Wine Quality Prediction with Spark on AWS

Overview

This project implements a wine quality prediction ML model using Apache Spark on AWS EMR. The model is trained in parallel on 4 EC2 instances and deployed for prediction on a single instance, both with and without Docker.

Assignment Requirements

- **Training**: Train a model on TrainingDataset.csv using 4 EC2 instances.
- **Validation**: Evaluate and tune the model using ValidationDataset.csv.
- **Prediction**: Perform predictions on a single EC2 instance, outputting the F1 score
    - Model used Logistic Regression.
- **Docker**: Containerize the prediction app for easy deployment.
- **Implementation**: Java, Ubuntu Linux, Spark MLlib.

Important Link:

- **GitHub Repo**: click here.
- **Docker Hub**: click_here.

Project Structure

- WineTrainApp.java: Training application code (Logistic Regression).
- WinePredictApp.java: Prediction application code.
- pom.xml: Maven configuration.
- Dockerfile: Docker setup for prediction app.
- README.md: Instruction to setup the project

Technologies Used:

- **Apache Spark**: For distributed data processing and machine learning.
- **Amazon AWS (EMR, S3):** To train models in a distributed cluster environment.
- **Docker:** To package the prediction application into a container.

Development Setup:

Desktop Setup - Windows :

Step 1 : Install or update Java

- Install oracle jdk 8 or openjdk 8 and configure the JAVA_HOME environment variable.
- update PATH variable to %JAVA_HOME%\bin; JAVA_HOME: PATH:
- open the command prompt and check the java version to verify the installation.

```
Microsoft Windows [Version 10.0.26100.3915]
(c) Microsoft Corporation. All rights reserved.

C:\Users\Vishal>java -version
java version "21" 2023-09-19 LTS
Java(TM) SE Runtime Environment (build 21+35-LTS-2513)
Java HotSpot(TM) 64-Bit Server VM (build 21+35-LTS-2513, mixed mode, sharing)

C:\Users\Vishal>
```

Step 2 : Install Maven

- Get it from official site: https://maven.apache.org/download.cgi
- Download the binary zip archive (e.g., apache-maven-3.9.6-bin.zip).
- Extract the ZIP file to a location, e.g., C:\apache-maven-3.9.6
- Under System Variables:
  Click New:
  - Variable name: MAVEN_HOME
  - Variable value: C:\apache-maven-3.9.6
- Update the Path variable:
  - Edit the Path variable in System Variables and Add "C:\apache-maven-3.9.6\bin"
- Verify installation of Maven using mvn –version command.

```
C:\Users\Vishal>mvn --version
Apache Maven 3.9.9 (8e8579a9e76f7d015ee5ec7bfcdc97d260186937)
Maven home: C:\Program Files\Apache\Maven\apache-maven-3.9.9-bin\apache-maven-3.9.9
Java version: 21, vendor: Oracle Corporation, runtime: C:\Program Files\Java\jdk-21
Default locale: en_US, platform encoding: UTF-8
OS name: "windows 11", version: "10.0", arch: "amd64", family: "windows"

C:\Users\Vishal>
```

Step 3 : Create Project Using Maven

Commands:

- mkdir CC-CS643-Prgm-Assgn-2
- cd CC-CS643-Prgm-Assgn-2
- mvn archetype:generate -DgroupId=com.wine -DartifactId=wine-ml-spark -DarchetypeArtifactId=maven-archetype-quickstart -DinteractiveMode=false
- cd wine-ml-spark

Step 4 : Crated the following java files in src\main\java\com\wine

- **WinePrediction.java – To train and save model**

- **WinePredictApp.java – To evaluate saved model**

Lot of additional files were created/updated like POM file, Dockerfile, etc everything is available on GitHub Repo.

Step 5 : Build the Project

- mvn clean package : will Output: JAR in target/wine-ml-spark-1.0-SNAPSHOT.jar

Step 6 : Push everything on github

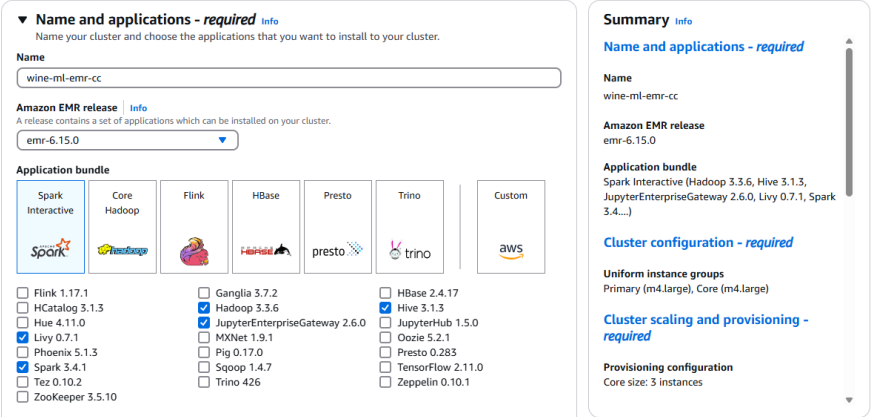
Cloud Setup :

1 : Create an EMR Cluster :

Step 1 : Enter basic Information:

- Give cluster Name
- Select the Amazon EMR Release as emr—6.15.0 (stable version)
- Check services like spark, Hadoop, Hive (all other are optional)

