Project Report

Course Name: Software and Data Engineering (SDE)

Course Code: CSL7090

Indian Institute of Technology, Jodhpur

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Project Title: Exploring BigData: CDH Platform Architecture, EDA on Local Machine

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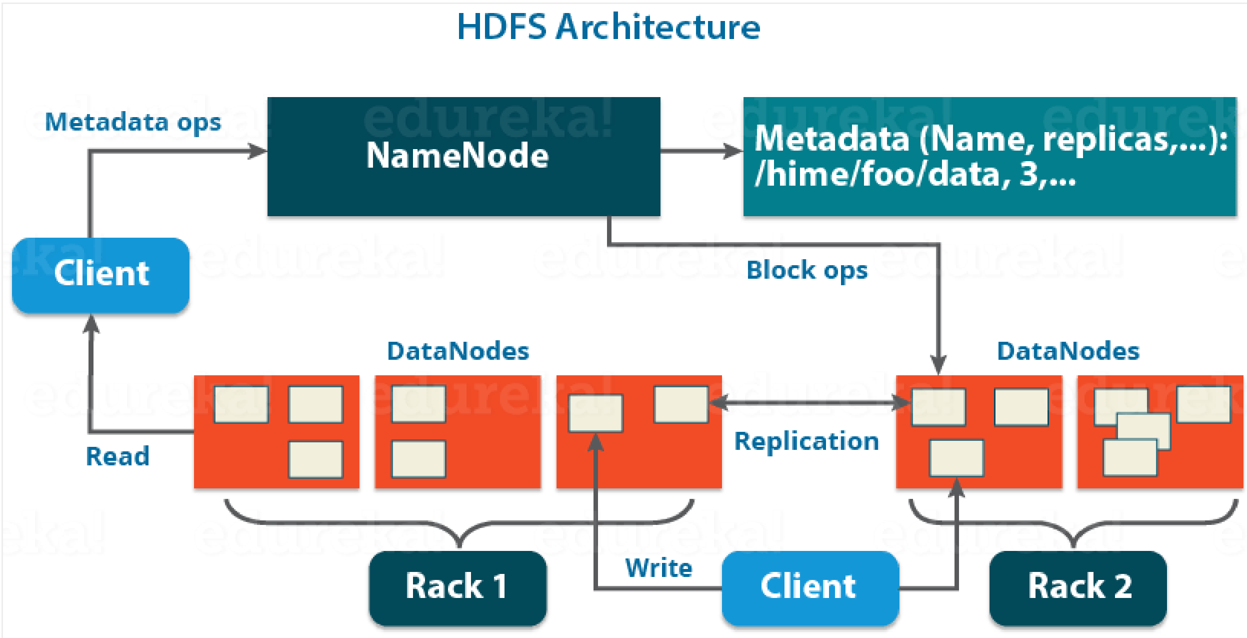
Abstract

As big data and associated technologies continue to advance and gain widespread acceptance, the demand for a comprehensive big data ecosystem encompassing data resources, APIs, open-source platforms, data infrastructure, and components for big data analysis and applications has become increasingly significant. This project delves into the utilization of the big data ecosystem specifically centered around the Cloudera Distribution for Hadoop (CDH), the recent trends in data scale development and the current state-of-the-art advancements in big data analysis systems. It then shifts focus to the technical architecture of the big data ecosystem built on CDH, providing an analysis of the system's hierarchical structure. Users can leverage its resources for data exploration, analysis, and visualization, all within an interactive and user-friendly interface. The platform supports various data science and machine learning libraries, allowing for the seamless integration of advanced analytical techniques into big data workflows.

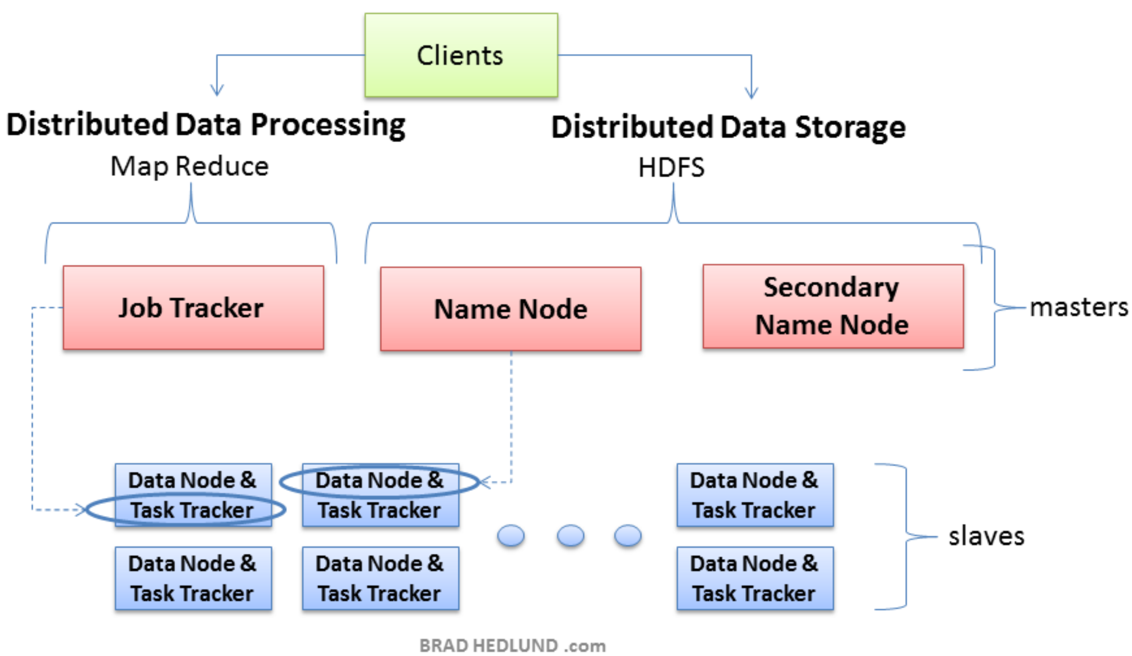
Introduction

Over the past few years, there has been a swift expansion in the volume of data. As reported by the International Data Corporation (IDC), a global information technology consulting firm, the worldwide data storage capacity escalated to 44ZB in 2020 and is projected to potentially reach 2500ZB by 2030. Notably, the quantity of data requiring processing has far surpassed the upper limits of available processing capacity, leading to a significant backlog of data that cannot be collected or processed promptly. The big data ecosystem such as CDH, on-premise resources or local platform comprehend intricate systems and we will look at all these and observe the processing techniques. This project includes two chapters. Chapter-1 contains practical insights into CDH platform architecture and tools, chapter 2 contains exploratory data analysis on local machine platform.

Platform 1 : CDH Architecture



In the customized distribution, we are using Namenode and YARN Resource Manager, which is "Yet Another Resource Negotiator" to manage and allocate resources within a Hadoop cluster. In more recent versions, the Job Tracker and Task Tracker functionalities have been replaced by the ResourceManager and NodeManagers, respectively, offering a more flexible and scalable resource management framework and that is the version we will be using.



