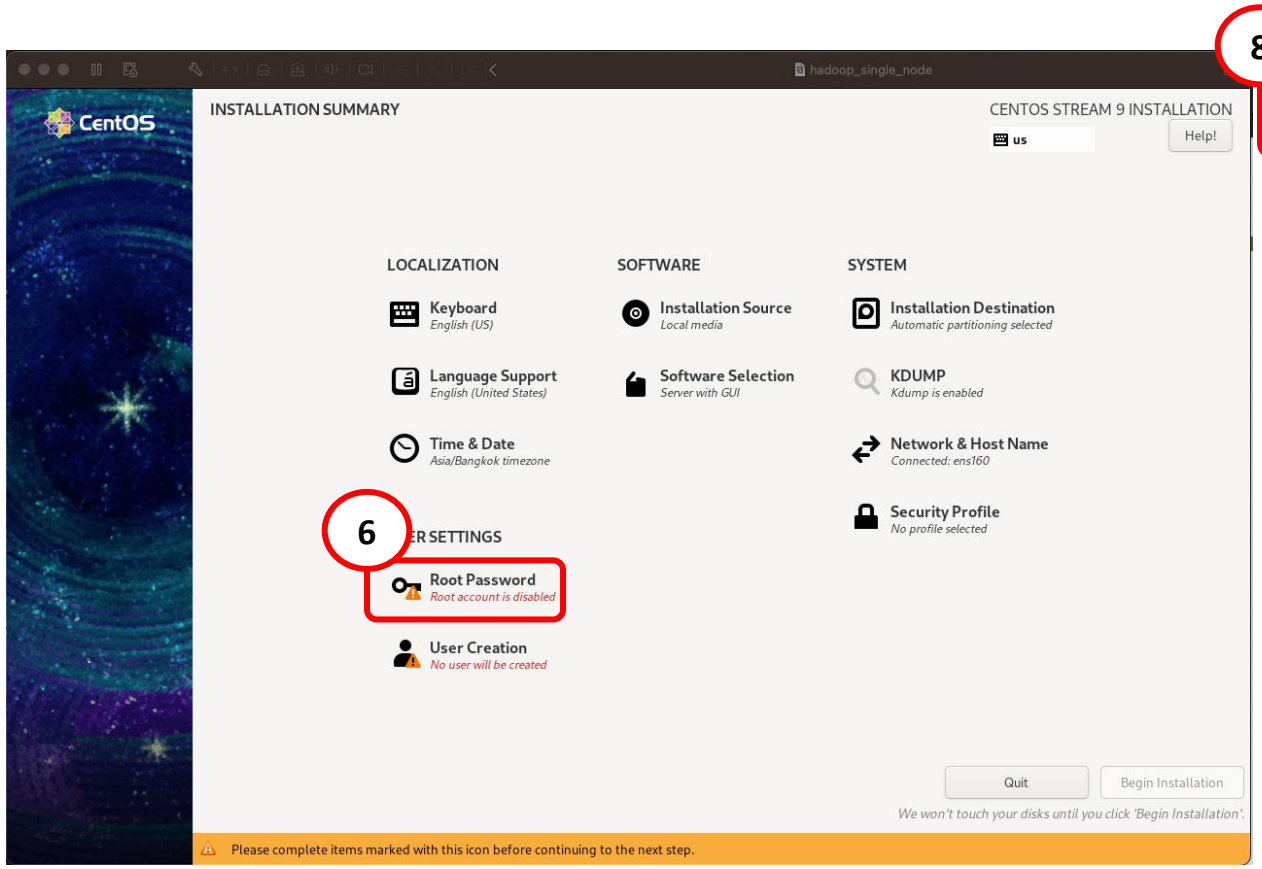
❖ Installation: Setup CentOS

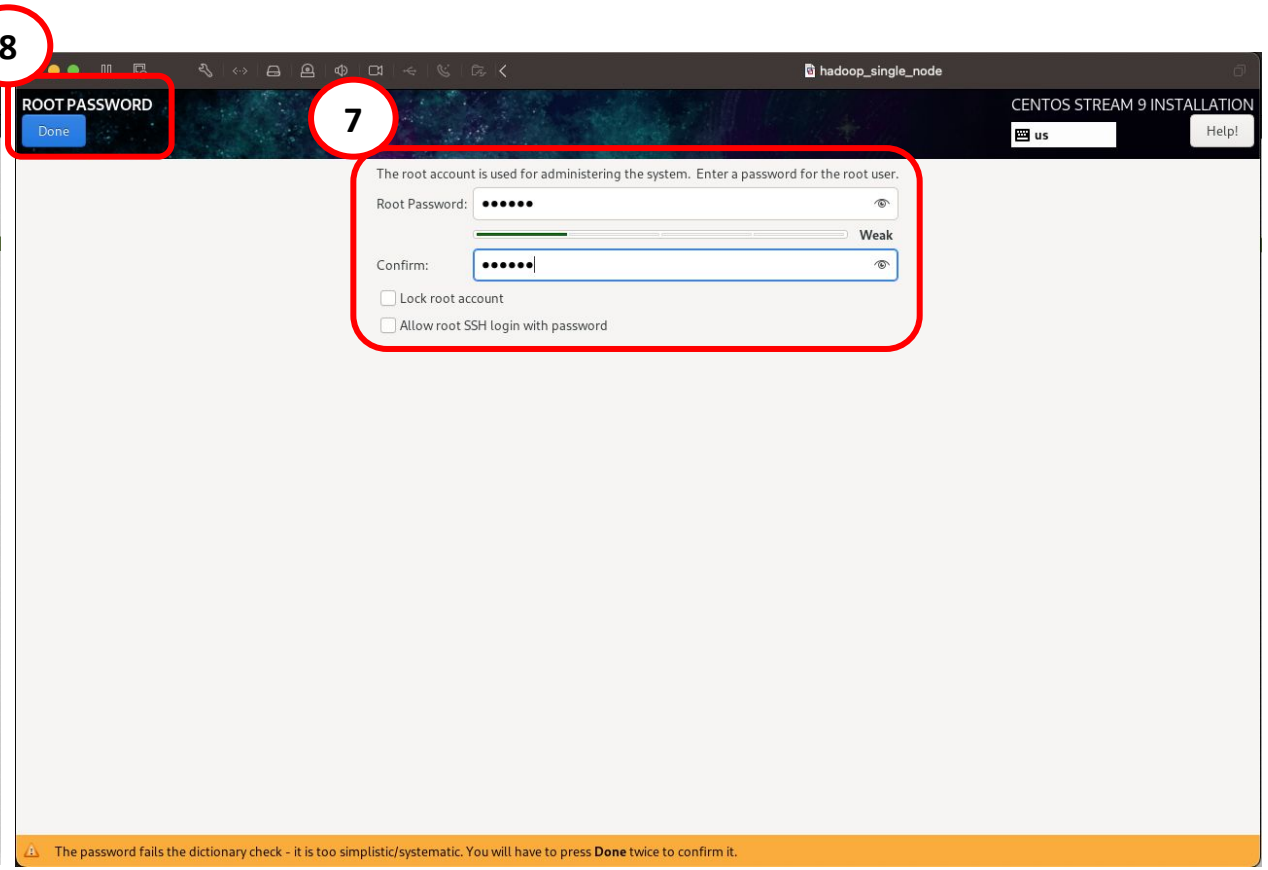




Hadoop

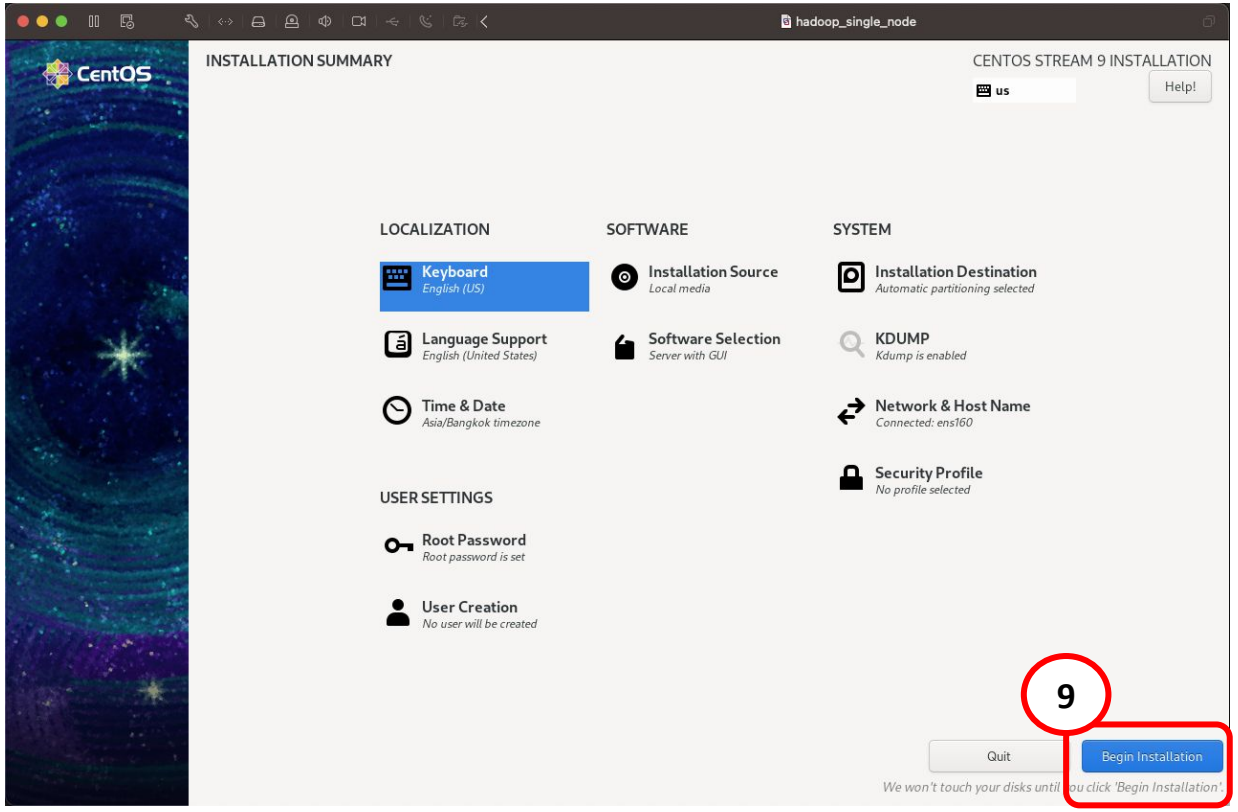
❖ Installation: Setup CentOS

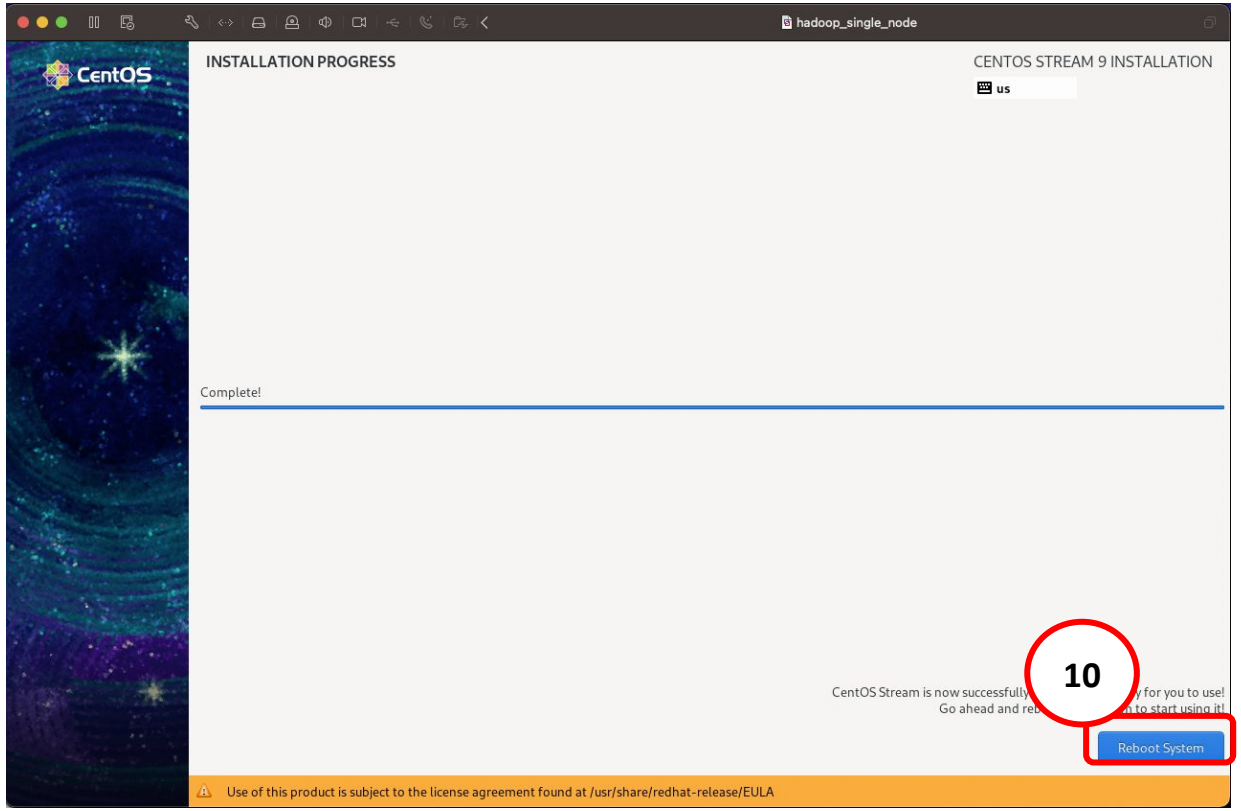




Hadoop

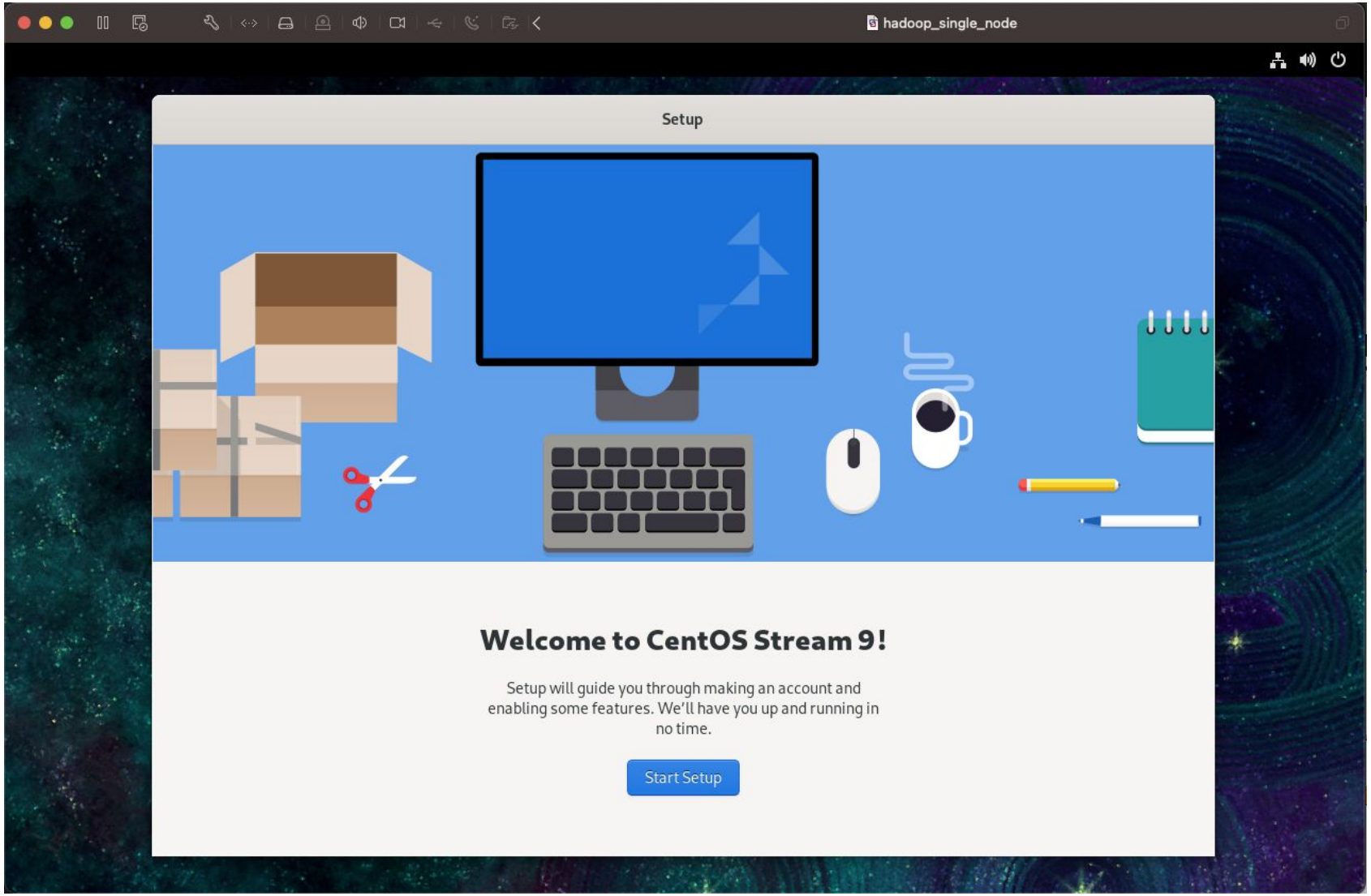
❖ Installation: Setup CentOS





Hadoop

❖ Installation: Setup CentOS



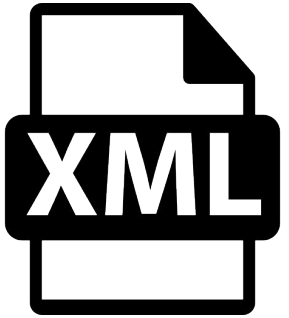
Hadoop

❖ Installation: Hadoop Requirements

1. Install Java

2. Install Hadoop

3. Set up Hadoop



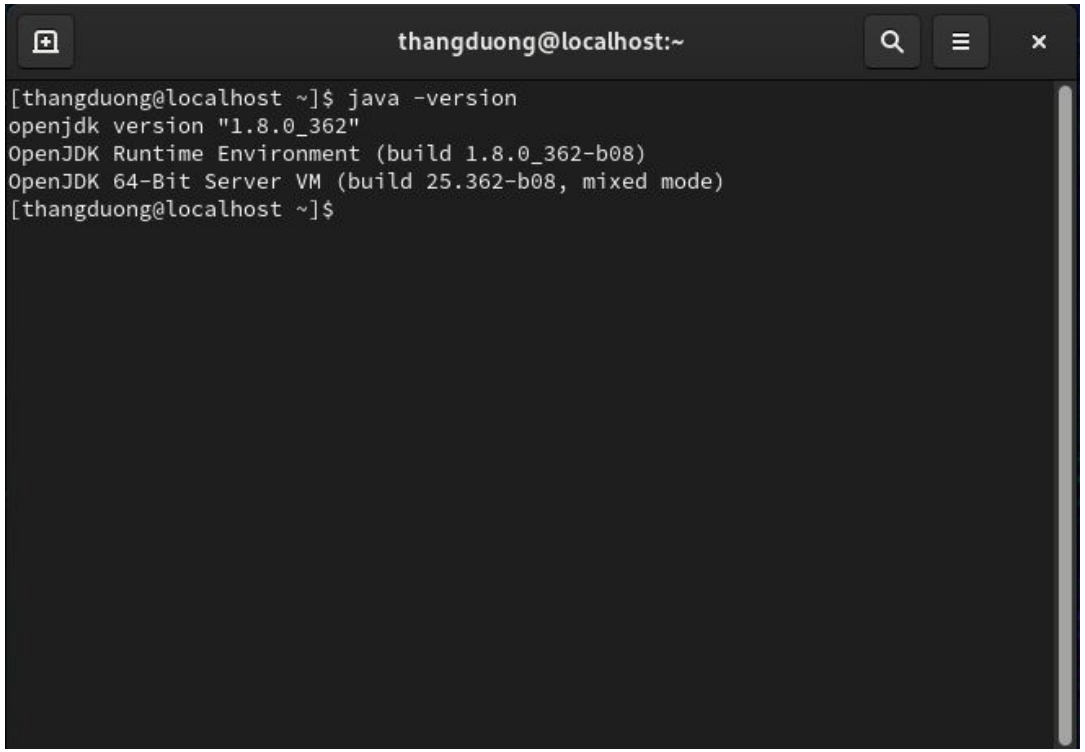
Hadoop

❖ Installation: Java

Java: A high-level, class-based, object-oriented programming language that is designed to have as few implementation dependencies as possible.

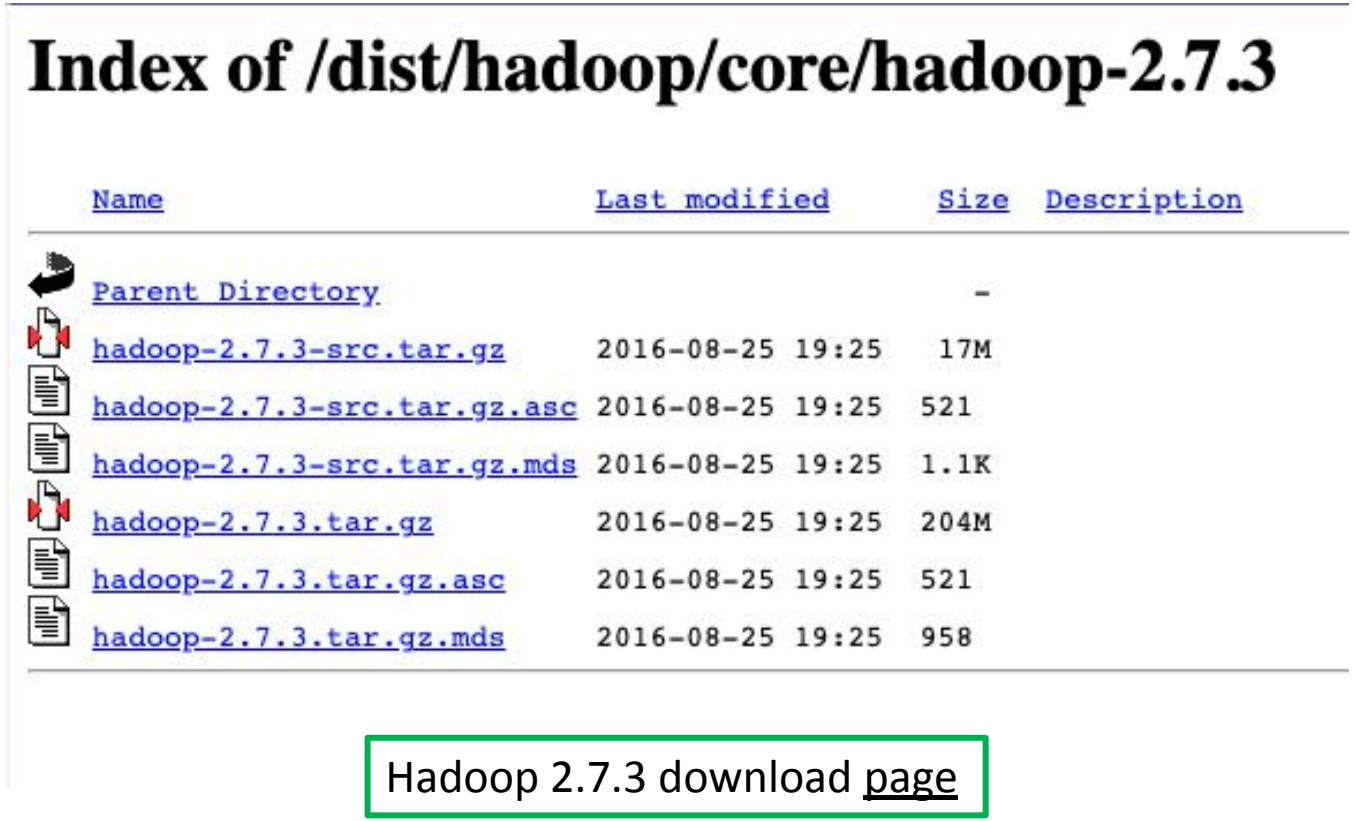
Install Java 8 on CentOS:

```
1. sudo yum -y update
2. sudo yum install -y java-1.8.0-openjdk
```



Hadoop

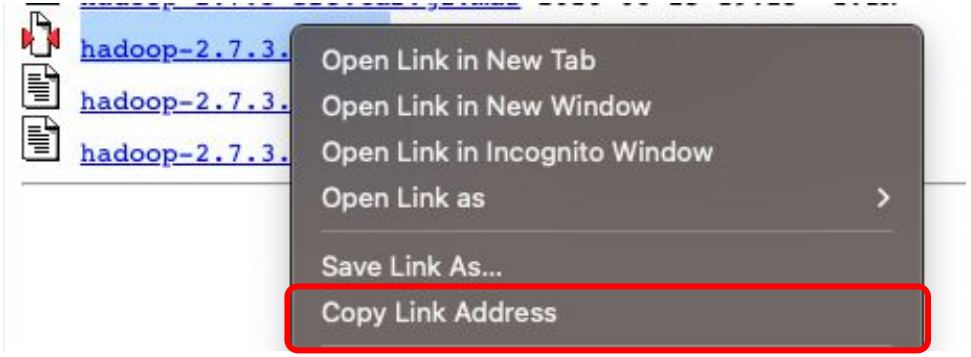
❖ Installation: Hadoop

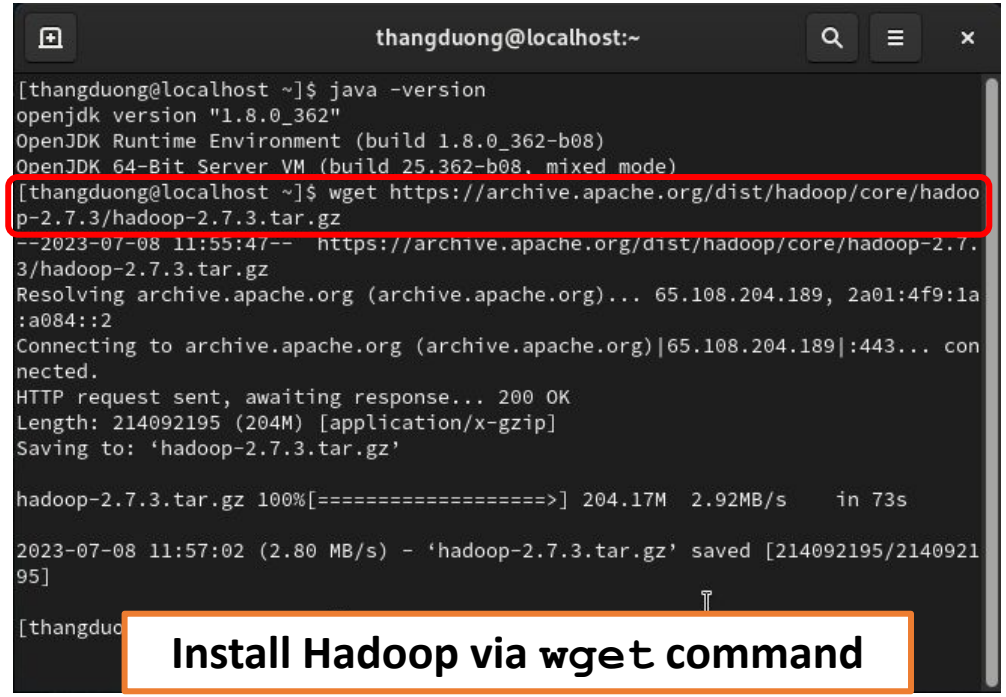


Index of /dist/hadoop/core/hadoop-2.7.3

Name	Last modified	Size	Description
Parent Directory		-	
hadoop-2.7.3-src.tar.gz	2016-08-25 19:25	17M	
hadoop-2.7.3-src.tar.gz.asc	2016-08-25 19:25	521	
hadoop-2.7.3-src.tar.gz.mds	2016-08-25 19:25	1.1K	
hadoop-2.7.3.tar.gz	2016-08-25 19:25	204M	
hadoop-2.7.3.tar.gz.asc	2016-08-25 19:25	521	
hadoop-2.7.3.tar.gz.mds	2016-08-25 19:25	958	

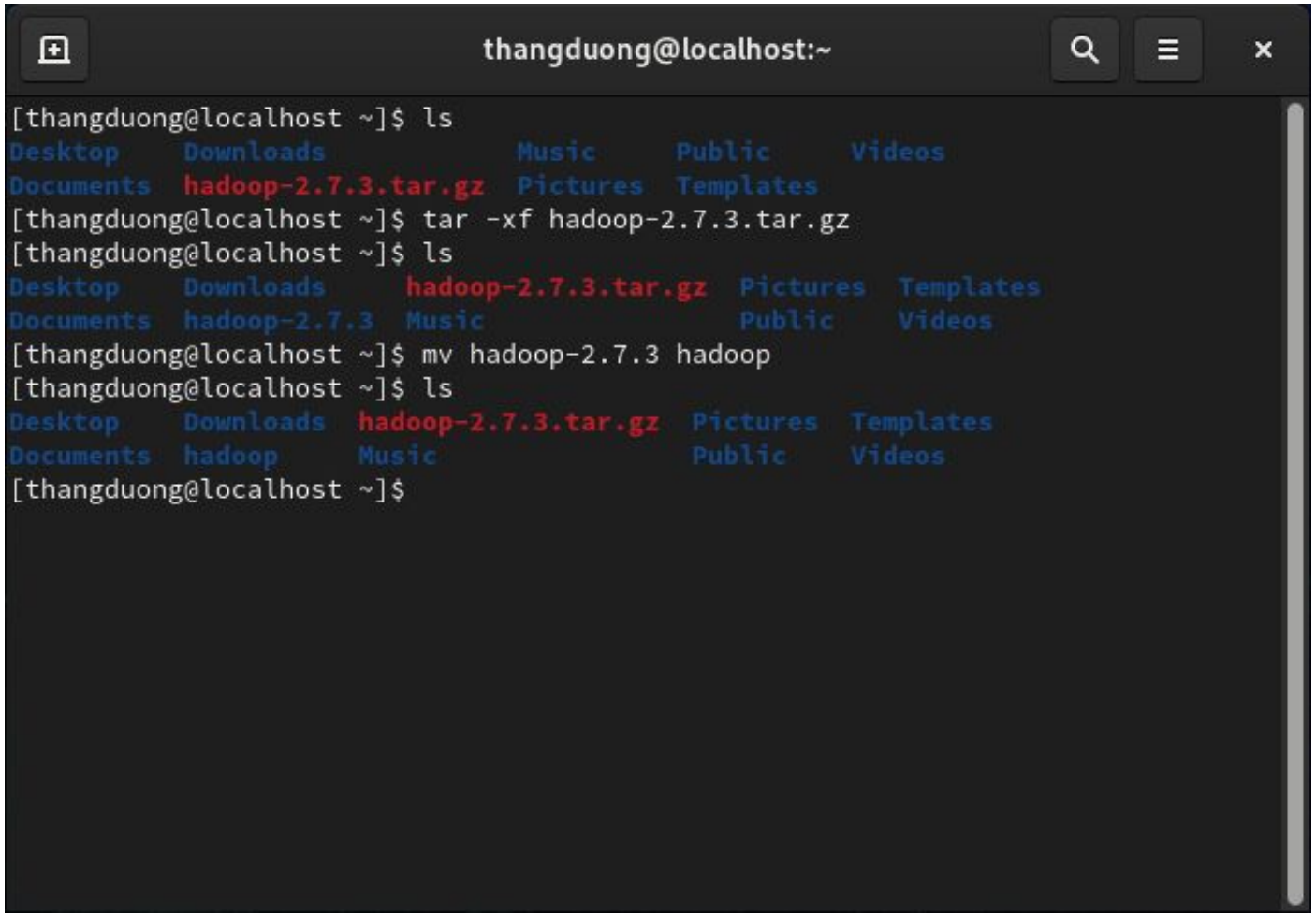
Hadoop 2.7.3 download page





Hadoop

❖ Installation: Hadoop



- **Extract downloaded file via tar command:**

```
tar -xf hadoop-2.7.3.tar.gz
```