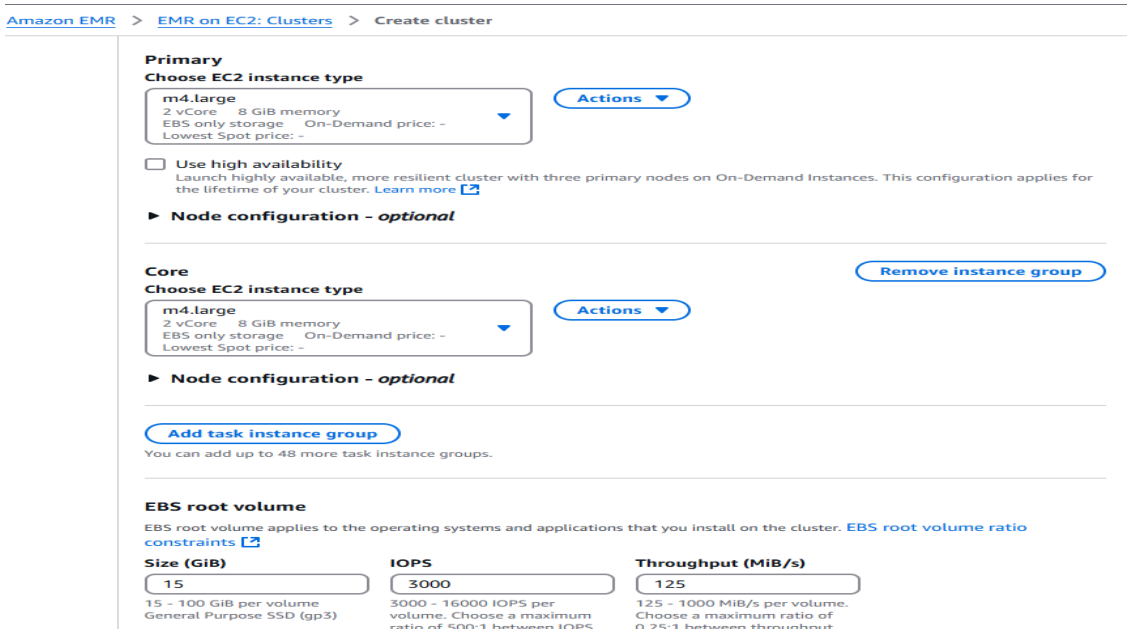
Snippet:



Step 2 : Cluster Configuration:

- Primary Node : Select node type m4.large
- Core Node : Select node type m4.large
- Keep EBS volume as default which is 15 GiB
- Remove Spot node section (Not needed)
- Give core count node as 3 (Total 4 nodes 3 core and 1 master)

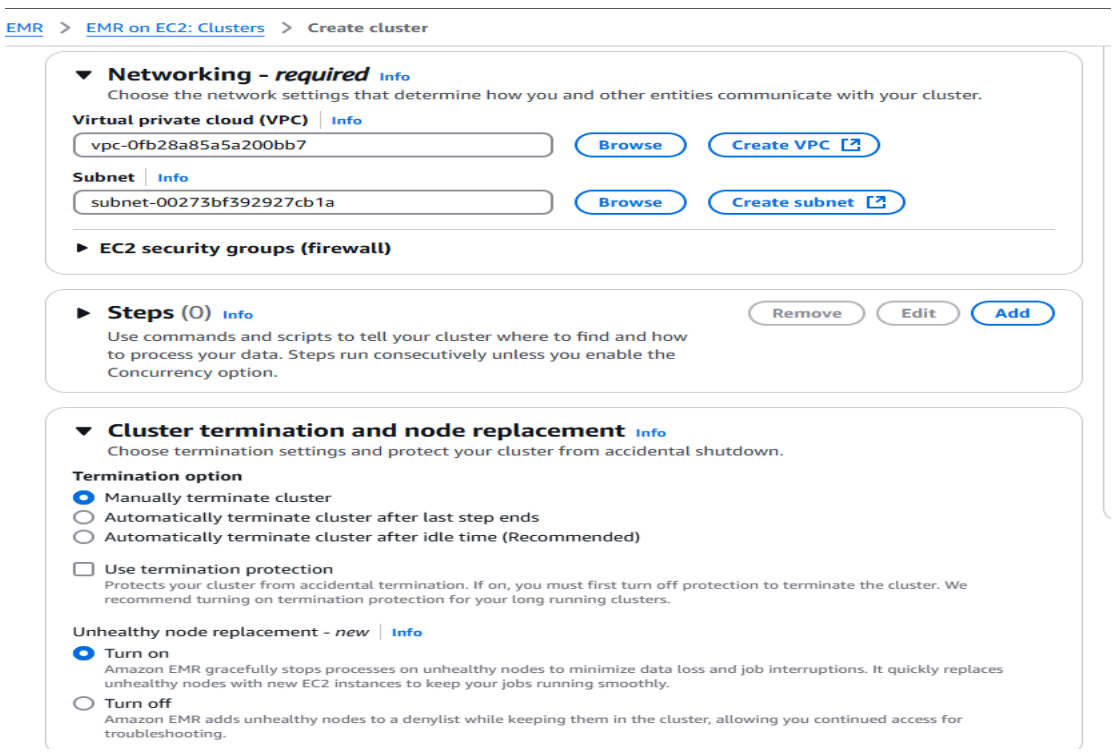
Snippet:



Step 3 : Networking Requirement & Cluster termination criteria:

- **Select the default VPC and subnet in networking.**
- **Keep cluster termination criteria as default.**