1.1 Setting the CDH Cluster

1.1.1 Customized Cloudera Distribution for Hadoop Image:-

```
bhawnabhoria@Bhawnas-MacBook-Pro Scripts % docker images
REPOSITORY              TAG       IMAGE ID       CREATED         SIZE
sde_project             latest    b7be6f417387   13 days ago     7.37GB
cloudera-5-13           latest    35b346d3eb86   4 weeks ago     7GB
cloudera/quickstart     latest    4239cd2958c6   7 years ago     6.34GB
```

Mapping the required ports in order to run the CDH Ecosystem.

```
bhawnabhoria@Bhawnas-MacBook-Pro Scripts % docker run --hostname=quickstart.cloudera --privileged=true -t -
i -p 8888:8888 -p 10000:10000 -p 10020:10020 -p 11000:11000 -p 18080:18080 -p 18081:18081 -p 18088:18088 -p
 19888:19888 -p 21000:21000 -p 21050:21050 -p 2181:2181 -p 25000:25000 -p 25010:25010 -p 25020:25020 -p 500
10:50010 -p 50030:50030 -p 50060:50060 -p 50070:50070 -p 50075:50075 -p 50090:50090 -p 60000:60000 -p 60010
:60010 -p 60020:60020 -p 60030:60030 -p 7180:7180 -p 7183:7183 -p 7187:7187 -p 80:80 -p 8020:8020 -p 8032:8
032 -p 802:8042 -p 8088:8081 -p 8983:8983 -p 9083:9083 35b346d3eb86 /usr/bin/docker-quickstart
Starting mysqld:                                           [  OK  ]
```

Further installation of the services available on CDH.

```
Started Hadoop httpfs (hadoop-httpfs):                     [  OK  ]
starting historyserver, logging to /var/log/hadoop-mapreduce/mapred-mapred-historyserver-quickstart.cloudera.out
Started Hadoop historyserver:                              [  OK  ]
starting nodemanager, logging to /var/log/hadoop-yarn/yarn-yarn-nodemanager-quickstart.cloudera.out
Started Hadoop nodemanager:                                [  OK  ]
starting resourcemanager, logging to /var/log/hadoop-yarn/yarn-yarn-resourcemanager-quickstart.cloudera.out
Started Hadoop resourcemanager:                            [  OK  ]
starting master, logging to /var/log/hbase/hbase-hbase-master-quickstart.cloudera.out
Started HBase master daemon (hbase-master):                [  OK  ]
starting rest, logging to /var/log/hbase/hbase-hbase-rest-quickstart.cloudera.out
Started HBase rest daemon (hbase-rest):                    [  OK  ]
starting thrift, logging to /var/log/hbase/hbase-hbase-thrift-quickstart.cloudera.out
Started HBase thrift daemon (hbase-thrift):                [  OK  ]
Starting Hive Metastore (hive-metastore):                  [  OK  ]
Started Hive Server2 (hive-server2):                       [  OK  ]
Starting Sqoop Server:                                     [  OK  ]
Sqoop home directory: /usr/lib/sqoop2
Setting SQOOP_HTTP_PORT:     12000
```

jps output :-

```
[root@quickstart /]# jps
880 JournalNode
2000 NodeManager
7292
6163 Bootstrap
2713 HMaster
5165 HistoryServer
5073 Bootstrap
5494 HRegionServer
1673 Bootstrap
674 DataNode
1321 SecondaryNameNode
```

```
1081 NameNode
563 QuorumPeerMain
1802 JobHistoryServer
7183 Bootstrap
2281 ResourceManager
9166 Jps
3953 RunJar
3346 ThriftServer
7443
3030 RESTServer
3616 RunJar
```

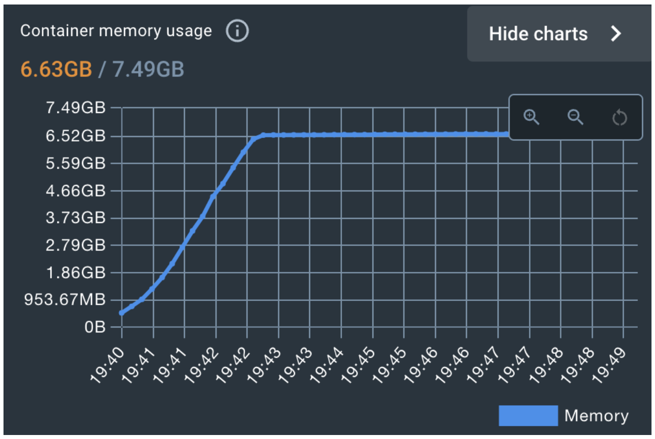
Checking Namenode :-

```
[root@quickstart /]# hdfs getconf -confKey fs.defaultFS
hdfs://quickstart.cloudera:8020
```