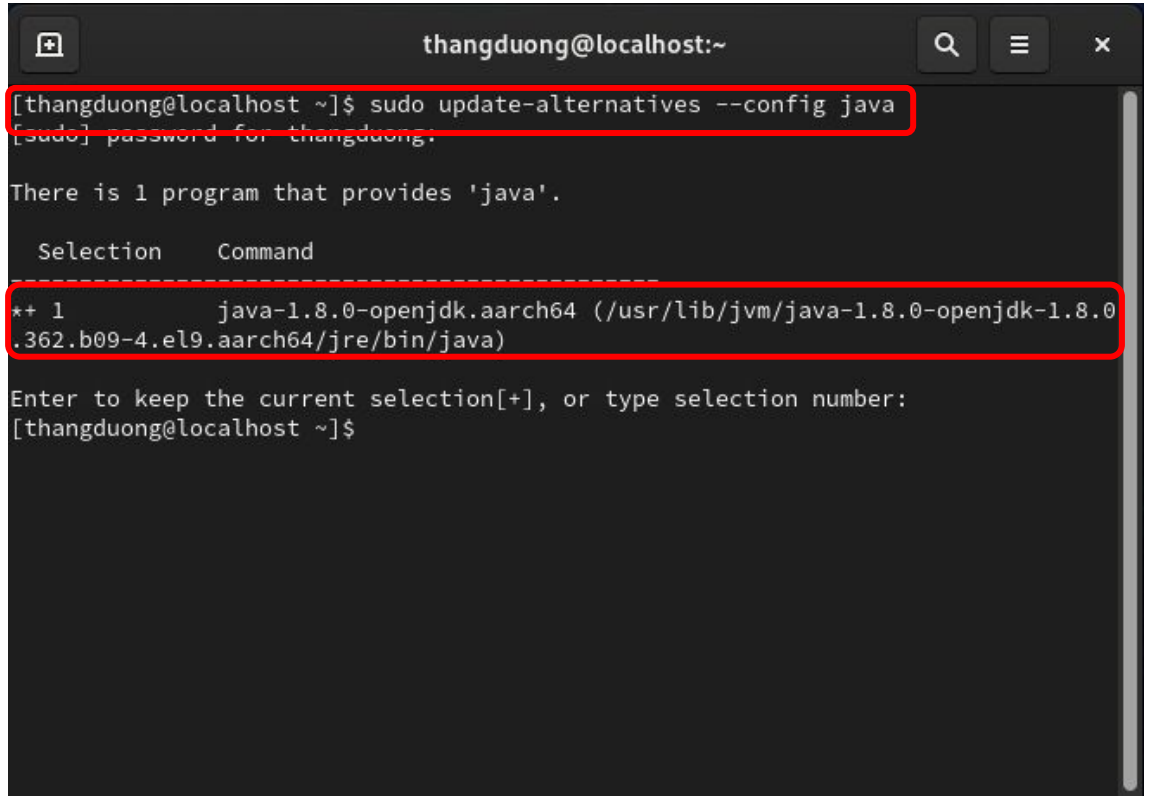
- **Rename Hadoop folder:**

```
mv hadoop-2.7.3 hadoop
```

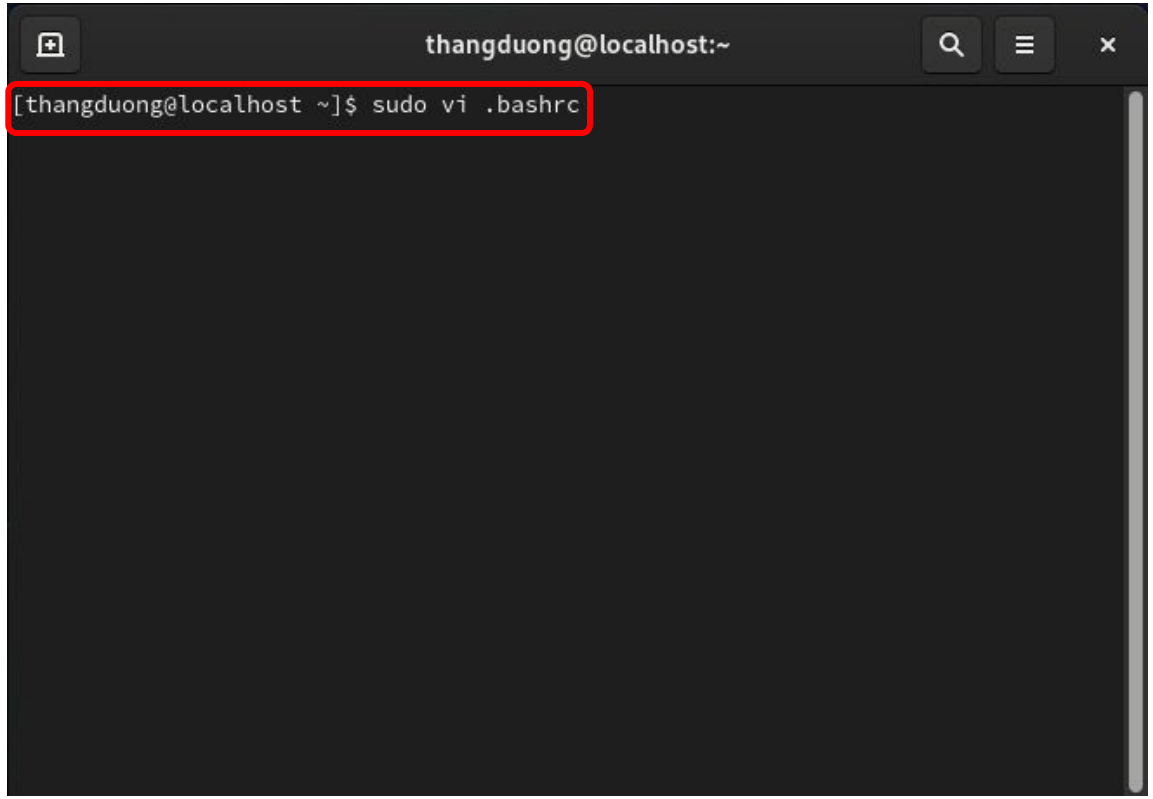
Hadoop

❖ Installation: Config Hadoop

1. Check Java configuration



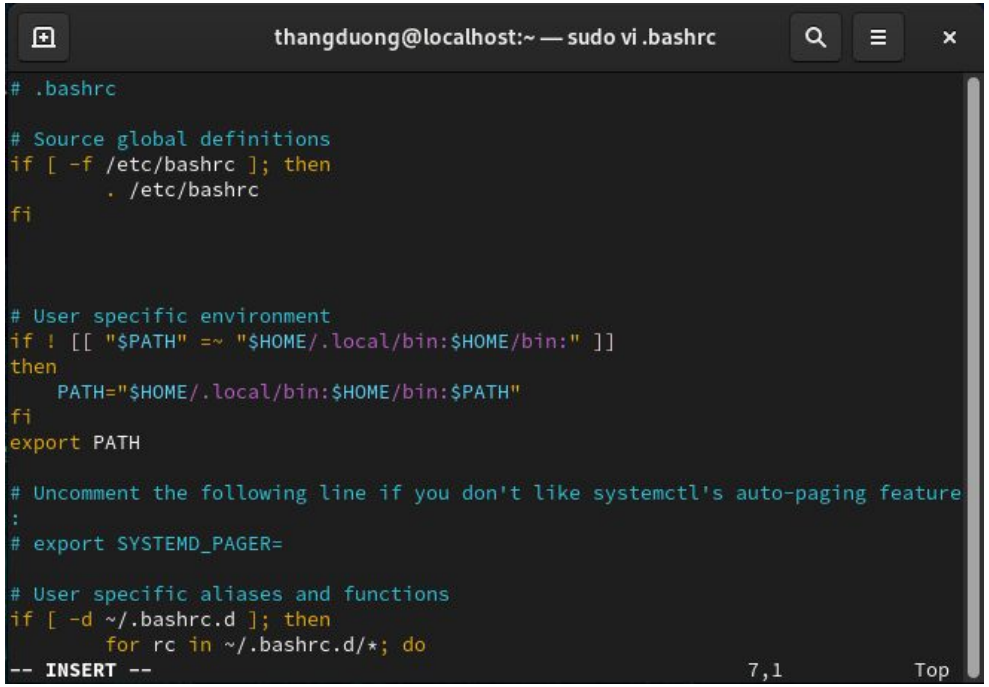
2. Enter ~/.bashrc script



Hadoop

❖ Installation: Hadoop

3. Set up .bashrc script

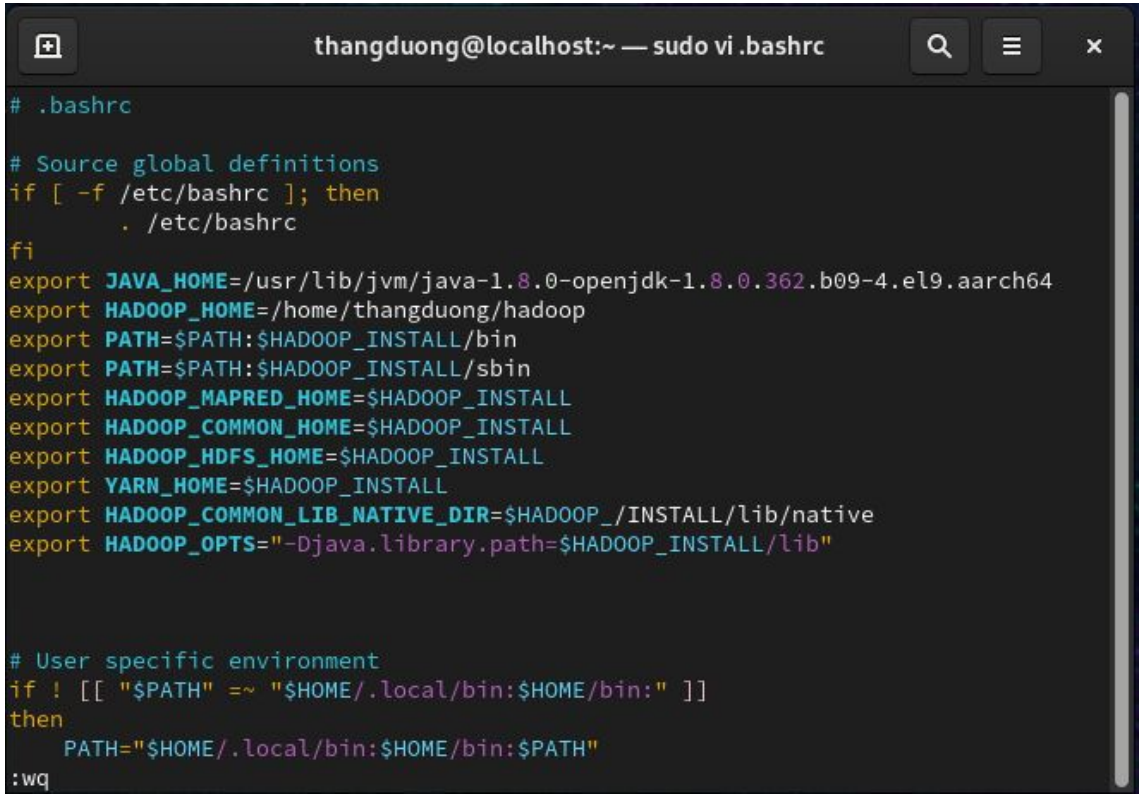


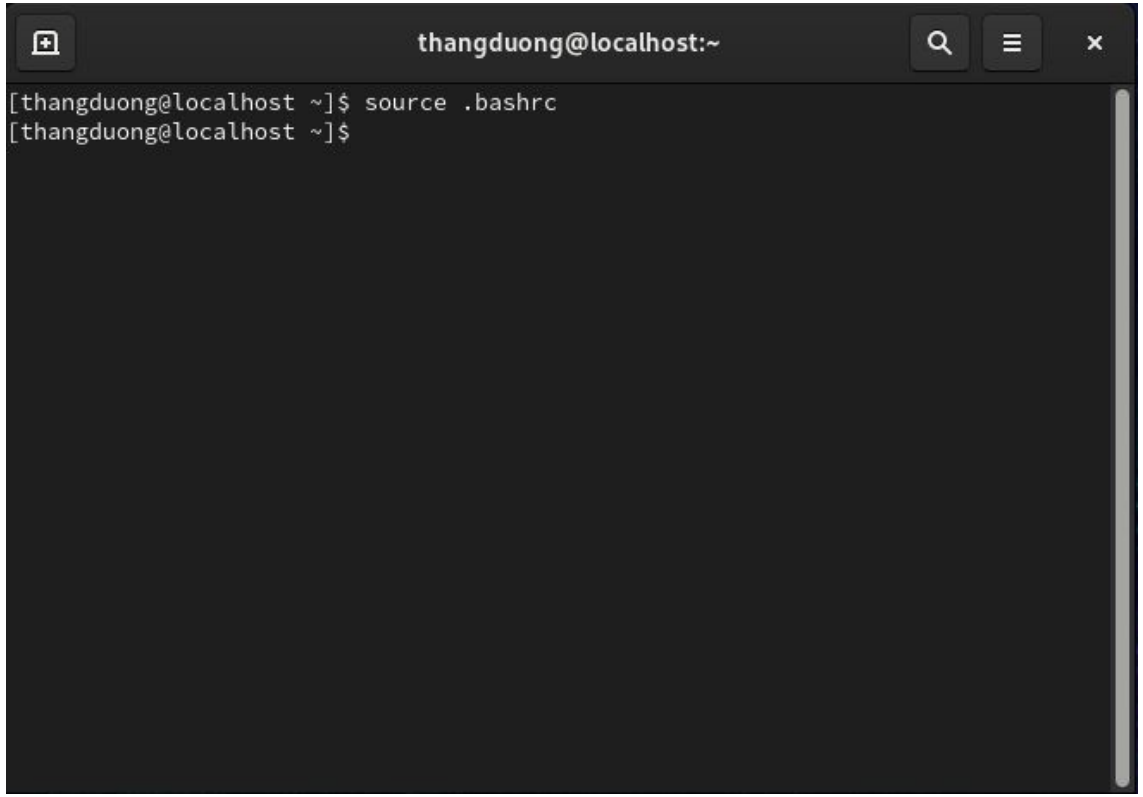
Paste the code below:

```
export
JAVA_HOME=/usr/lib/jvm/java-1.8.0-openjdk-1.8.
0.362.b09-4.el9.aarch64
export HADOOP_HOME=/home/thangduong/hadoop
export PATH=$PATH:$HADOOP_INSTALL/bin
export PATH=$PATH:$HADOOP_INSTALL/sbin
export HADOOP_MAPRED_HOME=$HADOOP_INSTALL
export HADOOP_COMMON_HOME=$HADOOP_INSTALL
export HADOOP_HDFS_HOME=$HADOOP_INSTALL
export YARN_HOME=$HADOOP_INSTALL
export
HADOOP_COMMON_LIB_NATIVE_DIR=$HADOOP_/INSTALL/
lib/native
export
HADOOP_OPTS=”-Djava.library.path=$HADOOP_INSTA
LL/lib”
```