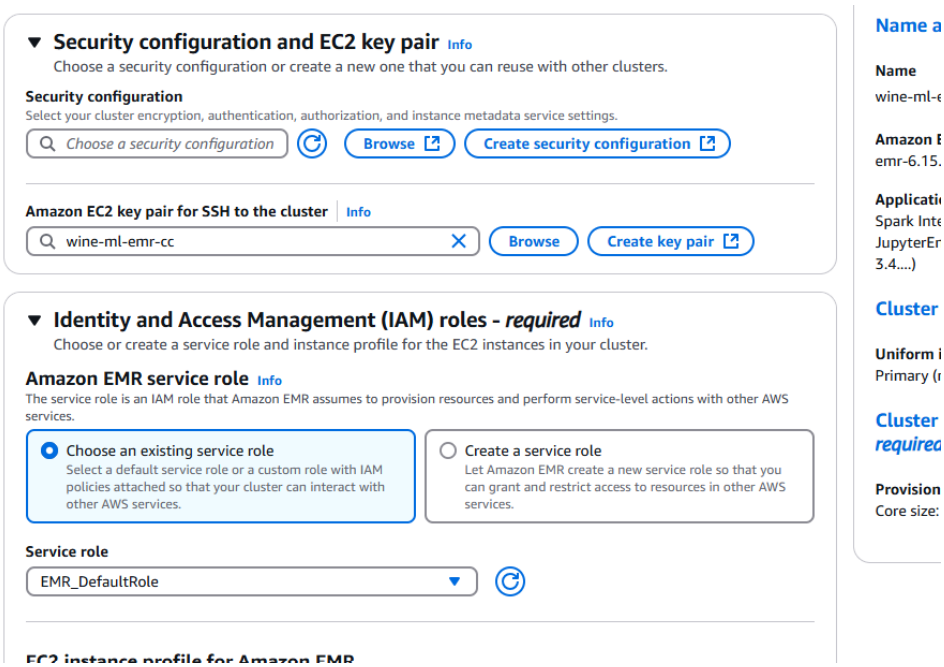
Snippet:



Step 4 :Create an EC2 Pair and Amazon EMR Service Role:

- **Create a new EC2 pair and save it as .pem file**
- **Use default EMR_defaultRole**

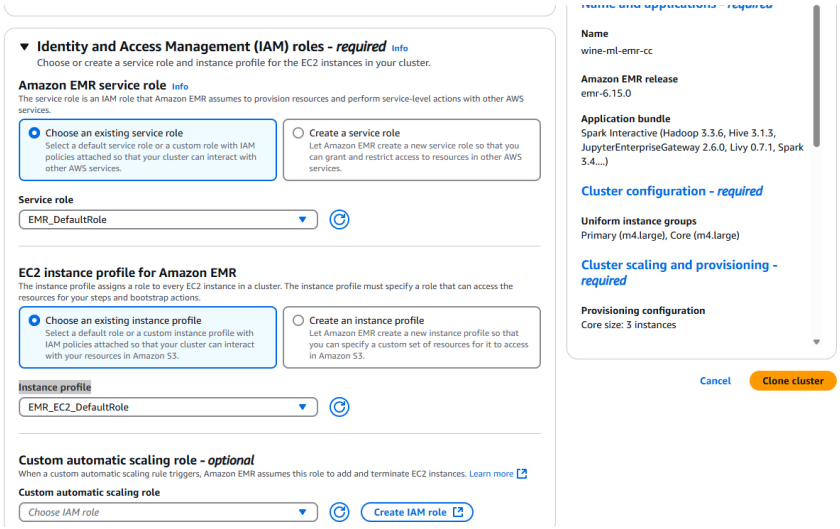
Snippet:



Step 5 : Select default EC2 instance profile for Amazon EMR:

- Select default Instance profile “EMR_EC2_DefaultRole”
- After this select create cluster

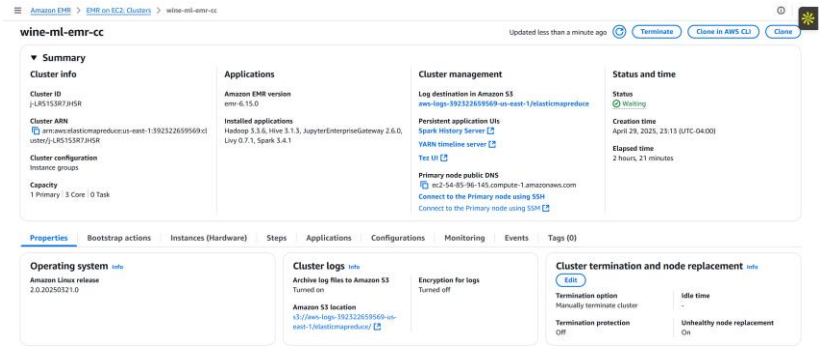
Snippet:



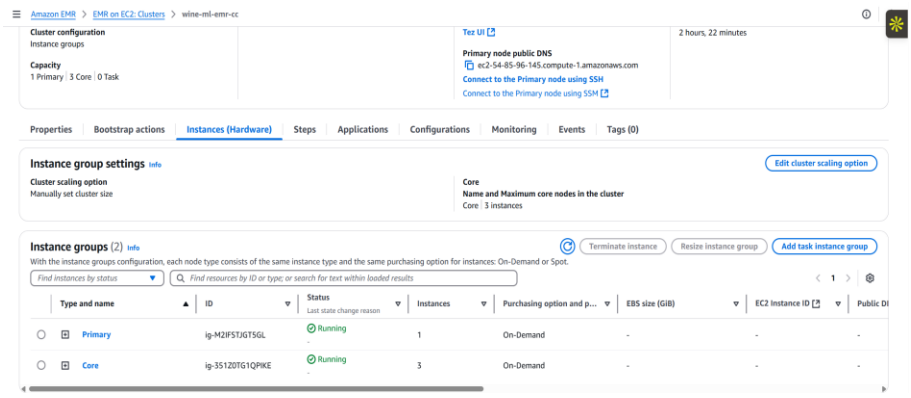
Note : Select only the required field, we can skip the optional setting, after creating cluster will go in creating state for 10 mins then it should go in waiting state, this is when cluster is ready to be used.