1.1.2 Laptop configurations:

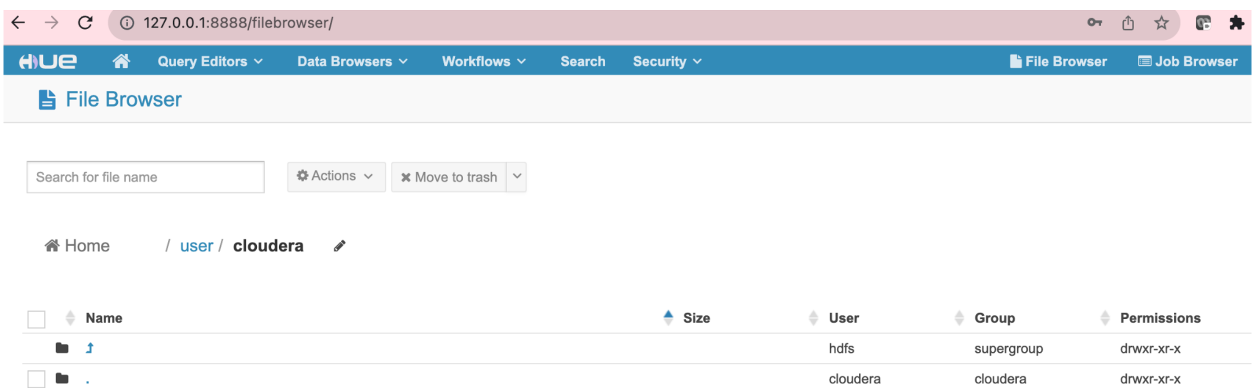
Physical Memory on device: 16GB

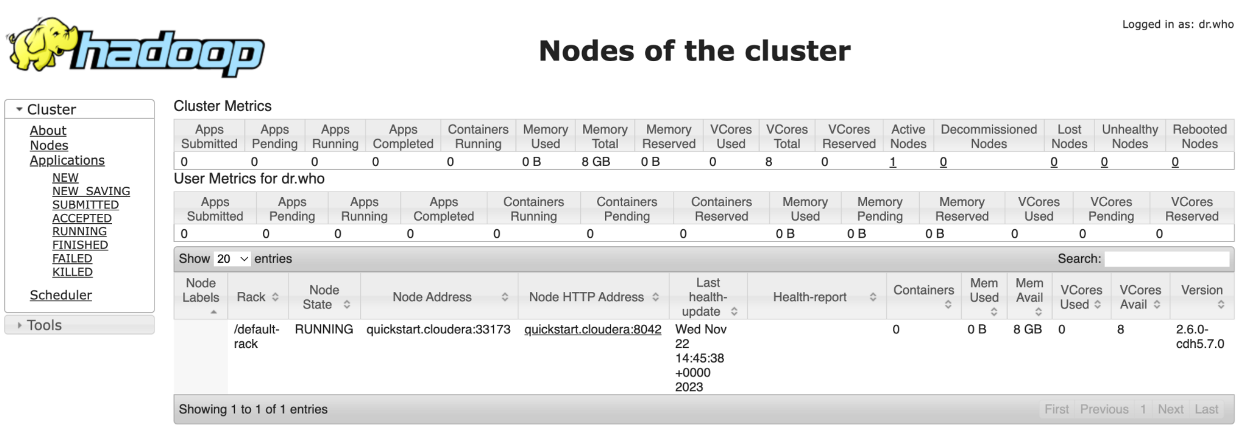
CDH Distribution Memory Occupance : 8 GB



1.2 Running the CDH Ecosystem and checking the Node of the cluster :-

The user interface of CDH is available at port 8888 with user credentials as **cloudera**.

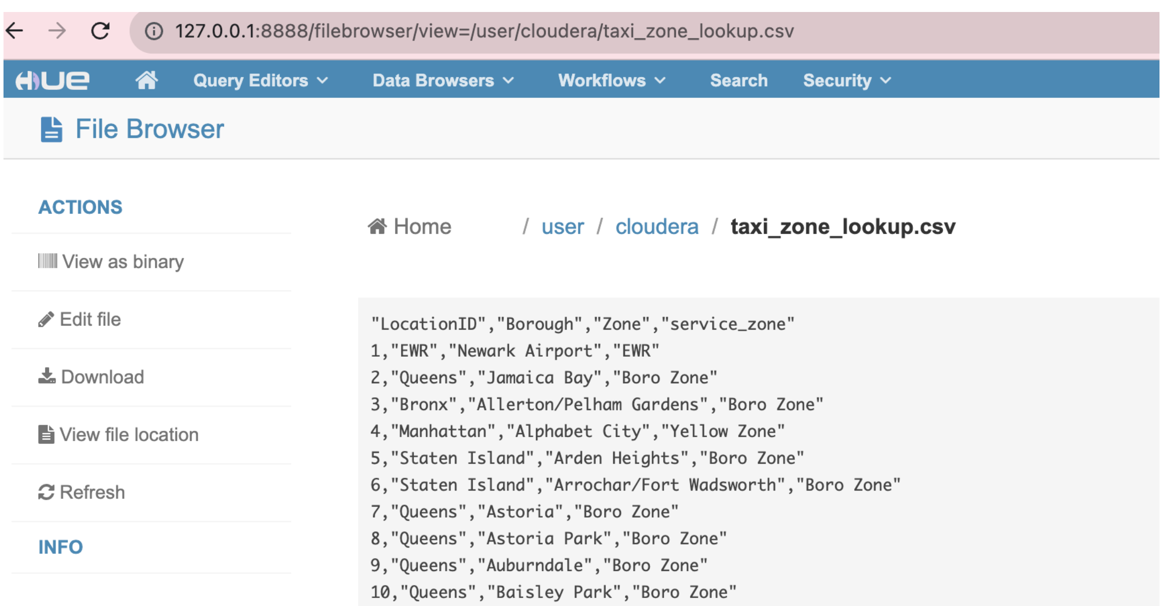




The fault-tolerant and distributed characteristics of the Hadoop Distributed File System (HDFS) are well-known. A client requests that a file be uploaded from the NameNode during a write operation. After confirming the file's existence and approving the upload, the NameNode points the client towards a DataNode to find out which server the block ought to be kept on. After that, the client uploads the file to the designated DataNode, sending the matching block to the DataNode server to finish the write request. When performing a read operation, the client applies to the NameNode in order to obtain metadata. The NameNode then locates the DataNode server in the cluster where the file is located and arbitrarily chooses one. There are various tools and technologies' interfaces available in this Ecosystem and we will look at a few of those.

Taking input data of yellow_taxi_cab and putting it on hdfs by using the put command:-

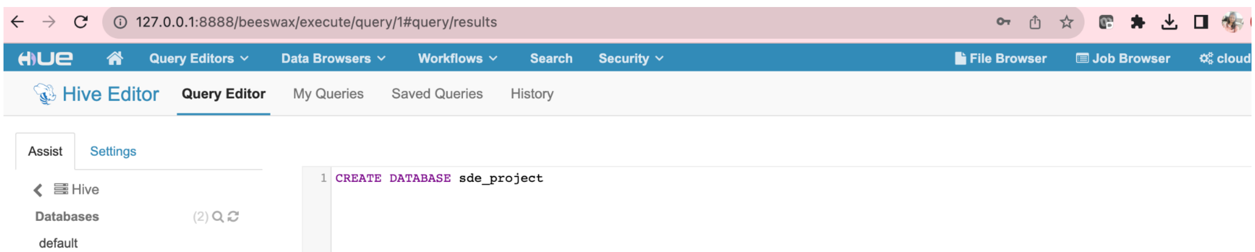
```
[root@quickstart /]#
[root@quickstart /]# hdfs dfs -put /user/sde_project/taxi_zone_lookup.csv /user/cloudera/
```