Hadoop

❖ Installation: Hadoop



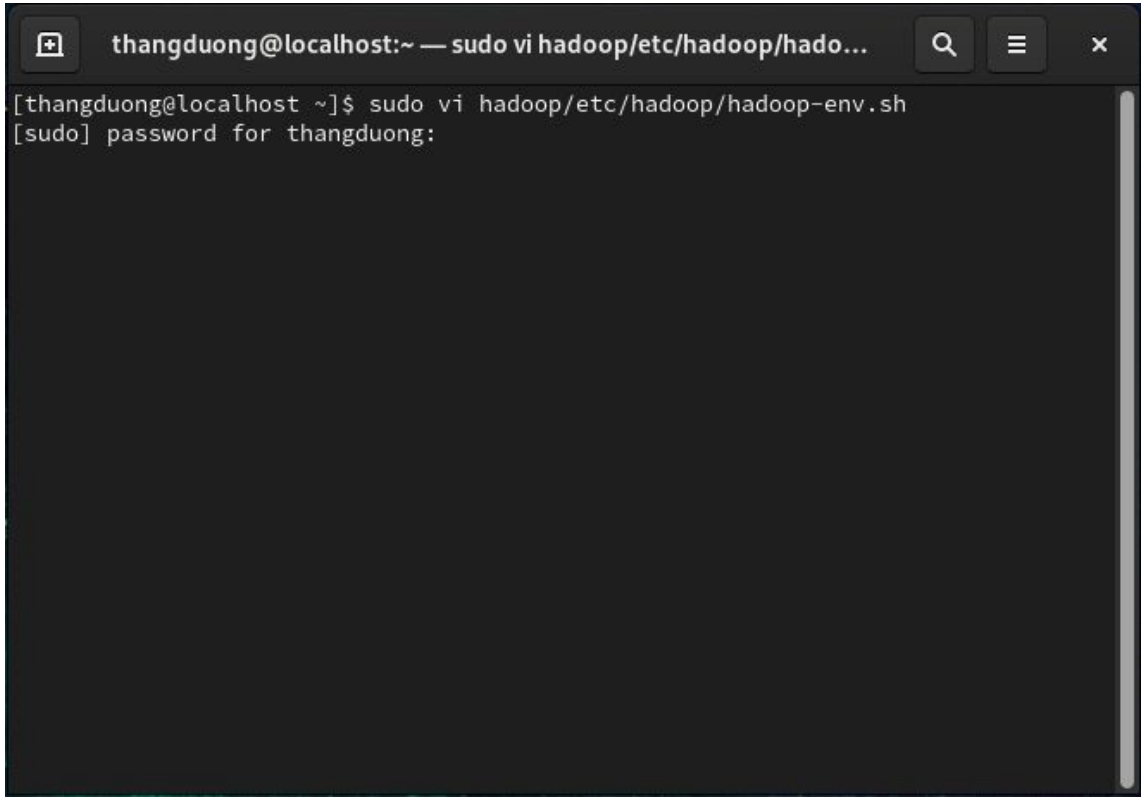


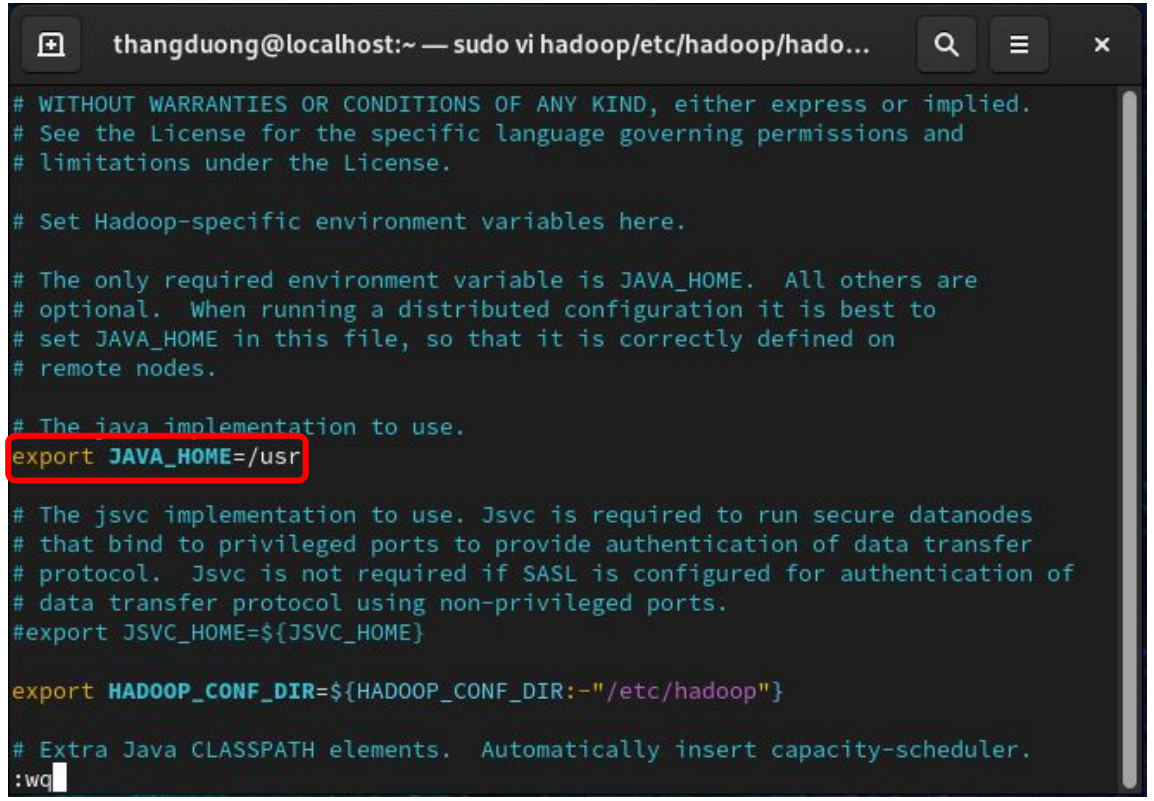
3. Set up .bashrc script then run it

Hadoop

❖ Installation: Hadoop

4. Config hadoop-env.sh

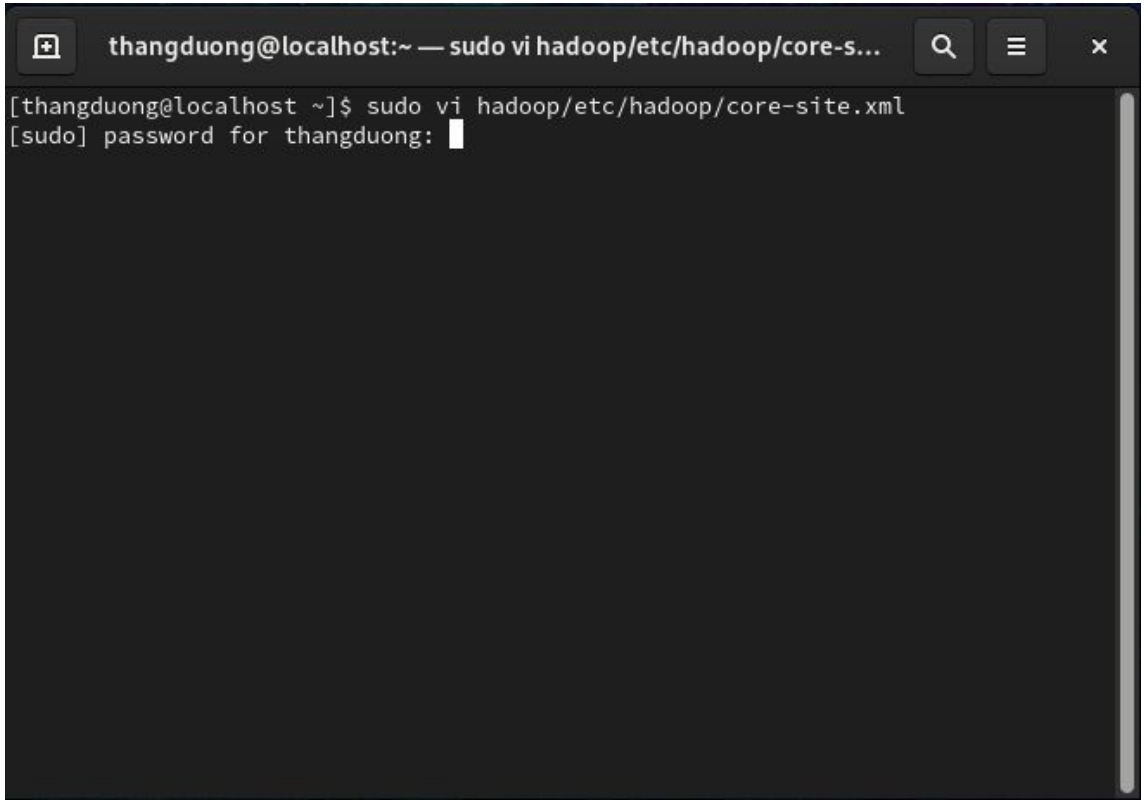




Hadoop

❖ Installation: Hadoop

5. Config core-site.xml

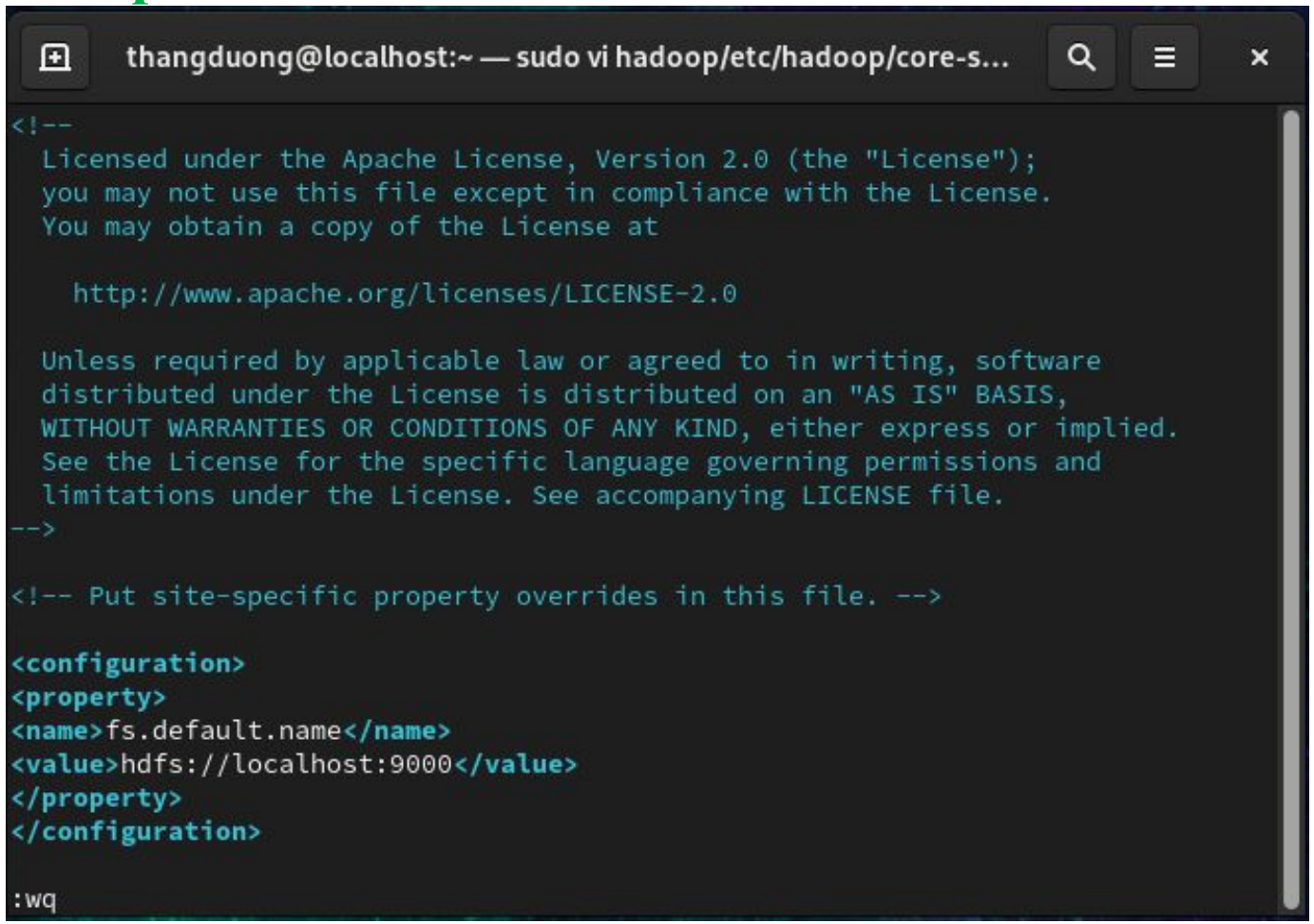


Paste the code below:

```
<configuration>
    <property>
        <name>fs.default.name</name>
        <value>hdfs://localhost:9000</value>
    </property>
</configuration>
```