This is how cluster will look like once it's available:

Snippet of Cluster Info :



Snippet of Cluster Hardware :



2 : Create an S3 Bucket and upload the required files :

- Created a S3 bucket with Bucket name wine-ml-bucket-vk722
- Put name and basic details and Click create bucket
- Upload following Files to S3

  Steps to Upload:

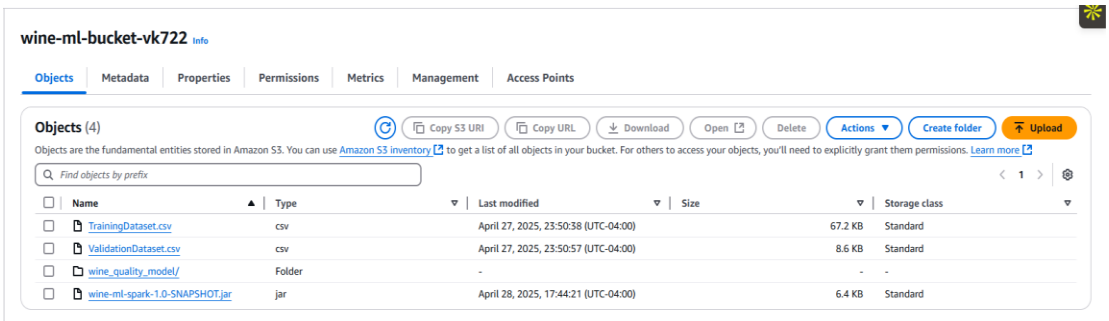
  - Select the bucket and click "Upload".
  - Drag and drop the files or browse to select them.
  - Confirm upload by clicking "Upload".

Uploaded following files:

- **TrainingDataset.csv** – Training dataset
- **ValidationDataset.csv** – Validation Dataset

  image file

Snippet of uploaded files:

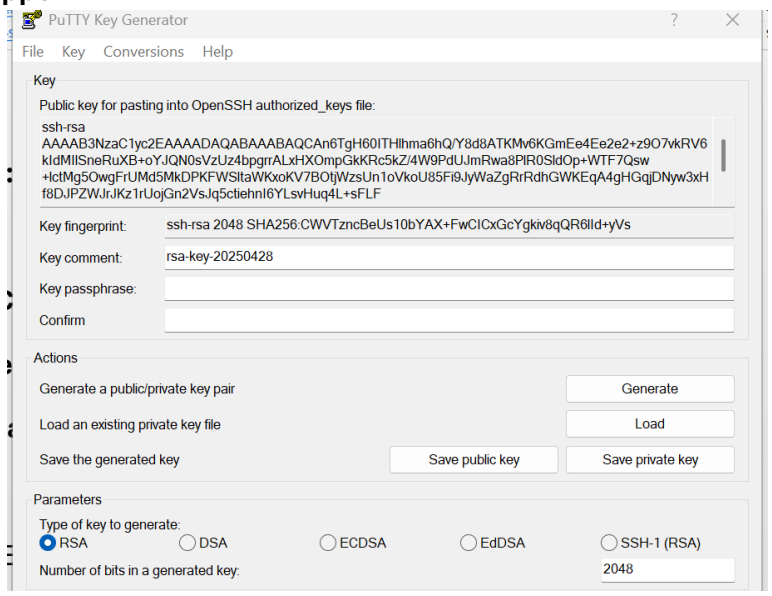


Initial Setup on Cloud:

1.Generate the Private Key(.ppk) using PuttyGen:

- Conver the .pem file to .ppk file using PuttyGen
- Click Load and upload the .pem file of EMR cluster
- Then click on Save Private key, will create .ppk file

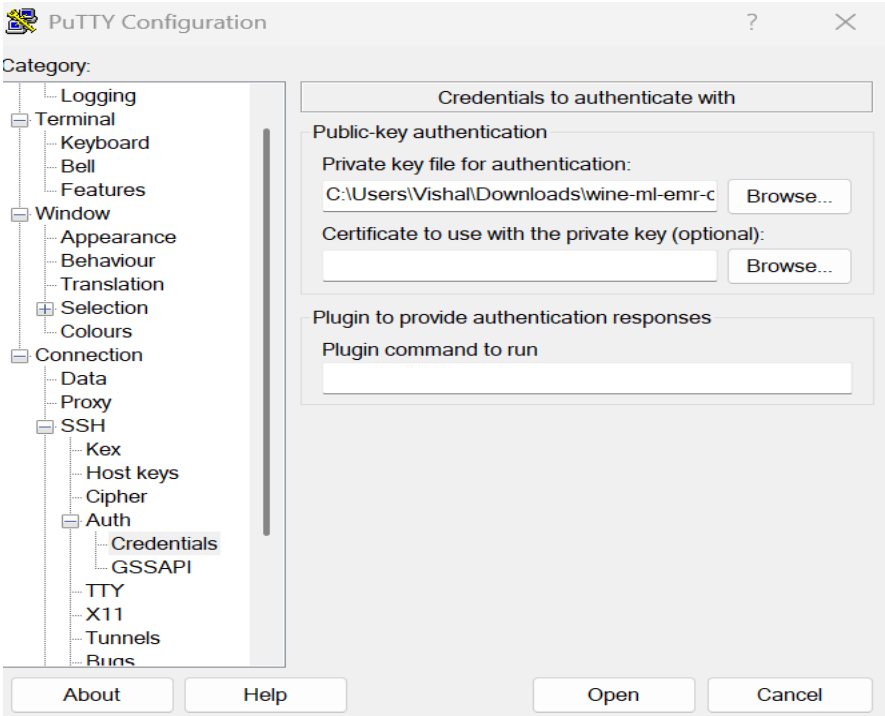
Snippet:



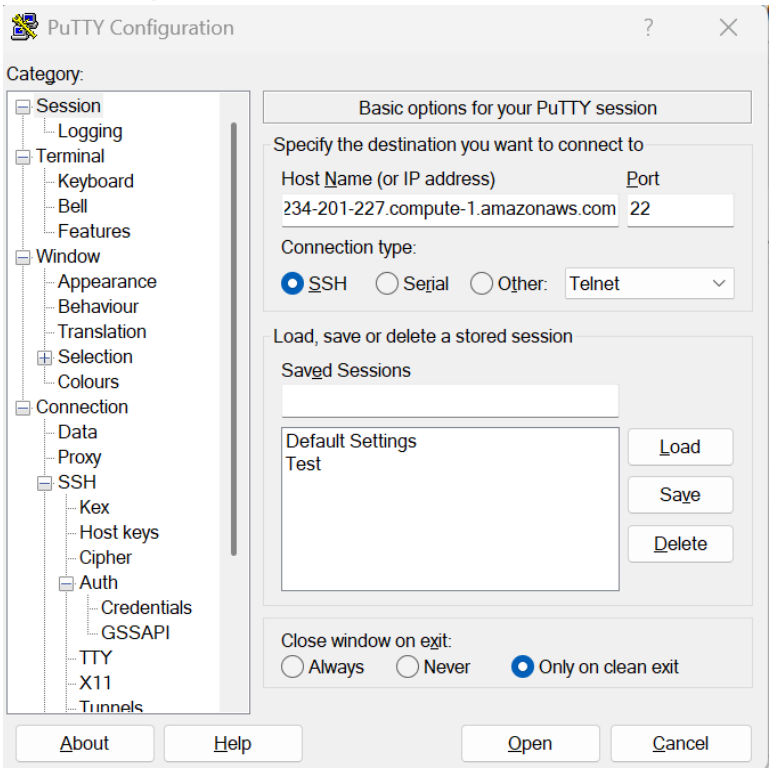
2. Connect to EMR Cluster using Putty :

- Click on Connection then SHH then Auth and load .ppk file created in step 1

Snippet:



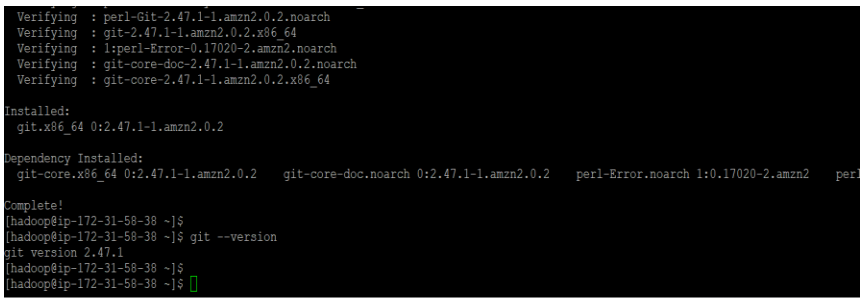
- After that enter the hostname of primary node of your EMR cluster in Hostname in putty e.g hostname **:** **hadoop@ec2-34-234-201-227.compute-1.amazonaws.com**
- After that click on open



- After connecting to Cluster, it should look like the snippet below:

3.Install necessary things which we need throughout project on EMR cluster:

1. **Install git on EMR Cluster & Versify Version:**
   Run below commands one by one
   - sudo yum update -y
   - sudo yum install git -y
   - git --version



2. **Install Docker & Versify Version:**
   Run below commands one by one
   - sudo amazon-linux-extras enable docker
   - sudo yum install docker -y
   - sudo service docker start
   - sudo usermod -aG docker hadoop
   - sudo docker info

```
[hadoop@ip-172-31-58-38 CC-CS643-Prgm-Assgn-2-]$ sudo docker info
Client:
 Version:    25.0.8
 Context:    default
 Debug Mode: false
 Plugins:
  buildx: Docker Buildx (Docker Inc.)
    Version:  0.12.1
    Path:     /usr/libexec/docker/cli-plugins/docker-buildx

Server:
 Containers: 0
  Running: 0
  Paused: 0
  Stopped: 0
 Images: 0
 Server Version: 25.0.8
 Storage Driver: overlay2
  Backing Filesystem: xfs
  Supports d_type: true
  Using metacopy: false
  Native Overlay Diff: true
  userxattr: false
 Logging Driver: json-file
 Cgroup Driver: cgroupfs
 Cgroup Version: 1
 Plugins:
  Volume: local
  Network: bridge host ipvlan macvlan null overlay
  Log: awslogs fluentd gcplogs gelf journald json-file local splunk syslog
 Swarm: inactive
 Runtimes: io.containerd.runc.v2 runc
 Default Runtime: runc
 Init Binary: docker-init
 containerd version: 05044ec0a9a75232cad458027ca83437aae3f4da
 runc version: 6c52b3fc541fb26fe8c374d5f58112a0a5dbda66
 init version: de40ad0
 Security Options:
  seccomp
    Profile: builtin
 Kernel Version: 4.14.355-275.603.amzn2.x86_64
 Operating System: Amazon Linux 2
 OSType: linux
 Architecture: x86_64
 CPUs: 2
 Total Memory: 7.775GiB
 Name: ip-172-31-58-38
 ID: 9455685f-7c2d-4987-bdb5-36c1abdae06f
 Docker Root Dir: /mnt/var/lib/docker
 Debug Mode: false
 Experimental: false
 Insecure Registries:
  127.0.0.0/8
```