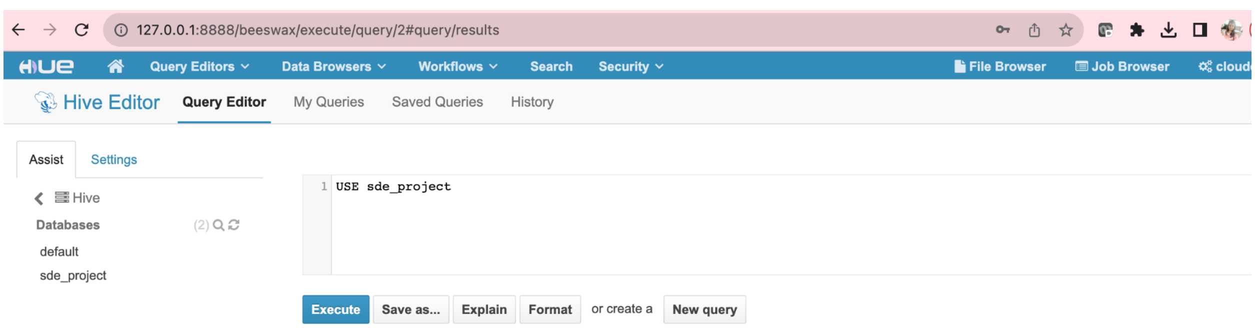


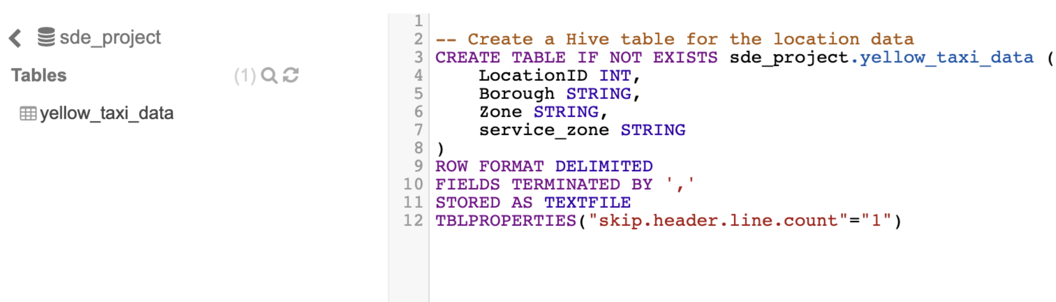
1.3 HIVE

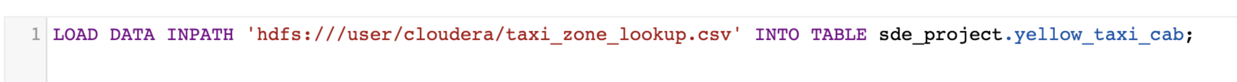
Hive, built upon Hadoop, functions as a data warehouse tool capable of transforming, loading, and extracting data. It serves as a mechanism for the storage, retrieval, and analysis of extensive datasets within Hadoop. The tool efficiently processes queries, swiftly generating query results. Similar to MySQL, Hive executes statements [10]. Upon user task submission, the compiler takes charge of the user's task. It retrieves metadata information from the meta-store, compiles the task, selects the optimal strategy, and ultimately delivers the results. The subsequent pseudocode outlines Hive's process for data transformation, loading, and extraction.

Creating a database and table to process the file using Hive :-



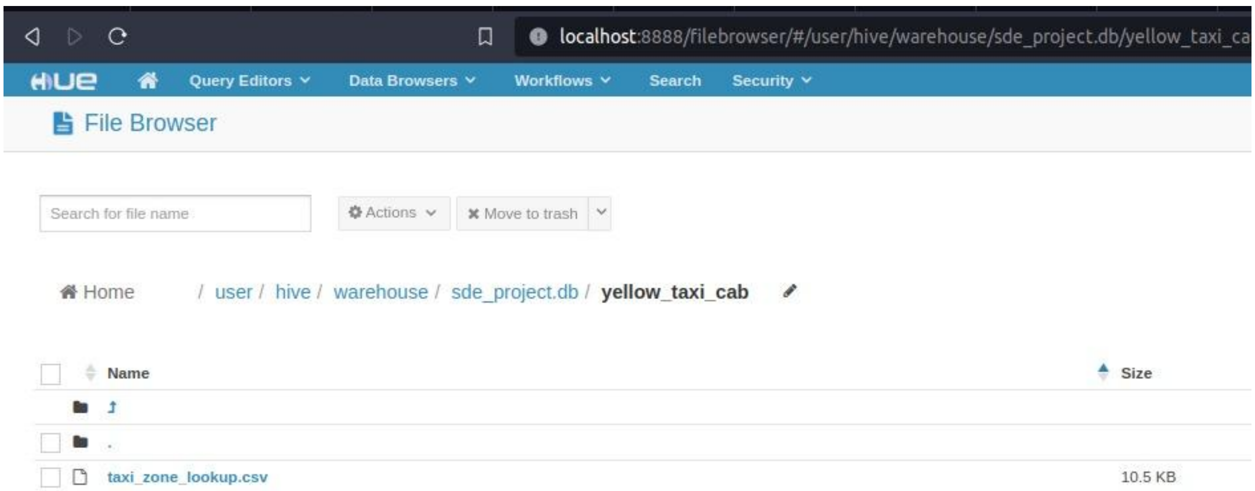




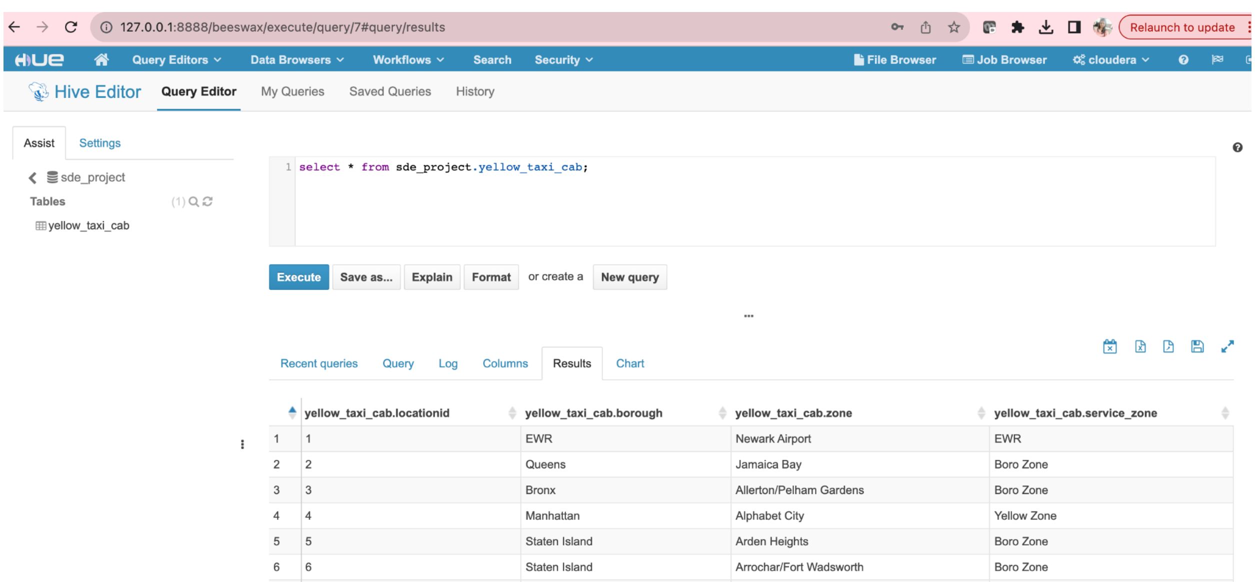


Why do files move from the Table's loading directory to the Hive Table directory? "- A Hive table can have data loaded from an HDFS (Hadoop Distributed File System) path using the LOAD DATA INPATH command. After running this command, the data files are moved into the Hive table directory in order to guarantee that Hive has management and control over the data inside the Hive table.

Hive integrates with the Hive Metastore to store table metadata, such as location and schema. Hive changes its metastore with the new data location when we load data into a table using LOAD DATA INPATH. Data is arranged by Hive within HDFS according to a particular directory layout. The HDFS directory that each Hive table usually relates to holds the data files that are related to that table.