Hadoop

❖ Installation: Hadoop

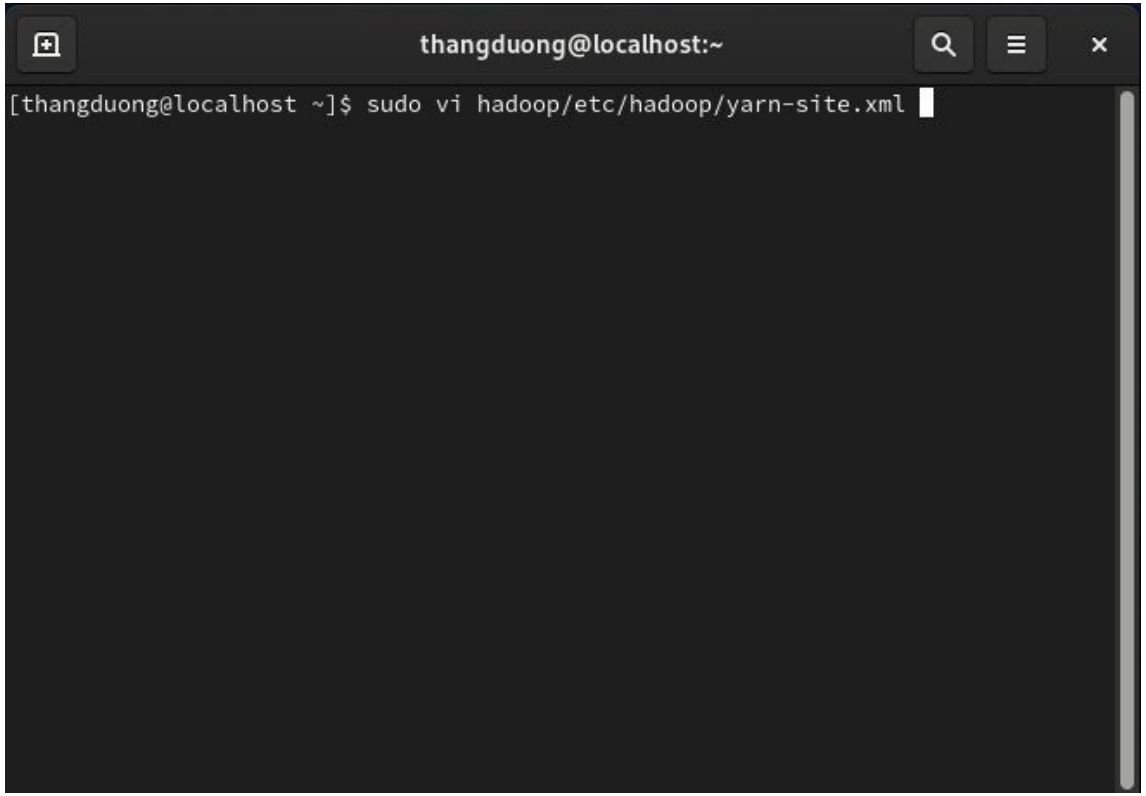


5. Config core-site.xml

Hadoop

❖ Installation: Hadoop

6. Config yarn-site.xml

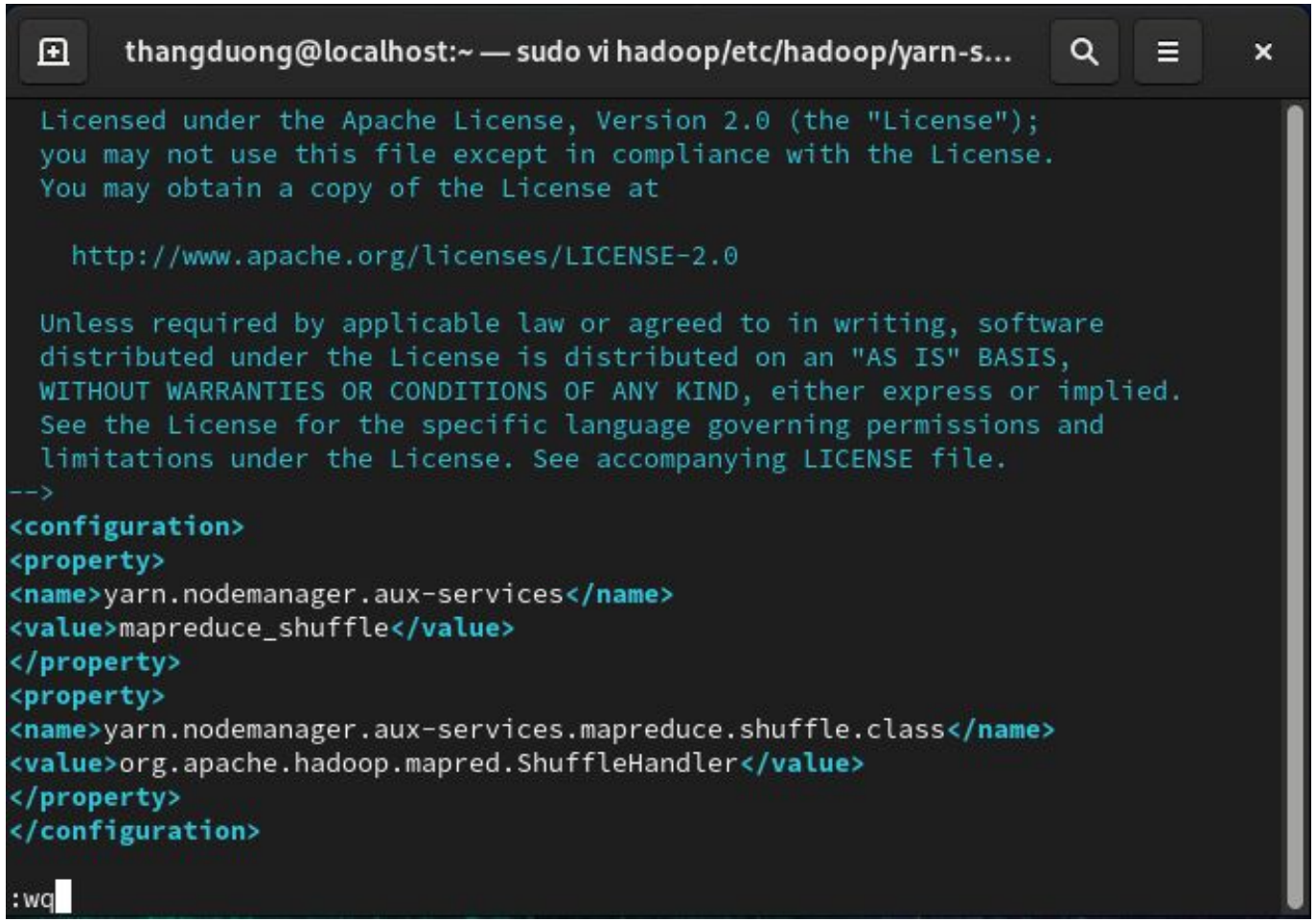


Paste the code below:

```
<configuration>
<property>
<name>yarn.nodemanager.aux-services</name>
<value>mapreduce_shuffle</value>
</property>
<property>
<name>yarn.nodemanager.aux-services.mapredu
ce.shuffle.class</name>
<value>org.apache.hadoop.mapred.ShuffleHand
ler</value>
</property>
</configuration>
```

Hadoop

❖ Installation: Hadoop

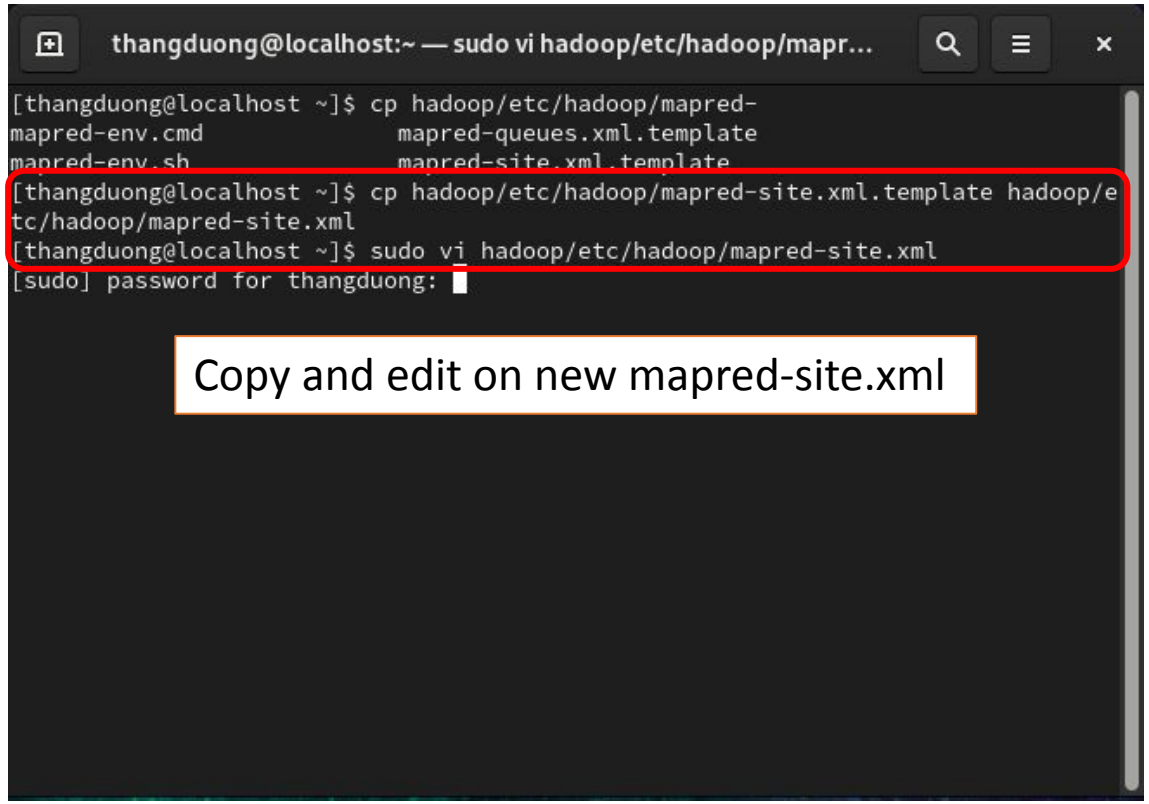


6. Config yarn-site.xml

Hadoop

❖ Installation: Hadoop

7. Config mapred-site.xml

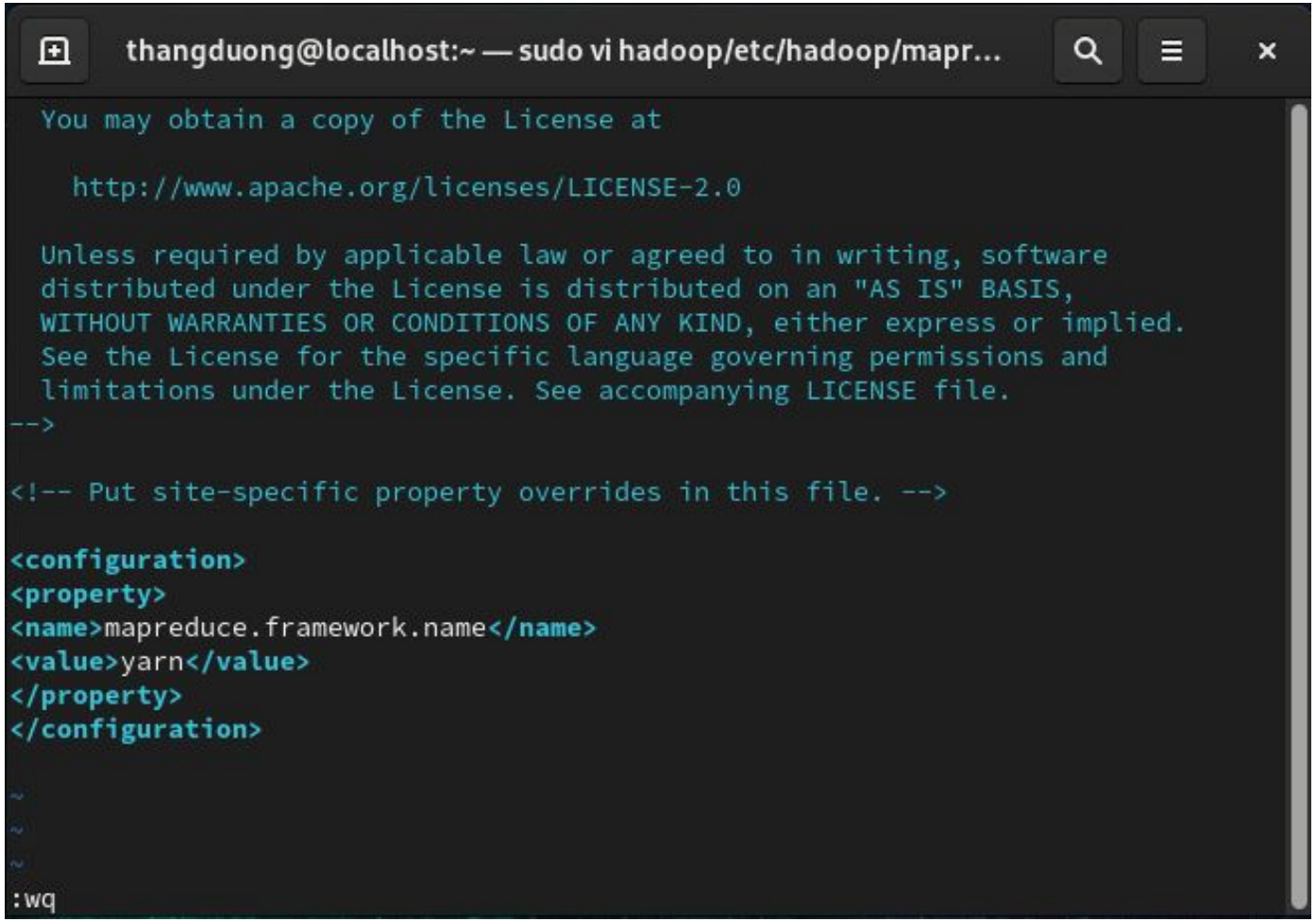


Paste the code below:

```
<configuration>
<property>
<name>mapreduce.framework.name</name>
<value>yarn</value>
</property>
</configuration>
```