3. Login to Docker Hub**:**
   - Run below command and enter the Docker hub credentials:
     command : sudo docker login

```
Username: vishalk722
Password:
WARNING! Your password will be stored unencrypted in /home/hadoop/.docker/config.json.
Configure a credential helper to remove this warning. See
https://docs.docker.com/engine/reference/commandline/login/#credentials-store

Login Succeeded
[hadoop@ip-172-31-58-38 CC-CS643-Prgm-Assgn-2-]$
```

Running the Project-Step by Step Guide:

1. Now Clone the Git Hub Repo on EMR Cluster:

- git clone https://github.com/vishal2609/CC-CS643-Prgm-Assgn-2-.git

```
[hadoop@ip-172-31-63-75 ~]$ git clone https://github.com/vishal2609/CC-CS643-Prgm-Assgn-2-.git
Cloning into 'CC-CS643-Prgm-Assgn-2-'...
remote: Enumerating objects: 103, done.
remote: Counting objects: 100% (103/103), done.
remote: Compressing objects: 100% (53/53), done.
remote: Total 103 (delta 22), reused 102 (delta 21), pack-reused 0 (from 0)
Receiving objects: 100% (103/103), 649.66 KiB | 19.69 MiB/s, done.
Resolving deltas: 100% (22/22), done.
[hadoop@ip-172-31-63-75 ~]$
```

2. Give permission to the folder :

- chmod 777 CC-CS643-Prgm-Assgn-2-/

```
CC-CS643-Prgm-Assgn-2-
[hadoop@ip-172-31-63-75 ~]$ chmod 777 CC-CS643-Prgm-Assgn-2-/
[hadoop@ip-172-31-63-75 ~]$ ls
CC-CS643-Prgm-Assgn-2-
[hadoop@ip-172-31-63-75 ~]$
```

3. Change directory to CC-CS643-Prgm-Assgn-2-

- cd CC-CS643-Prgm-Assgn-2-/

```
[hadoop@ip-172-31-63-75 ~]$ cd CC-CS643-Prgm-Assgn-2-/
[hadoop@ip-172-31-63-75 CC-CS643-Prgm-Assgn-2-]$ ls
DOCKERFILE  pom.xml  README.md  screenshots  src  target
[hadoop@ip-172-31-63-75 CC-CS643-Prgm-Assgn-2-]$
```

4. Submitting Spark Job For Parallel Training

Command:

```
spark-submit \
 --class com.wine.WinePrediction \
 --master yarn \
 --deploy-mode cluster \
 --num-executors 4 \
 --executor-cores 2 \
 --executor-memory 2G \
 target/wine-ml-spark-1.0-SNAPSHOT.jar
```

Snippet:

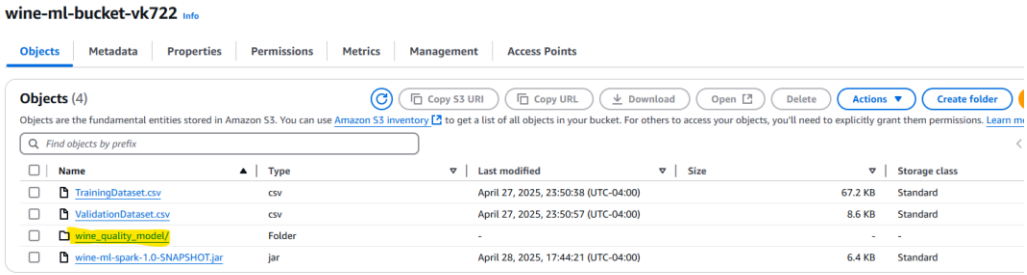
```
[hadoop@ip-172-31-48-14 CC-CS643-Prgm-Assgn-2-]$ spark-submit \
>   --class com.wine.WinePrediction \
>   --master yarn \
>   --deploy-mode cluster \
>   --num-executors 4 \
>   --executor-cores 2 \
>   --executor-memory 2G \
>   target/wine-ml-spark-1.0-SNAPSHOT.jar

25/04/30 21:39:22 WARN NativeCodeLoader: Unable to load native-hadoop library for your platform... using builtin-java classes where applicable
25/04/30 21:39:23 INFO DefaultNoHARMFailoverProxyProvider: Connecting to ResourceManager at ip-172-31-48-14.ec2.internal/172.31.48.14:8032
25/04/30 21:39:24 INFO Configuration: resource-types.xml not found
25/04/30 21:39:24 INFO ResourceUtils: Unable to find 'resource-types.xml'.
25/04/30 21:39:24 INFO Client: Verifying our application has not requested more than the maximum memory capability of the cluster (6144 MB per container)
25/04/30 21:39:24 INFO Client: Will allocate AM container, with 2432 MB memory including 384 MB overhead
25/04/30 21:39:24 INFO Client: Setting up container launch context for our AM
25/04/30 21:39:24 INFO Client: Setting up the launch environment for our AM container
25/04/30 21:39:24 INFO Client: Preparing resources for our AM container
25/04/30 21:39:24 WARN Client: Neither spark.yarn.jars nor spark.yarn.archive is set, falling back to uploading libraries under SPARK_HOME.
```