Now checking if the data is available via performing queries on the table :-



1.4 Performing query that requires MapReduce task to be performed :-

```
SELECT Borough, COUNT(*) AS row_count FROM sde_project.yellow_taxi_cab GROUP BY Borough;
```

Execute | Save as... | Explain | Format | or create a | New query

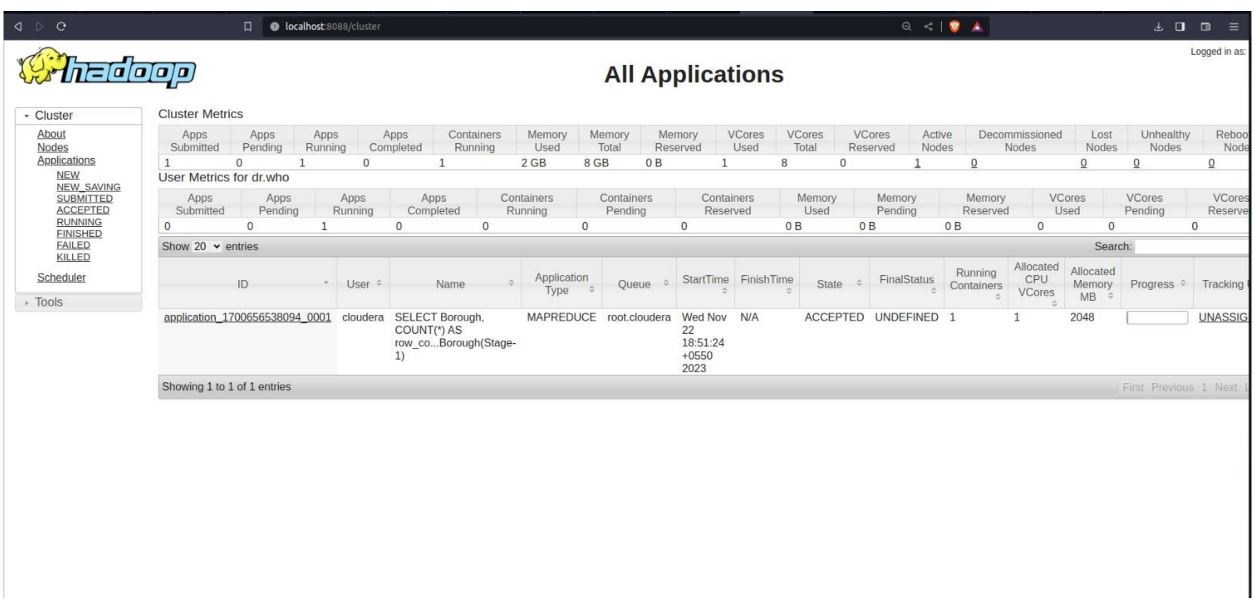
Recent queries | Query | Log | Columns | Results | Chart

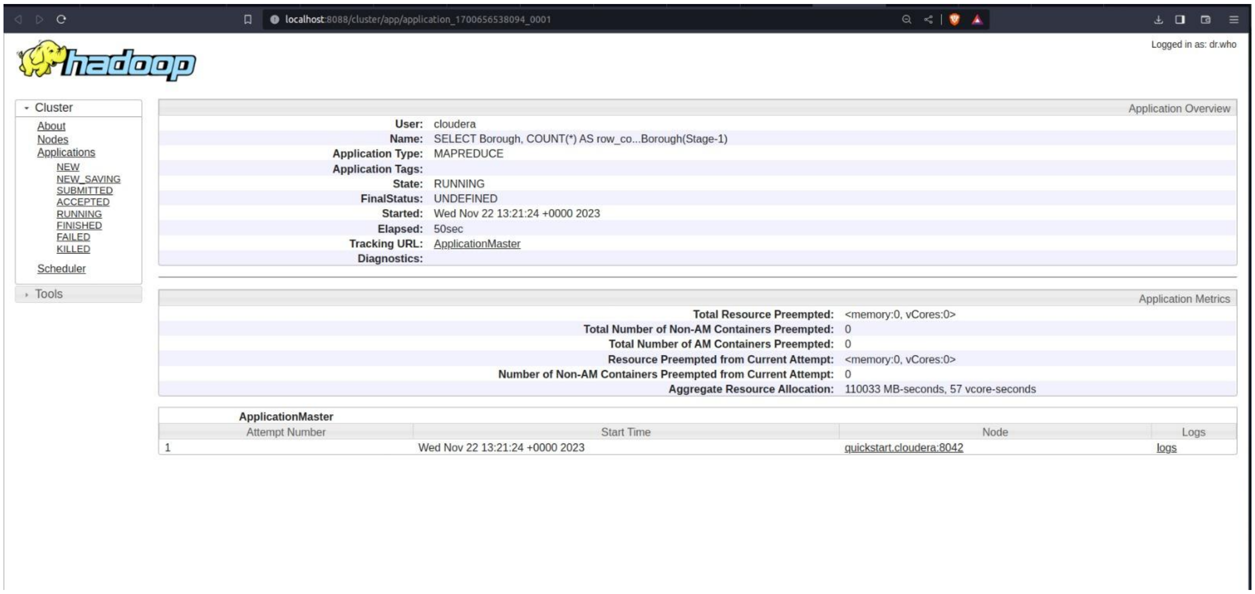
	borough	row_count
1	Bronx	43
2	Brooklyn	61
3	EWR	1
4	Manhattan	69
5	Queens	69
6	Staten Island	20

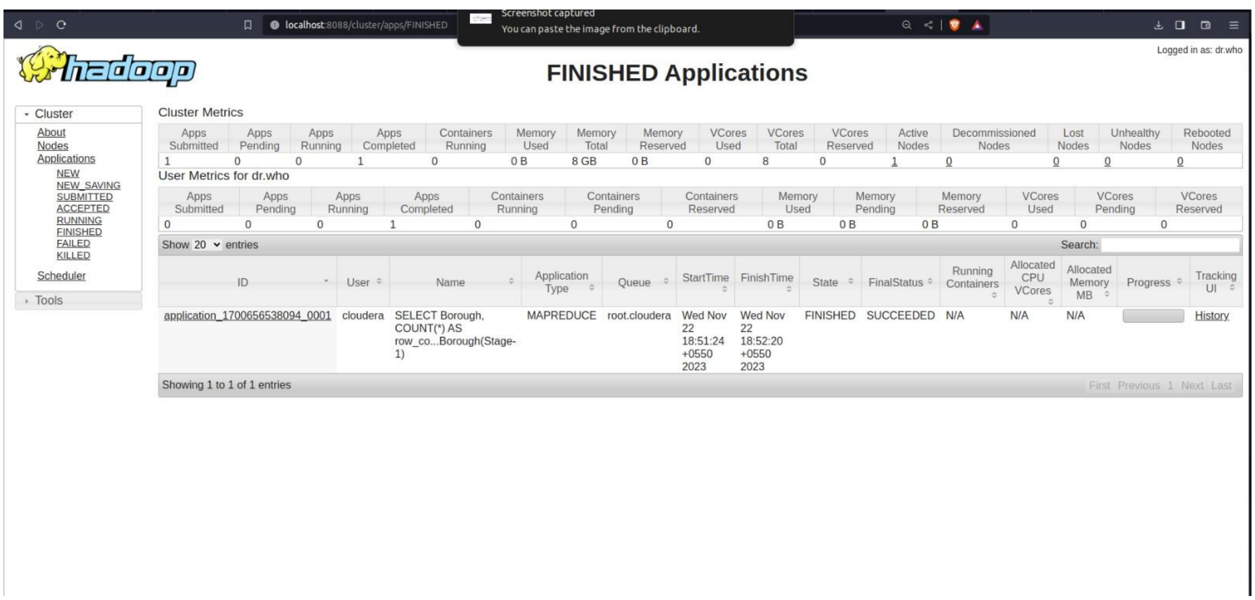
Behind the curtains tasks:-

Details about the Application Master in the process of executing a Hive query using MapReduce on a Cloudera Distribution for Hadoop (CDH) cluster:

1. **Query Submission**: The HiveServer assembles the Hive SQL query into a number of MapReduce jobs when we submit it.
2. **Job Submission**: The MapReduce jobs are submitted to the YARN ResourceManager.
3. **Application Master Creation**: YARN ResourceManager initiates an Application Master (AM) for every job that is submitted. The Application Master is in charge of negotiating resources with the ResourceManager, organizing the completion of tasks, and keeping track of the status of jobs.