Hadoop

❖ Installation: Hadoop

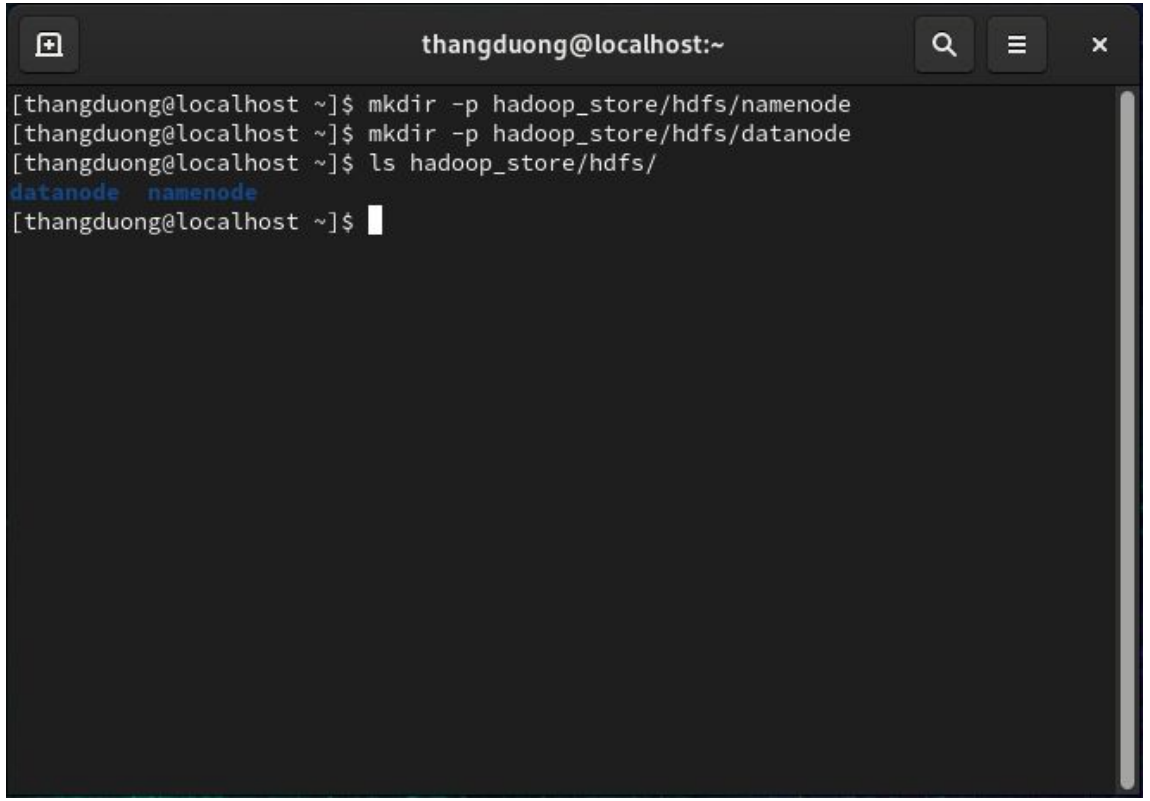


7. Config mapred-site.xml

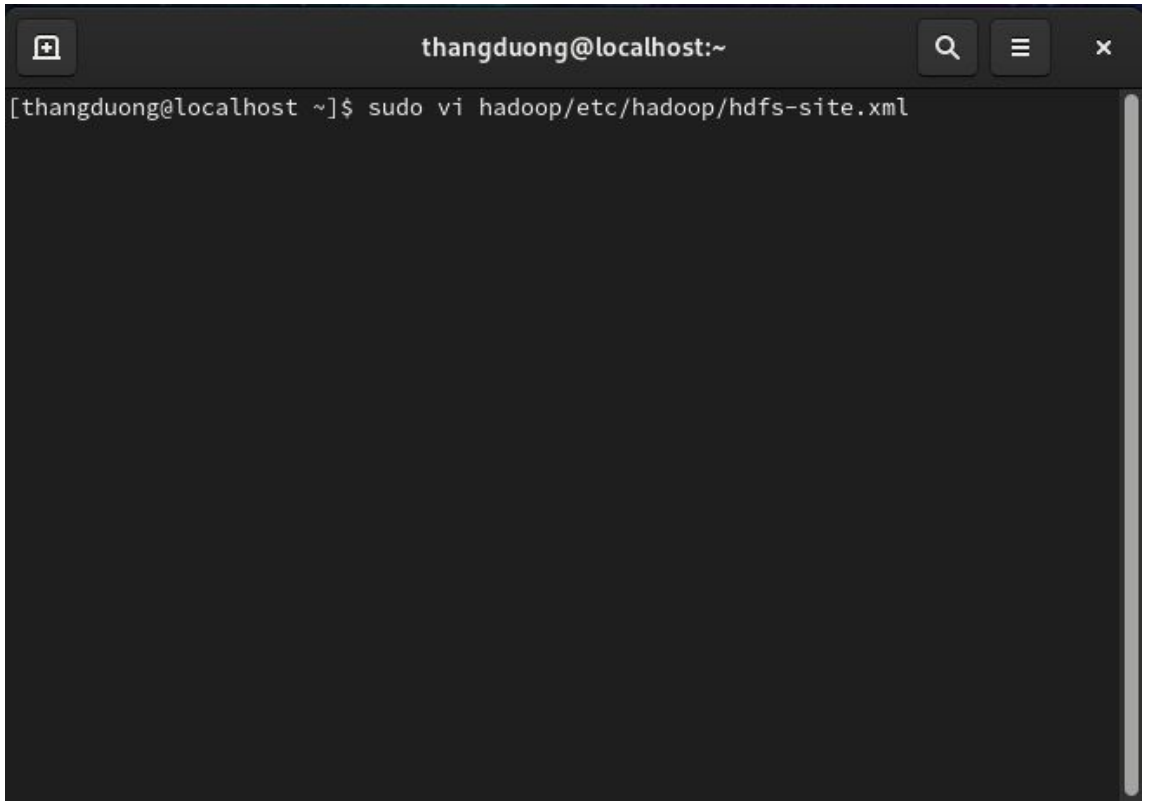
Hadoop

❖ Installation: Hadoop

8.1. Create namenode and datanode folder

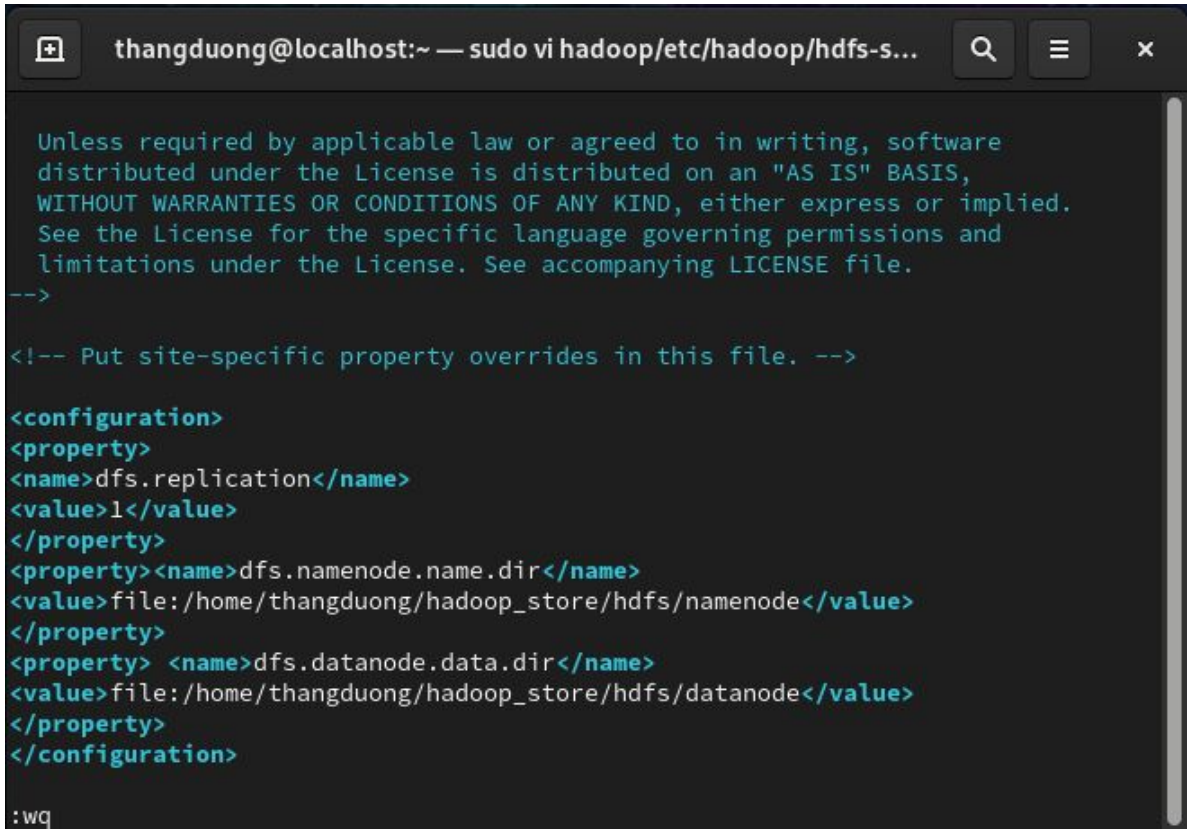


8.2. Config hdfs-site.xml



Hadoop

❖ Installation: Hadoop

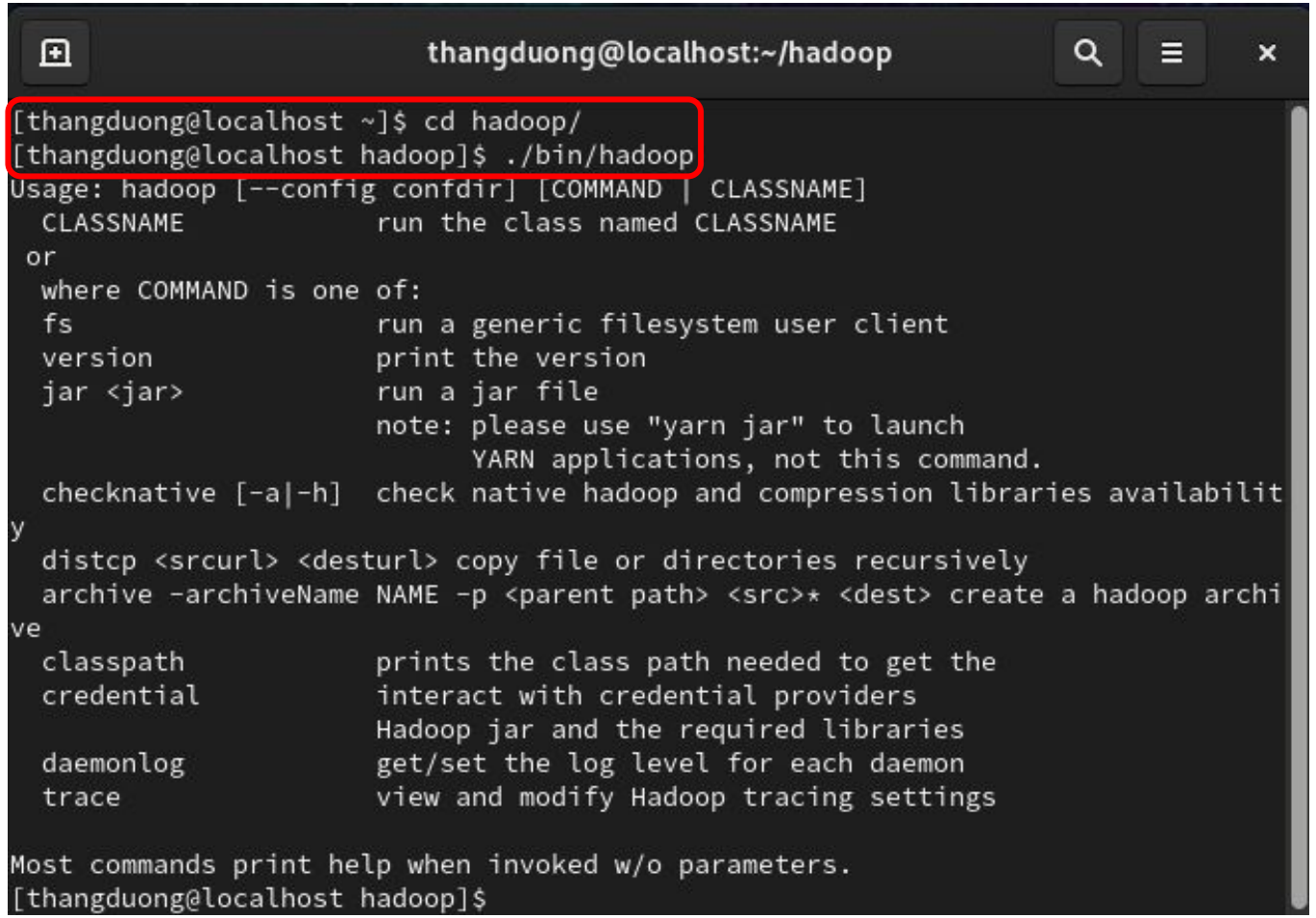


Paste the code below:

```
<configuration>
<property>
<name>dfs.replication</name>
<value>1</value>
</property>
<property>
<name>dfs.namenode.name.dir</name>
<value>file:/home/thangduong/hadoop_store/h
dfs/namenode</value>
</property>
<property>
<name>dfs.datanode.data.dir</name>
<value>file:/home/thangduong/hadoop_store/h
dfs/datanode</value>
</property>
</configuration>
```

Hadoop

❖ Installation: Check Hadoop



Check Hadoop Installation

Hadoop

❖ Example: Search text

grep Command

Last Updated: 2023-03-24

Purpose

Searches for a pattern in a file.

Syntax

grep [**-E** | **-F**] [**-i**] [**-h**] [**-H**] [**-L**] [**-r** | **-R**] [**-s**][**-u**] [**-v**] [**-w**] [**-x**] [**-y**] [[[**-b**] [**-n**]] | [**-c** | **-l** | **-q**]] [**-p** [*Separator*]] { [**-e** *PatternList* ...] [**-f** *PatternFile* ...] | PatternList ... } [File ...]

Description

The **grep** command searches for the pattern specified by the *Pattern* parameter and writes each matching line to standard output. The patterns are limited regular expressions in the style of the **ed** or **egrep** command. The **grep** command uses a compact non-deterministic algorithm.

Pattern to search: “dfs[a-z.]”

Hadoop

❖ Example: Search text

1. Initialize namenode

```
[thangduong@localhost hadoop]$ ./bin/hdfs namenode -format
23/07/08 14:26:34 INFO namenode.NameNode: STARTUP_MSG:
/************************************************************
STARTUP_MSG: Starting NameNode
STARTUP_MSG:   host = localhost/127.0.0.1
STARTUP_MSG:   args = [-format]
STARTUP_MSG:   version = 2.7.3
STARTUP_MSG:   classpath = /home/thangduong/hadoop/etc/hadoop:/home/thangduong/h
adoop/share/hadoop/common/lib/jaxb-impl-2.2.3-1.jar:/home/thangduong/hadoop/shar
e/hadoop/common/lib/jaxb-api-2.2.2.jar:/home/thangduong/hadoop/share/hadoop/comm
on/lib/stax-api-1.0-2.jar:/home/thangduong/hadoop/share/hadoop/common/lib/activa
tion-1.1.jar:/home/thangduong/hadoop/share/hadoop/common/lib/jackson-core-asl-1.
9.13.jar:/home/thangduong/hadoop/share/hadoop/common/lib/jackson-mapper-asl-1.9.
13.jar:/home/thangduong/hadoop/share/hadoop/common/lib/jackson-jaxrs-1.9.13.jar:
/home/thangduong/hadoop/share/hadoop/common/lib/jackson-xc-1.9.13.jar:/home/than
gduong/hadoop/share/hadoop/common/lib/jersey-server-1.9.jar:/home/thangduong/had
oop/share/hadoop/common/lib/asm-3.2.jar:/home/thangduong/hadoop/share/hadoop/com
mon/lib/log4j-1.2.17.jar:/home/thangduong/hadoop/share/hadoop/common/lib/jets3t-
0.9.0.jar:/home/thangduong/hadoop/share/hadoop/common/lib/httpclient-4.2.5.jar:/
home/thangduong/hadoop/share/hadoop/common/lib/httpcore-4.2.5.jar:/home/thangduo
ng/hadoop/share/hadoop/common/lib/java-xmlbuilder-0.4.jar:/home/thangduong/hadoo
```

2. Start namenode and datanode daemon

```
[thangduong@localhost hadoop]$ ./sbin/start-dfs.sh
23/07/08 14:26:44 WARN util.NativeCodeLoader: Unable to load native-hadoop libra
ry for your platform... using builtin-java classes where applicable
Starting namenodes on [localhost]
thangduong@localhost's password:
localhost: starting namenode, logging to /home/thangduong/hadoop/logs/hadoop-tha
ngduong-namenode-localhost.localdomain.out
thangduong@localhost's password:
localhost: datanode running as process 39009. Stop it first.
Starting secondary namenodes [0.0.0.0]
thangduong@0.0.0.0's password:
0.0.0.0: secondarynamenode running as process 39216. Stop it first.
23/07/08 14:26:55 WARN util.NativeCodeLoader: Unable to load native-hadoop libra
ry for your platform... using builtin-java classes where applicable
```

Hadoop

❖ Example: Search text

3. Create input folder and move all .xml file into input

```
[thangduong@localhost hadoop]$ ./bin/hdfs dfs -mkdir /input
23/07/08 14:27:36 WARN util.NativeCodeLoader: Unable to load native-hadoop libra
ry for your platform... using builtin-java classes where applicable
[thangduong@localhost hadoop]$ ./bin/hdfs dfs -put etc/hadoop/*.xml /input
23/07/08 14:27:56 WARN util.NativeCodeLoader: Unable to load native-hadoop libra
ry for your platform... using builtin-java classes where applicable
```

4. Perform grep with string pattern “dfs[a-z.]+”

```
[thangduong@localhost hadoop]$ ./bin/hadoop jar share/hadoop/mapreduce/hadoop-ma
preduce-examples-2.7.3.jar grep /input /output 'dfs[a-z.]+'
23/07/08 14:29:21 WARN util.NativeCodeLoader: Unable to load native-hadoop libra
ry for your platform... using builtin-java classes where applicable
23/07/08 14:29:21 INFO client.RMProxy: Connecting to ResourceManager at /0.0.0.0
:8032
23/07/08 14:29:22 INFO input.FileInputFormat: Total input paths to process : 9
23/07/08 14:29:22 WARN hdfs.DFSClient: Caught exception
java.lang.InterruptedException
        at java.lang.Object.wait(Native Method)
        at java.lang.Thread.join(Thread.java:1257)
        at java.lang.Thread.join(Thread.java:1331)
        at org.apache.hadoop.hdfs.DFSOutputStream$DataStreamer.closeResponder(DF
SOutputStream.java:609)
        at org.apache.hadoop.hdfs.DFSOutputStream$DataStreamer.endBlock(DFSOutpu
tStream.java:370)
        at org.apache.hadoop.hdfs.DFSOutputStream$DataStreamer.run(DFSOutputStre
```

Hadoop

❖ Example: Search text

```
[thangduong@localhost hadoop]$ ./bin/hdfs dfs -get /output output
23/07/08 14:30:45 WARN util.NativeCodeLoader: Unable to load native-hadoop libra
ry for your platform... using builtin-java classes where applicable
[thangduong@localhost hadoop]$ cat output/*
1       dfsadmin
1       dfs.replication
1       dfs.namenode.name.dir
1       dfs.datanode.data.dir
```

5. Get output and print results

Hadoop

❖ Example: Search text

```
[thangduong@localhost hadoop]$ ./bin/hdfs dfs -get /output output
23/07/08 14:30:45 WARN util.NativeCodeLoader: Unable to load native-hadoop libra
ry for your platform... using builtin-java classes where applicable
[thangduong@localhost hadoop]$ cat output/*
1       dfsadmin
1       dfs.replication
1       dfs.namenode.name.dir
1       dfs.datanode.data.dir
```

5. Get output and print results

Hadoop

❖ Example: Other default applications

```
Valid program names are:
  aggregatewordcount: An Aggregate based map/reduce program that counts the words in the i
nput files.
  aggregatewordhist: An Aggregate based map/reduce program that computes the histogram of
the words in the input files.
  bbp: A map/reduce program that uses Bailey-Borwein-Plouffe to compute exact digits of Pi
.
  dbcount: An example job that count the pageview counts from a database.
  distbbp: A map/reduce program that uses a BBP-type formula to compute exact bits of Pi.
  grep: A map/reduce program that counts the matches of a regex in the input.
  join: A job that effects a join over sorted, equally partitioned datasets
  multifilewc: A job that counts words from several files.
  pentomino: A map/reduce tile laying program to find solutions to pentomino problems.
  pi: A map/reduce program that estimates Pi using a quasi-Monte Carlo method.
  randomtextwriter: A map/reduce program that writes 10GB of random textual data per node.
  randomwriter: A map/reduce program that writes 10GB of random data per node.
  secondarysort: An example defining a secondary sort to the reduce.
  sort: A map/reduce program that sorts the data written by the random writer.
  sudoku: A sudoku solver.
  teragen: Generate data for the terasort
  terasort: Run the terasort
  teravalidate: Checking results of terasort
  wordcount: A map/reduce program that counts the words in the input files.
  wordmean: A map/reduce program that counts the average length of the words in the input
files.
  wordmedian: A map/reduce program that counts the median length of the words in the input
 files.
  wordstandarddeviation: A map/reduce program that counts the standard deviation of the le
ngth of the words in the input files.
```

QUIZ

Spark

Spark

❖ Introduction

Apache Spark: an open-source unified analytics engine for **large-scale data processing.** Spark is an alternative replacement for Hadoop MapReduce.