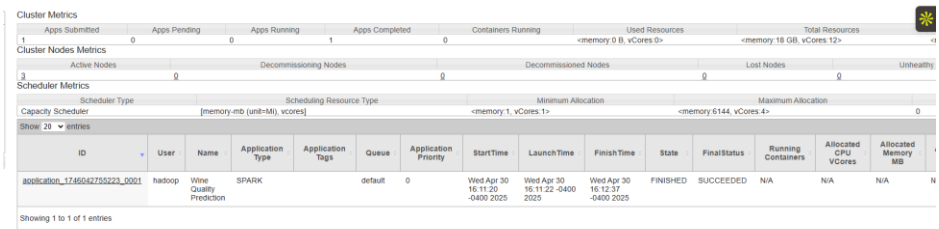
```
25/04/30 21:41:05 INFO Client: Application report for application_1746042755223_0004 (state: RUNNING)
25/04/30 21:41:06 INFO Client: Application report for application_1746042755223_0004 (state: RUNNING)
25/04/30 21:41:07 INFO Client: Application report for application_1746042755223_0004 (state: RUNNING)
25/04/30 21:41:08 INFO Client: Application report for application_1746042755223_0004 (state: RUNNING)
25/04/30 21:41:09 INFO Client: Application report for application_1746042755223_0004 (state: RUNNING)
25/04/30 21:41:10 INFO Client: Application report for application_1746042755223_0004 (state: FINISHED)
25/04/30 21:41:10 INFO Client:
         client token: N/A
         diagnostics: N/A
         ApplicationMaster host: ip-172-31-59-217.ec2.internal
         ApplicationMaster RPC port: 44331
         queue: default
         start time: 1746049174307
         final status: SUCCEEDED
         tracking URL: http://ip-172-31-48-14.ec2.internal:20888/proxy/application_1746042755223_0004/
         user: hadoop
25/04/30 21:41:10 INFO ShutdownHookManager: Shutdown hook called
25/04/30 21:41:10 INFO ShutdownHookManager: Deleting directory /mnt/tmp/spark-bb3b1a75-7dbc-4e38-96f7-bddaf728d82d
25/04/30 21:41:10 INFO ShutdownHookManager: Deleting directory /mnt/tmp/spark-b5edc5b2-6d58-4f81-b5f3-5a4c57f97afd
```

5. Confirm the model is saved on s3:

Snippet:



Yarn log of stating job ran on 4 nodes in parallel setup – 3 Core and 1 Master



6. Running Prediction without Docker on EMR cluster:

Command:

```
spark-submit \
 --class com.wine.WinePredictApp \
 --master yarn \
 target/wine-ml-spark-1.0-SNAPSHOT.jar
```

Snippet:

```
[hadoop@ip-172-31-48-14 CC-CS643-Prgm-Assgn-2-]$ spark-submit \
>   --class com.wine.WinePredictApp \
>   --master yarn \
>   target/wine-ml-spark-1.0-SNAPSHOT.jar

25/04/30 20:19:26 INFO SparkContext: Running Spark version 3.4.1-amzn-2
25/04/30 20:19:27 INFO ResourceUtils: ==============================================================
25/04/30 20:19:27 INFO ResourceUtils: No custom resources configured for spark.driver.
25/04/30 20:19:27 INFO ResourceUtils: ==============================================================
25/04/30 20:19:27 INFO SparkContext: Submitted application: Wine Quality Prediction - Prediction Phase
25/04/30 20:19:27 INFO ResourceProfile: Default ResourceProfile created, executor resources: Map(cores -> name: cores, amount: 4, script: ,
Heap -> name: offHeap, amount: 0, script: , vendor: ), task resources: Map(cpus -> name: cpus, amount: 1.0)
25/04/30 20:19:27 INFO ResourceProfile: Limiting resource is cpus at 4 tasks per executor
25/04/30 20:19:27 INFO ResourceProfileManager: Added ResourceProfile id: 0
25/04/30 20:19:27 INFO SecurityManager: Changing view acls to: hadoop
25/04/30 20:19:27 INFO SecurityManager: Changing modify acls to: hadoop
25/04/30 20:19:27 INFO SecurityManager: Changing view acls groups to:
25/04/30 20:19:27 INFO SecurityManager: Changing modify acls groups to:
25/04/30 20:19:27 INFO SecurityManager: SecurityManager: authentication disabled; ui acls disabled; users with view permissions: hadoop; gr
; groups with modify permissions: EMPTY
```