4. **Application ID Creation**: The submitted query receives an Application ID from YARN that is specific to it and linked to the Application Master.
5. **Task Assignment and Execution**: Resources (containers) on different cluster nodes are negotiated by the Application Master in conjunction with the ResourceManager. After that, it assigns tasks—including map and reduce tasks—in collaboration with NodeManagers.
6. **Map Phase**: The map step involves reading data from HDFS and processing it concurrently throughout the cluster. Keys are used by the MapReduce system to sort and shuffle intermediate data.

7. **Reduce Phase**: The Application Master organizes the aggregation of intermediate data using keys during the reduction phase. The findings are written back to HDFS and the final output is generated.
8. **Task and Job Monitoring**: The Application Master keeps an eye on each task's development as well as the overall completion of the assignment. It updates status by communication with the ResourceManager.
9. **Job Completion**: The MapReduce job is concluded when the Application Master notifies the ResourceManager that all tasks have been successfully performed.
10. **History Server**: The history server holds comprehensive historical data, including as logs, counters, and other metadata, regarding finished MapReduce jobs. Performance analysis and troubleshooting can benefit from this information.

1.5 Oozie Workflows

Various other processing jobs can be done using the CDH but how do these tasks connect with each other? Answer is the Oozie workflows and coordinators of the CDH. Below is example:-

Task1. Workflow to create HDFS directories and files (action name : fs-12c7) :-

```
<workflow-app name="My_Workflow" xmlns="uri:oozie:workflow:0.5">
    <start to="fs-12c7"/>
    <kill name="Kill">
        <message>Action failed, error message[${wf:errorMessage(wf:lastErrorNode())}]</message>
    </kill>
    <action name="fs-12c7">
        <fs>
              <touchz path='${nameNode}/user/cloudera/test'/>
        </fs>
        <ok to="End"/>
        <error to="Kill"/>
    </action>
    <end name="End"/>
</workflow-app>
```

cloudera

STATUS

SUCCEEDED

PROGRESS

100%

ID

0000001-231122121616918-oozie-oozi-W

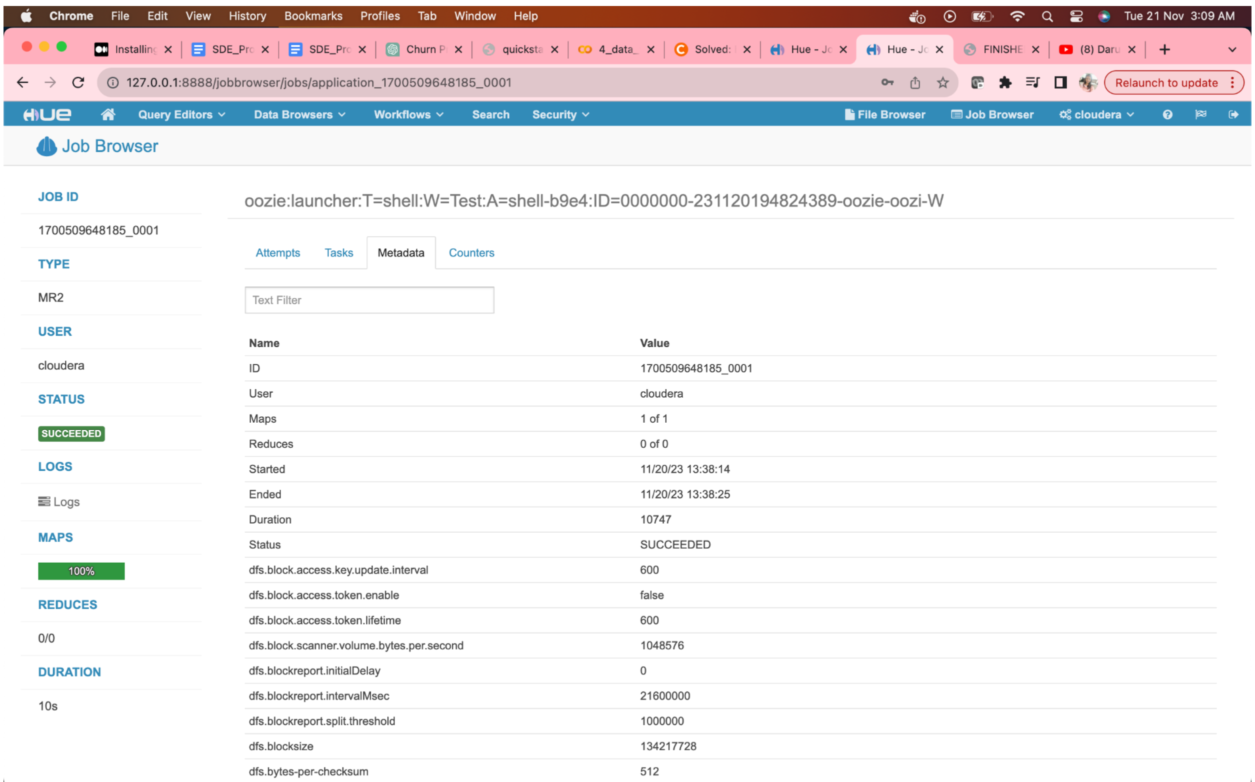
VARIABLES

Name	Value
dryrun	False
hue-id-w	3
jobTracker	localhost:8032
mapreduce.job.user.name	cloudera
nameNode	hdfs://quickstart.cloudera:8020
oozie.use.system.libpath	True
oozie.wf.application.path	hdfs://quickstart.cloudera:8020/user/hue/oozie/workspaces/hue-oozie-1700655912.35
security_enabled	False
user.name	cloudera

Back

Task2. Workflow to run shell script checking availability of file on hdfs :-

```
<workflow-app name="Test" xmlns="uri:oozie:workflow:0.5">
    <start to="shell-869a"/>
    <kill name="Kill">
        <message>Action failed, error message[${wf:errorMessage(wf:lastErrorNode())}]</message>
    </kill>
    <action name="shell-869a">
        <shell xmlns="uri:oozie:shell-action:0.1">
            <job-tracker>${jobTracker}</job-tracker>
            <name-node>${nameNode}</name-node>
            <exec>/user/cloudera/file_avail_check.sh</exec>
              <capture-output/>
        </shell>
        <ok to="End"/>
        <error to="Kill"/>
    </action>
    <end name="End"/>
</workflow-app>
```



Platform 2 : EDA on Local Machine

Now, let's look at one of the processes on the local machine platform and observe the memory occupancies.