Spark

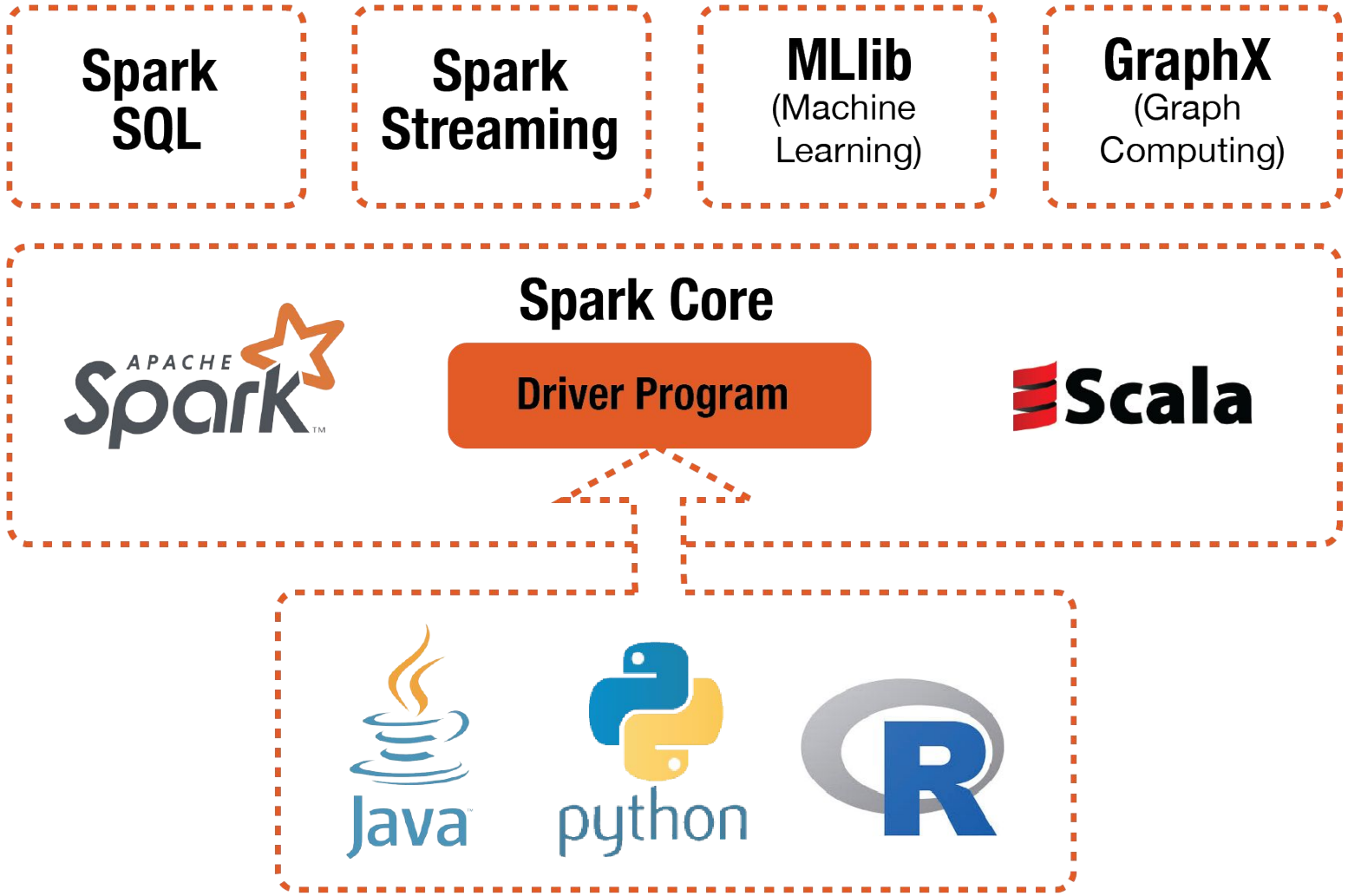
Why Spark?

- Fast
- Batch Processing
- Stores Data on Disk
- Written in Java
- Low Cost

- 100x Faster than MapReduce
- Real-time Processing
- Stores Data Memory
- Written in Scala
- High Cost

Spark

❖ Spark Modules



Spark

❖ PySpark Introduction

PySpark: The Python API for Apache Spark. It enables to perform real-time, large-scale data processing in a distributed environment using Python.

Spark

❖ PySpark Installation

▾ Install pyspark

```
[ ]  1 !pip install pyspark==3.4.1
```

```
Requirement already satisfied: pyspark==3.4.1 in /usr/local/lib/python3.10/dist-packages (3.4.1)
Requirement already satisfied: py4j==0.10.9.7 in /usr/local/lib/python3.10/dist-packages (from pyspark==3.4.1) (0.10.9.7)
```

Spark

❖ PySpark Usage

▾ Init pyspark session

```
[ ]  1 from pyspark.sql import SparkSession
```

```
[ ]  1 spark = SparkSession.builder.appName('Example').getOrCreate()
```

```
[ ]  1 print(spark)
```

```
<pyspark.sql.session.SparkSession object at 0x7efffefc7190>
```

SparkSession: Represents the connection to a Spark cluster and provides a way to interact with various Spark APIs. It allows to create DataFrames, execute SQL queries, and perform distributed data processing tasks.

Spark

❖ PySpark Usage: Create DataFrame

```
1 data = [
2     {'name': 'Rin', 'age': 20, 'gender': 'F'},
3     {'name': 'Thang', 'age': 22, 'gender': 'M'},
4     {'name': 'Saitama', 'age': 25, 'gender': 'M'},
5     {'name': 'Edward', 'age': 31, 'gender': 'M'},
6     {'name': 'Violet', 'age': 17, 'gender': 'F'}
7 ]
```

```
1 df = spark.createDataFrame(
2     data=data
3 )
```

```
1 df.printSchema()
```

```
root
 |-- age: long (nullable = true)
 |-- gender: string (nullable = true)
 |-- name: string (nullable = true)
```

```
1 df.show()
```

```
+---+------+-------+
|age|gender|   name|
+---+------+-------+
| 20|     F|    Rin|
| 22|     M|  Thang|
| 25|     M|Saitama|
| 31|     M| Edward|
| 17|     F| Violet|
+---+------+-------+
```

Spark

❖ PySpark Usage: Operations

```
1 # Select
2 df.select('age').show()
```

```
+---+
|age|
+---+
| 20|
| 22|
| 25|
| 31|
| 17|
+---+
```

select(): Choose columns to show in table

```
1 # Filter
2 df.filter(df.gender == 'F').show()
```

```
+---+------+------+
|age|gender|  name|
+---+------+------+
| 20|     F|   Rin|
| 17|     F|Violet|
+---+------+------+
```

filter(): Extract rows satisfied a criteria

Spark

❖ PySpark Example: Working with csv file

Description: Perform some basic operation of Spark with Flights.csv dataset. Download link: here.

year	month	day	dep_time	dep_delay	arr_time	arr_delay	carrier	tailnum	flight	origin	dest	air_time	distance	hour	minute
2014	12	8	658	-7	935	-5	VX	N846VA	1780	SEA	LAX	132	954	6	58
2014	1	22	1040	5	1505	5	AS	N559AS	851	SEA	HNL	360	2677	10	40
2014	3	9	1443	-2	1652	2	VX	N847VA	755	SEA	SFO	111	679	14	43
2014	4	9	1705	45	1839	34	WN	N360SW	344	PDX	SJC	83	569	17	5
2014	3	9	754	-1	1015	1	AS	N612AS	522	SEA	BUR	127	937	7	54

Spark

❖ PySpark Example: Working with csv file

```
1 from pyspark.sql import SparkSession
```

```
1 spark = SparkSession.builder.appName('Example').getOrCreate()
```

```
1 flights_filepath = './flights_small.csv'
2 flights_df = spark.read.csv(flights_filepath, header=True)
```

```
1 print(flights_df.printSchema())
2 print(flights_df.show(5))
```

```
root
 |-- year: string (nullable = true)
 |-- month: string (nullable = true)
 |-- day: string (nullable = true)
 |-- dep_time: string (nullable = true)
 |-- dep_delay: string (nullable = true)
 |-- arr_time: string (nullable = true)
 |-- arr_delay: string (nullable = true)
 |-- carrier: string (nullable = true)
 |-- tailnum: string (nullable = true)
 |-- flight: string (nullable = true)
 |-- origin: string (nullable = true)
 |-- dest: string (nullable = true)
 |-- air_time: string (nullable = true)
 |-- distance: string (nullable = true)
 |-- hour: string (nullable = true)
 |-- minute: string (nullable = true)

None
+----+-----+---+--------+---------+--------+---------+-------+-------+------+------+----+--------+--------+----+------+
|year|month|day|dep_time|dep_delay|arr_time|arr_delay|carrier|tailnum|flight|origin|dest|air_time|distance|hour|minute|
+----+-----+---+--------+---------+--------+---------+-------+-------+------+------+----+--------+--------+----+------+
|2014|   12|  8|     658|       -7|     935|       -5|     VX| N846VA|  1780|   SEA| LAX|     132|     954|   6|    58|
|2014|    1| 22|    1040|        5|    1505|        5|     AS| N559AS|   851|   SEA| HNL|     360|    2677|  10|    40|
|2014|    3|  9|    1443|       -2|    1652|        2|     VX| N847VA|   755|   SEA| SFO|     111|     679|  14|    43|
|2014|    4|  9|    1705|       45|    1839|       34|     WN| N360SW|   344|   PDX| SJC|      83|     569|  17|     5|
|2014|    3|  9|     754|       -1|    1015|        1|     AS| N612AS|   522|   SEA| BUR|     127|     937|   7|    54|
+----+-----+---+--------+---------+--------+---------+-------+-------+------+------+----+--------+--------+----+------+
only showing top 5 rows
```

Spark

❖ PySpark Example: Working with csv file

▾ Create new column: Flight Duration

```
[ ]  1 flights_df = flights_df.withColumn('duration_hours', flights_df.air_time / 60)
     2 print(flights_df.show())
```

```
+----+-----+---+--------+---------+--------+---------+-------+-------+------+------+----+--------+--------+----+------+------------------+
|year|month|day|dep_time|dep_delay|arr_time|arr_delay|carrier|tailnum|flight|origin|dest|air_time|distance|hour|minute|    duration_hours|
+----+-----+---+--------+---------+--------+---------+-------+-------+------+------+----+--------+--------+----+------+------------------+
|2014|   12|  8|     658|       -7|     935|       -5|     VX| N846VA|  1780|   SEA| LAX|     132|     954|   6|    58|               2.2|
|2014|    1| 22|    1040|        5|    1505|        5|     AS| N559AS|   851|   SEA| HNL|     360|    2677|  10|    40|               6.0|
|2014|    3|  9|    1443|       -2|    1652|        2|     VX| N847VA|   755|   SEA| SFO|     111|     679|  14|    43|              1.85|
|2014|    4|  9|    1705|       45|    1839|       34|     WN| N360SW|   344|   PDX| SJC|      83|     569|  17|     5|1.3833333333333333|
|2014|    3|  9|     754|       -1|    1015|        1|     AS| N612AS|   522|   SEA| BUR|     127|     937|   7|    54|2.1166666666666667|
|2014|    1| 15|    1037|        7|    1352|        2|     WN| N646SW|    48|   PDX| DEN|     121|     991|  10|    37|2.0166666666666666|
|2014|    7|  2|     847|       42|    1041|       51|     WN| N422WN|  1520|   PDX| OAK|      90|     543|   8|    47|               1.5|
|2014|    5| 12|    1655|       -5|    1842|      -18|     VX| N361VA|   755|   SEA| SFO|      98|     679|  16|    55|1.6333333333333333|
|2014|    4| 19|    1236|       -4|    1508|       -7|     AS| N309AS|   490|   SEA| SAN|     135|    1050|  12|    36|              2.25|
|2014|   11| 19|    1812|       -3|    2352|       -4|     AS| N564AS|    26|   SEA| ORD|     198|    1721|  18|    12|               3.3|
|2014|   11|  8|    1653|       -2|    1924|       -1|     AS| N323AS|   448|   SEA| LAX|     130|     954|  16|    53|2.1666666666666665|
|2014|    8|  3|    1120|        0|    1415|        2|     AS| N305AS|   656|   SEA| PHX|     154|    1107|  11|    20| 2.566666666666667|
|2014|   10| 30|     811|       21|    1038|       29|     AS| N433AS|   608|   SEA| LAS|     127|     867|   8|    11|2.1166666666666667|
|2014|   11| 12|    2346|       -4|     217|      -28|     AS| N765AS|   121|   SEA| ANC|     183|    1448|  23|    46|              3.05|
|2014|   10| 31|    1314|       89|    1544|      111|     AS| N713AS|   306|   SEA| SFO|     129|     679|  13|    14|              2.15|
|2014|    1| 29|    2009|        3|    2159|        9|     UA| N27205|  1458|   PDX| SFO|      90|     550|  20|     9|               1.5|
|2014|   12| 17|    2015|       50|    2150|       41|     AS| N626AS|   368|   SEA| SMF|      76|     605|  20|    15|1.2666666666666666|
|2014|    8| 11|    1017|       -3|    1613|       -7|     WN| N8634A|   827|   SEA| MDW|     216|    1733|  10|    17|               3.6|
|2014|    1| 13|    2156|       -9|     607|      -15|     AS| N597AS|    24|   SEA| BOS|     290|    2496|  21|    56| 4.833333333333333|
|2014|    6|  5|    1733|      -12|    1945|      -10|     OO| N215AG|  3488|   PDX| BUR|     111|     817|  17|    33|              1.85|
+----+-----+---+--------+---------+--------+---------+-------+-------+------+------+----+--------+--------+----+------+------------------+
only showing top 20 rows
```

Spark

❖ PySpark Example: Working with csv file

▾ Assign tables

```
[ ]  1 flights_df.createOrReplaceTempView('flights')
```

```
[ ]  1 spark.catalog.listDatabases()
```

```
[Database(name='default', catalog='spark_catalog', description='default database', locationUri='file:/content/spark-warehouse')]
```

```
[ ]  1 spark.catalog.listTables()
```

```
[Table(name='airports', catalog=None, namespace=[], description=None, tableType='TEMPORARY', isTemporary=True),
 Table(name='flights', catalog=None, namespace=[], description=None, tableType='TEMPORARY', isTemporary=True)]
```