We used a dataset called creditcard.csv for EDA. The primary objective of exploratory data analysis, a crucial stage of data analysis, is to enumerate the salient features, patterns, and connections found in a dataset. To comprehend the structure of the data, find any patterns or anomalies, and get insights into it, statistical and visual aids are used. EDA frequently comes first in the data analysis process and serves as a roadmap for later investigations.

EDA is done using two ways - with and without Profiling.

2.1 Traditional way using standard libraries, numpy, matplotlib, pandas, seaborn

Without pandas_profiling method:-

Steps performed:-

2.1.1 Data Cleaning:-

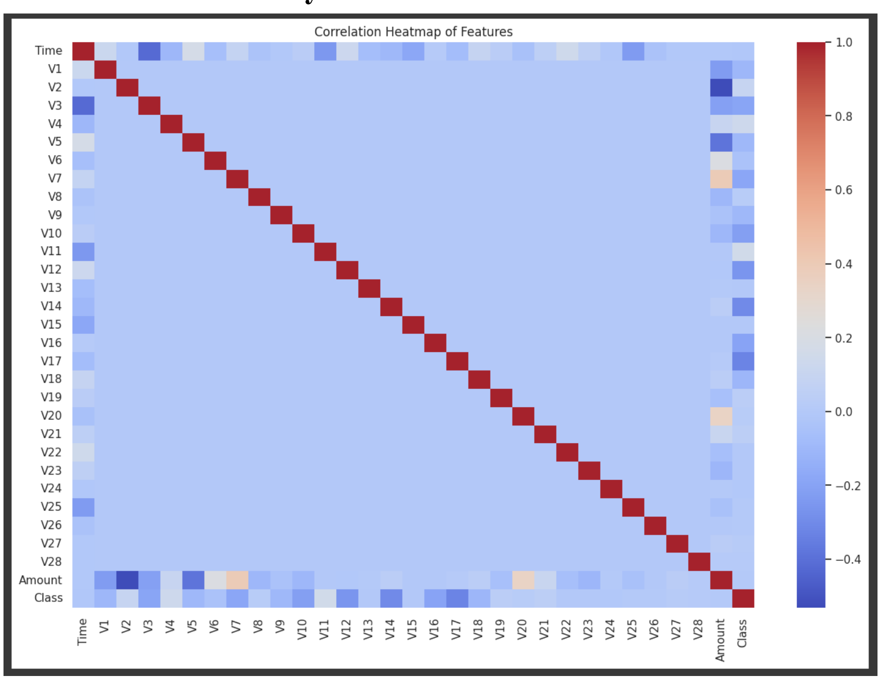
```
2 df.head()
```

	Time	V1	V2	V3	V4	V5	V6	V7	V8	V9	...	V21	V22	V23	V24	V25	V26	V27	V28	Amount	Class
0	0.0	-1.359807	-0.072781	2.536347	1.378155	-0.338321	0.462388	0.239599	0.098698	0.363787	...	-0.018307	0.277838	-0.110474	0.066928	0.128539	-0.189115	0.133558	-0.021053	149.62	0
1	0.0	1.191857	0.266151	0.166480	0.448154	0.060018	-0.082361	-0.078803	0.085102	-0.255425	...	-0.225775	-0.638672	0.101288	-0.339846	0.167170	0.125895	-0.008983	0.014724	2.69	0
2	1.0	-1.358354	-1.340163	1.773209	0.379780	-0.503198	1.800499	0.791461	0.247676	-1.514654	...	0.247998	0.771679	0.909412	-0.689281	-0.327642	-0.139097	-0.055353	-0.059752	378.66	0
3	1.0	-0.966272	-0.185226	1.792993	-0.863291	-0.010309	1.247203	0.237609	0.377436	-1.387024	...	-0.108300	0.005274	-0.190321	-1.175575	0.647376	-0.221929	0.062723	0.061458	123.50	0
4	2.0	-1.158233	0.877737	1.548718	0.403034	-0.407193	0.095921	0.592941	-0.270533	0.817739	...	-0.009431	0.798278	-0.137458	0.141267	-0.206010	0.502292	0.219422	0.215153	69.99	0

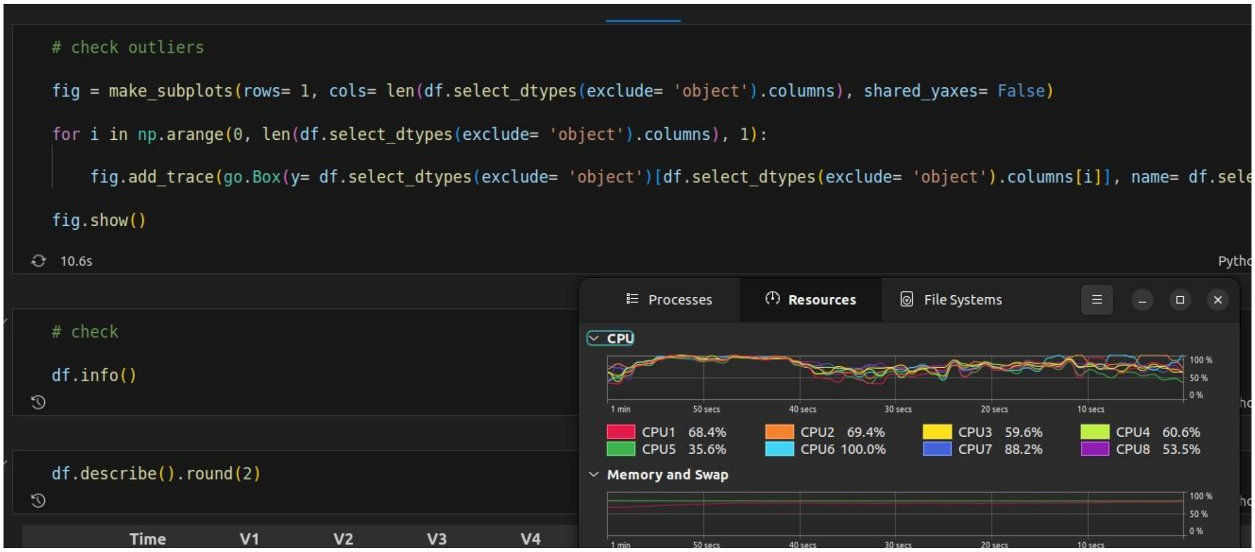
2.1.2 Understanding the Dataset:-

	Time	V1	V2	V3	V4	V5	V6	V7	V8	V9	...
count	283726.00	283726.00	283726.00	283726.00	283726.00	283726.00	283726.00	283726.00	283726.00	283726.00	...
mean	94811.08	0.01	-0.00	0.00	-0.00	0.00	-0.00	0.00	-0.00	-0.00	...
std	47481.05	1.95	1.65	1.51	1.41	1.38	1.33	1.23	1.18	1.10	...
min	0.00	-56.41	-72.72	-48.33	-5.68	-113.74	-26.16	-43.56	-73.22	-13.43	...
25%	54204.75	-0.92	-0.60	-0.89	-0.85	-0.69	-0.77	-0.55	-0.21	-0.64	...
50%	84692.50	0.02	0.06	0.18	-0.02	-0.05	-0.28	0.04	0.02	-0.05	...
75%	139298.00	1.32	0.80	1.03	0.74	0.61	0.40	0.57	0.33	0.60	...
max	172792.00	2.45	22.06	9.38	16.88	34.80	73.30	120.59	20.01	15.59	...

2.1.3 Correlation Analysis:-



2.1.4 CPU Utilization (All CPU cores are used at the same time):-



2.2 Using EDA library "dataprep" and profiling Method:-

2.2.1 Using the create_report method of dataprep to perform profiling.

Overview

Dataset Statistics

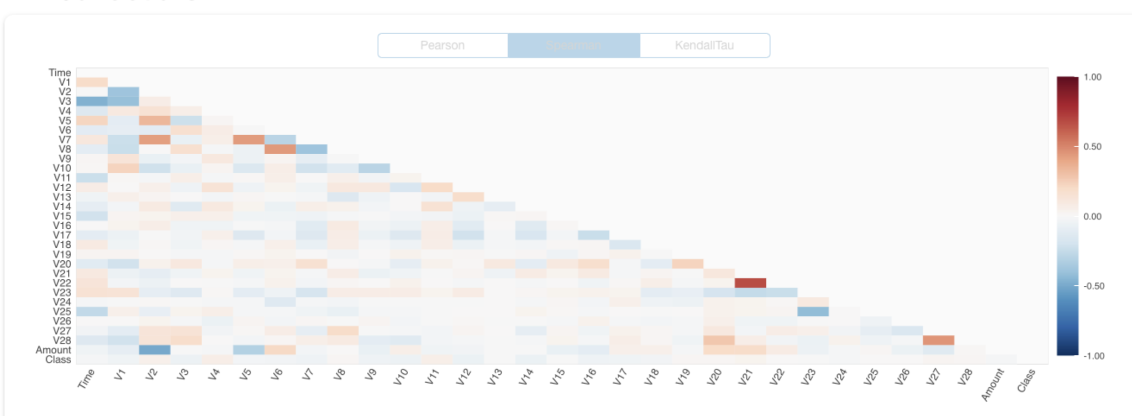
Number of Variables	31
Number of Rows	284807
Missing Cells	0
Missing Cells (%)	0.0%
Duplicate Rows	1081
Duplicate Rows (%)	0.4%
Total Size in Memory	67.4 MB
Average Row Size in Memory	248.0 B
Variable Types	Numerical: 30 Categorical: 1

Dataset Insights

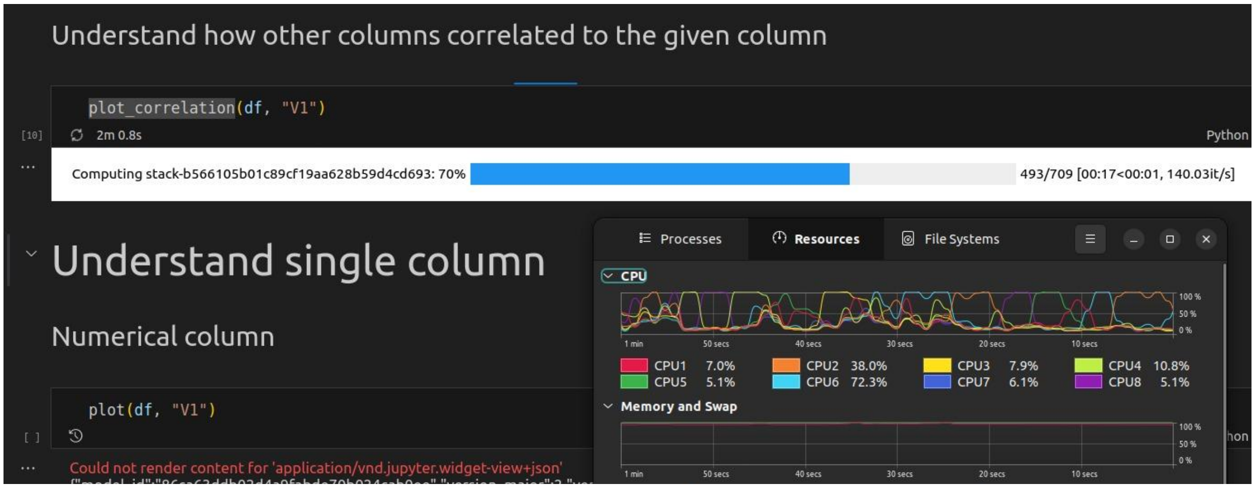
V4 and V5 have similar distributions	Similar Distribution
V4 and V13 have similar distributions	Similar Distribution
V5 and V9 have similar distributions	Similar Distribution
V5 and V11 have similar distributions	Similar Distribution
V5 and V13 have similar distributions	Similar Distribution
V7 and V15 have similar distributions	Similar Distribution
V7 and V16 have similar distributions	Similar Distribution
V7 and V19 have similar distributions	Similar Distribution
V9 and V11 have similar distributions	Similar Distribution
V9 and V13 have similar distributions	Similar Distribution

1 2 3 4 5 6 7

Correlations



2.2.2 CPU Utilisation after data profiling:-



2.3 CPU Utilization is reduced in every single core.

Below are the inferences:-

CPU Core	EDA with dataprep in %	EDA with standard lib in %
Core 1	7	68.4
Core 2	38	69.4
Core 3	7.9	59.6
Core 4	10.8	60.6
Core 5	5.1	35.6
Core 6	72.3	100
Core 7	6.1	88.2
Core 8	5.1	53.5
Average	19.0375	66.9125

Conclusion:

This study set out to conduct a thorough investigation of large data using the local machine Exploratory Data Analysis (EDA) and CDH platform architecture as lenses. The need for strong big data ecosystems is highlighted by the rise in the world's capacity for data storage, as reported by IDC. A practical overview of CDH, local machine EDA was given, emphasizing the subtle differences in the processing methods used by each platform. The flexibility of big data processing was demonstrated by the integration of Hadoop tools, the Hive data warehouse, and Oozie workflows in CDH. Conventional libraries and profiling techniques were used in local machine EDA, showing different CPU utilization. The project offers a comprehensive overview of big data platforms and tools, setting the groundwork for upcoming initiatives in the rapidly changing fields of data engineering and analytics.

CODE LINK:-

https://github.com/Bhawna-Bhoria/SDE_Project

References:-

https://blog.clairvoyantsoft.com/cloduera-quickstart-vm-using-docker-on-mac-2308acd196f2
https://cwiki.apache.org/confluence/display/Hive/LanguageManual+DDL
https://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=9463522&tag=1
https://github.com/sfu-db/dataprep