Assign DataFrame to Database

Spark

❖ PySpark Example: Working with csv file

```
1 flights_table = spark.table('flights')
2 print(flights_table.show())
```

```
+----+-----+---+--------+---------+--------+---------+-------+-------+------+------+----+--------+--------+----+------+------------------+
|year|month|day|dep_time|dep_delay|arr_time|arr_delay|carrier|tailnum|flight|origin|dest|air_time|distance|hour|minute|     duration_hours|
+----+-----+---+--------+---------+--------+---------+-------+-------+------+------+----+--------+--------+----+------+------------------+
|2014|   12|  8|     658|       -7|     935|       -5|     VX| N846VA|  1780|   SEA| LAX|     132|     954|   6|    58|               2.2|
|2014|    1| 22|    1040|        5|    1505|        5|     AS| N559AS|   851|   SEA| HNL|     360|    2677|  10|    40|               6.0|
|2014|    3|  9|    1443|       -2|    1652|        2|     VX| N847VA|   755|   SEA| SFO|     111|     679|  14|    43|              1.85|
|2014|    4|  9|    1705|       45|    1839|       34|     WN| N360SW|   344|   PDX| SJC|      83|     569|  17|     5|1.3833333333333333|
|2014|    3|  9|     754|       -1|    1015|        1|     AS| N612AS|   522|   SEA| BUR|     127|     937|   7|    54|2.1166666666666667|
|2014|    1| 15|    1037|        7|    1352|        2|     WN| N646SW|    48|   PDX| DEN|     121|     991|  10|    37|2.0166666666666666|
|2014|    7|  2|     847|       42|    1041|       51|     WN| N422WN|  1520|   PDX| OAK|      90|     543|   8|    47|               1.5|
|2014|    5| 12|    1655|       -5|    1842|      -18|     VX| N361VA|   755|   SEA| SFO|      98|     679|  16|    55|1.6333333333333333|
|2014|    4| 19|    1236|       -4|    1508|       -7|     AS| N309AS|   490|   SEA| SAN|     135|    1050|  12|    36|              2.25|
|2014|   11| 19|    1812|       -3|    2352|       -4|     AS| N564AS|    26|   SEA| ORD|     198|    1721|  18|    12|               3.3|
|2014|   11|  8|    1653|       -2|    1924|       -1|     AS| N323AS|   448|   SEA| LAX|     130|     954|  16|    53|2.1666666666666665|
|2014|    8|  3|    1120|        0|    1415|        2|     AS| N305AS|   656|   SEA| PHX|     154|    1107|  11|    20| 2.566666666666667|
|2014|   10| 30|     811|       21|    1038|       29|     AS| N433AS|   608|   SEA| LAS|     127|     867|   8|    11|2.1166666666666667|
|2014|   11| 12|    2346|       -4|     217|      -28|     AS| N765AS|   121|   SEA| ANC|     183|    1448|  23|    46|              3.05|
|2014|   10| 31|    1314|       89|    1544|      111|     AS| N713AS|   306|   SEA| SFO|     129|     679|  13|    14|              2.15|
|2014|    1| 29|    2009|        3|    2159|        9|     UA| N27205|  1458|   PDX| SFO|      90|     550|  20|     9|               1.5|
|2014|   12| 17|    2015|       50|    2150|       41|     AS| N626AS|   368|   SEA| SMF|      76|     605|  20|    15|1.2666666666666666|
|2014|    8| 11|    1017|       -3|    1613|       -7|     WN| N8634A|   827|   SEA| MDW|     216|    1733|  10|    17|               3.6|
|2014|    1| 13|    2156|       -9|     607|      -15|     AS| N597AS|    24|   SEA| BOS|     290|    2496|  21|    56| 4.833333333333333|
|2014|    6|  5|    1733|      -12|    1945|      -10|     OO| N215AG|  3488|   PDX| BUR|     111|     817|  17|    33|              1.85|
+----+-----+---+--------+---------+--------+---------+-------+-------+------+------+----+--------+--------+----+------+------------------+
only showing top 20 rows
```

Call the datatable

Spark

❖ PySpark Example: Working with csv file

```
1 flights_table.filter(flights_table.duration_hours > 5).show()
```

```
+----+-----+---+--------+---------+--------+---------+-------+-------+------+------+----+--------+--------+----+------+-----------------+
|year|month|day|dep_time|dep_delay|arr_time|arr_delay|carrier|tailnum|flight|origin|dest|air_time|distance|hour|minute|    duration_hours|
+----+-----+---+--------+---------+--------+---------+-------+-------+------+------+----+--------+--------+----+------+-----------------+
|2014|    1| 22|    1040|        5|    1505|        5|     AS| N559AS|   851|   SEA| HNL|     360|    2677|  10|    40|              6.0|
|2014|   12|  4|     954|       -6|    1348|      -17|     HA| N395HA|    29|   SEA| OGG|     333|    2640|   9|    54|             5.55|
|2014|    6|  7|    1823|       -7|    2112|      -28|     AS| N512AS|   815|   SEA| LIH|     335|    2701|  18|    23|5.583333333333333|
|2014|    4| 30|     801|        1|    1757|       90|     AS| N407AS|    18|   SEA| MCO|     342|    2554|   8|     1|              5.7|
|2014|    4|  1|    1010|       -5|    1258|      -17|     HA| N381HA|    25|   PDX| HNL|     328|    2603|  10|    10|5.466666666666667|
|2014|    7| 27|     925|       25|    1232|       27|     AS| N513AS|   875|   SEA| LIH|     343|    2701|   9|    25|5.716666666666667|
|2014|    8| 18|    2116|       -4|     541|       18|     B6| N536JB|   264|   SEA| JFK|     304|    2422|  21|    16|5.066666666666666|
|2014|   11|  3|     840|        0|    1703|      -17|     AS| N462AS|    38|   SEA| FLL|     307|    2717|   8|    40|5.116666666666666|
|2014|    9|  2|     705|       -5|     950|      -15|     AS| N442AS|   833|   PDX| HNL|     326|    2603|   7|     5|5.433333333333334|
|2014|   12| 28|    1705|      -10|    2046|      -42|     AS| N517AS|   863|   PDX| OGG|     324|    2562|  17|     5|              5.4|
|2014|    4| 10|     829|       -1|    1128|       -7|     AS| N589AS|   861|   SEA| OGG|     332|    2640|   8|    29|5.533333333333333|
|2014|    9| 19|    1039|       -1|    1335|       -6|     AS| N431AS|   843|   SEA| KOA|     332|    2688|  10|    39|5.533333333333333|
|2014|    9| 28|     657|       -3|    1557|       34|     DL|  N704X|  2588|   SEA| JFK|     311|    2422|   6|    57|5.183333333333334|
|2014|   10| 13|     853|       -2|    1217|       16|     AS| N517AS|   879|   SEA| LIH|     358|    2701|   8|    53|5.966666666666667|
|2014|    5|  2|    1022|       -3|    1408|       38|     AS| N508AS|   843|   SEA| KOA|     378|    2688|  10|    22|              6.3|
|2014|    3| 30|    1646|        6|    1938|      -17|     AS| N537AS|   867|   SEA| OGG|     332|    2640|  16|    46|5.533333333333333|
|2014|    5| 29|     705|       -3|    1547|       15|     DL| N3750D|   400|   PDX| JFK|     311|    2454|   7|     5|5.183333333333334|
|2014|    3| 22|    1007|       -8|    1305|      -20|     HA| N389HA|    25|   PDX| HNL|     338|    2603|  10|     7|5.633333333333334|
|2014|    8| 16|    1032|       -8|    1315|      -20|     HA| N395HA|    25|   PDX| HNL|     304|    2603|  10|    32|5.066666666666666|
|2014|    4|  4|    1008|       -7|    1248|      -27|     HA| N385HA|    25|   PDX| HNL|     320|    2603|  10|     8|5.333333333333333|
+----+-----+---+--------+---------+--------+---------+-------+-------+------+------+----+--------+--------+----+------+-----------------+
only showing top 20 rows
```

Perform filtering: Using function or SQL Query

Spark

❖ PySpark Example: Working with csv file

```
1 spark.sql('SELECT * FROM flights WHERE duration_hours > 5').show()
```

```
+----+-----+---+--------+---------+--------+---------+-------+-------+------+------+----+--------+--------+----+------+-----------------+
|year|month|day|dep_time|dep_delay|arr_time|arr_delay|carrier|tailnum|flight|origin|dest|air_time|distance|hour|minute|   duration_hours|
+----+-----+---+--------+---------+--------+---------+-------+-------+------+------+----+--------+--------+----+------+-----------------+
|2014|    1| 22|    1040|        5|    1505|        5|     AS| N559AS|   851|   SEA| HNL|     360|    2677|  10|    40|              6.0|
|2014|   12|  4|     954|       -6|    1348|      -17|     HA| N395HA|    29|   SEA| OGG|     333|    2640|   9|    54|             5.55|
|2014|    6|  7|    1823|       -7|    2112|      -28|     AS| N512AS|   815|   SEA| LIH|     335|    2701|  18|    23|5.583333333333333|
|2014|    4| 30|     801|        1|    1757|       90|     AS| N407AS|    18|   SEA| MCO|     342|    2554|   8|     1|              5.7|
|2014|    4|  1|    1010|       -5|    1258|      -17|     HA| N381HA|    25|   PDX| HNL|     328|    2603|  10|    10|5.466666666666667|
|2014|    7| 27|     925|       25|    1232|       27|     AS| N513AS|   875|   SEA| LIH|     343|    2701|   9|    25|5.716666666666667|
|2014|    8| 18|    2116|       -4|     541|       18|     B6| N536JB|   264|   SEA| JFK|     304|    2422|  21|    16|5.066666666666666|
|2014|   11|  3|     840|        0|    1703|      -17|     AS| N462AS|    38|   SEA| FLL|     307|    2717|   8|    40|5.116666666666666|
|2014|    9|  2|     705|       -5|     950|      -15|     AS| N442AS|   833|   PDX| HNL|     326|    2603|   7|     5|5.433333333333334|
|2014|   12| 28|    1705|      -10|    2046|      -42|     AS| N517AS|   863|   PDX| OGG|     324|    2562|  17|     5|              5.4|
|2014|    4| 10|     829|       -1|    1128|       -7|     AS| N589AS|   861|   SEA| OGG|     332|    2640|   8|    29|5.533333333333333|
|2014|    9| 19|    1039|       -1|    1335|       -6|     AS| N431AS|   843|   SEA| KOA|     332|    2688|  10|    39|5.533333333333333|
|2014|    9| 28|     657|       -3|    1557|       34|     DL|  N704X|  2588|   SEA| JFK|     311|    2422|   6|    57|5.183333333333334|
|2014|   10| 13|     853|       -2|    1217|       16|     AS| N517AS|   879|   SEA| LIH|     358|    2701|   8|    53|5.966666666666667|
|2014|    5|  2|    1022|       -3|    1408|       38|     AS| N508AS|   843|   SEA| KOA|     378|    2688|  10|    22|              6.3|
|2014|    3| 30|    1646|        6|    1938|      -17|     AS| N537AS|   867|   SEA| OGG|     332|    2640|  16|    46|5.533333333333333|
|2014|    5| 29|     705|       -3|    1547|       15|     DL| N3750D|   400|   PDX| JFK|     311|    2454|   7|     5|5.183333333333334|
|2014|    3| 22|    1007|       -8|    1305|      -20|     HA| N389HA|    25|   PDX| HNL|     338|    2603|  10|     7|5.633333333333334|
|2014|    8| 16|    1032|       -8|    1315|      -20|     HA| N395HA|    25|   PDX| HNL|     304|    2603|  10|    32|5.066666666666666|
|2014|    4|  4|    1008|       -7|    1248|      -27|     HA| N385HA|    25|   PDX| HNL|     320|    2603|  10|     8|5.333333333333333|
+----+-----+---+--------+---------+--------+---------+-------+-------+------+------+----+--------+--------+----+------+-----------------+
only showing top 20 rows
```

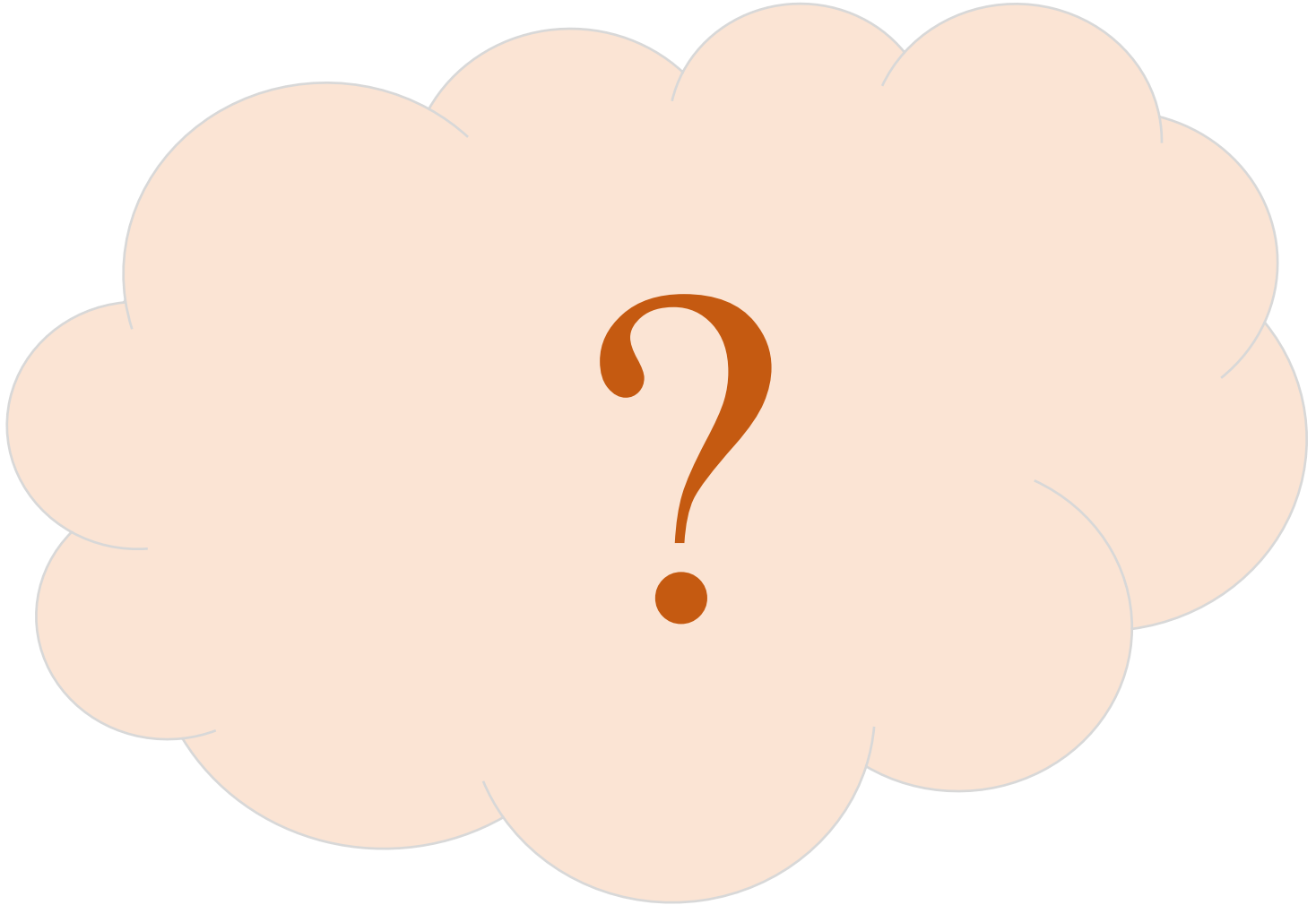
Perform filtering: Using function or SQL Query

Summarization

In this session, we will discuss about:

- Introduction to big data.
- Introduction to Hadoop.
- How to install virtual machine.
- How to install and use Hadoop on virtual machine.
- Introduction to spark and pyspark.

Question




Thank you!