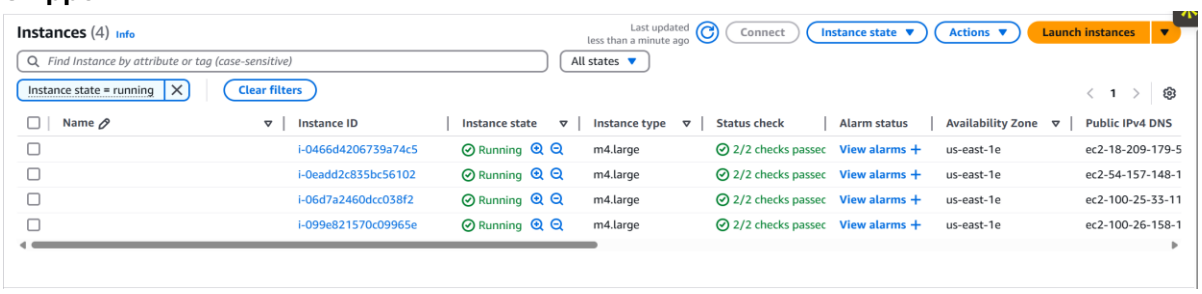
Confirm the prediction:

```
25/04/30 20:20:36 INFO BlockManagerInfo: Added broadcast_12_piece0 in memory on ip-172-31-48-14.ec2.internal:38483 (size: 2.9 KiB, fr
25/04/30 20:20:36 INFO SparkContext: Created broadcast 12 from broadcast at DAGScheduler.scala:1592
25/04/30 20:20:36 INFO DAGScheduler: Submitting 1 missing tasks from ResultStage 6 (ShuffledRDD[26] at reduceByKey at MulticlassMetri
25/04/30 20:20:36 INFO YarnScheduler: Adding task set 6.0 with 1 tasks resource profile 0
25/04/30 20:20:36 INFO TaskSetManager: Starting task 0.0 in stage 6.0 (TID 6) (ip-172-31-50-248.ec2.internal, executor 1, partition 0
25/04/30 20:20:36 INFO BlockManagerInfo: Added broadcast_12_piece0 in memory on ip-172-31-50-248.ec2.internal:44967 (size: 2.9 KiB, f
25/04/30 20:20:36 INFO MapOutputTrackerMasterEndpoint: Asked to send map output locations for shuffle 0 to 172.31.50.248:39014
25/04/30 20:20:37 INFO TaskSetManager: Finished task 0.0 in stage 6.0 (TID 6) in 273 ms on ip-172-31-50-248.ec2.internal (executor 1)
25/04/30 20:20:37 INFO YarnScheduler: Removed TaskSet 6.0, whose tasks have all completed, from pool
25/04/30 20:20:37 INFO DAGScheduler: ResultStage 6 (collectAsMap at MulticlassMetrics.scala:61) finished in 0.347 s
25/04/30 20:20:37 INFO DAGScheduler: Job 5 is finished. Cancelling potential speculative or zombie tasks for this job
25/04/30 20:20:37 INFO YarnScheduler: Killing all running tasks in stage 6: Stage finished
25/04/30 20:20:37 INFO DAGScheduler: Job 5 finished: collectAsMap at MulticlassMetrics.scala:61, took 4.865467 s
F1 Score on Validation Data = 0.5625522927084354
25/04/30 20:20:37 INFO SparkContext: SparkContext is stopping with exitCode 0.
25/04/30 20:20:37 INFO SparkUI: Stopped Spark web UI at http://ip-172-31-48-14.ec2.internal:4040
25/04/30 20:20:37 INFO YarnClientSchedulerBackend: Interrupting monitor thread
25/04/30 20:20:37 INFO YarnClientSchedulerBackend: Shutting down all executors
25/04/30 20:20:37 INFO YarnSchedulerBackend$YarnDriverEndpoint: Asking each executor to shut down
25/04/30 20:20:37 INFO YarnClientSchedulerBackend: YARN client scheduler backend Stopped
25/04/30 20:20:37 INFO MapOutputTrackerMasterEndpoint: MapOutputTrackerMasterEndpoint stopped!
25/04/30 20:20:37 INFO MemoryStore: MemoryStore cleared
25/04/30 20:20:37 INFO BlockManager: BlockManager stopped
25/04/30 20:20:37 INFO BlockManagerMaster: BlockManagerMaster stopped
25/04/30 20:20:37 INFO OutputCommitCoordinator$OutputCommitCoordinatorEndpoint: OutputCommitCoordinator stopped!
25/04/30 20:20:37 INFO SparkContext: Successfully stopped SparkContext
25/04/30 20:20:37 INFO ShutdownHookManager: Shutdown hook called
25/04/30 20:20:37 INFO ShutdownHookManager: Deleting directory /mnt/tmp/spark-14fd4c97-cda8-462a-9d51-38695b8971ee
```

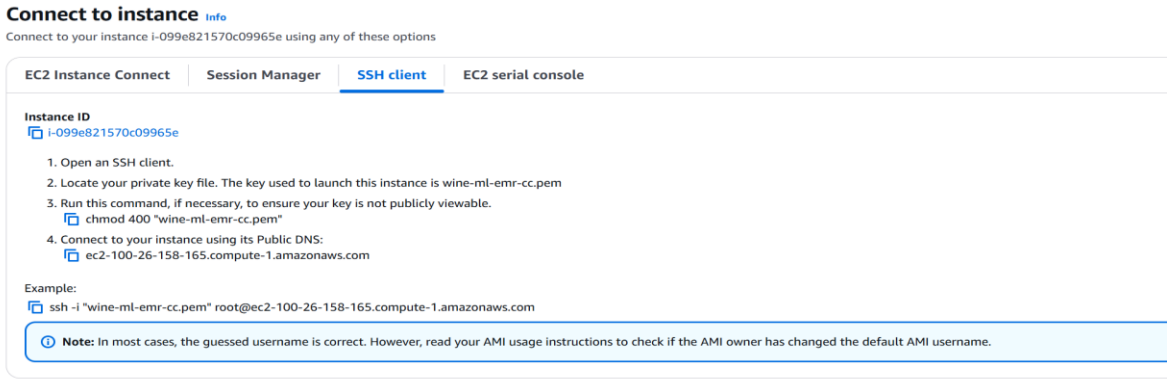
7.Running Prediction without Docker on Single instance:

Check the EC2 running instance of Cluster :

Snippet:



Connect to your master EC2 instance:



Go to folder where the pem file is stored and open cmd & run the command to connect:

- ssh -i "wine-ml-emr-cc.pem" ec2-user@ec2-100-26-158-165.compute-1.amazonaws.com

Snippet:

```
PS C:\Users\Vishal\Downloads> ssh -i "wine-ml-emr-cc.pem" ec2-user@ec2-100-26-158-165.compute-1.amazonaws.com
       #_
   ~\_  ####_        Amazon Linux 2
  ~~  \_#####\
  ~~     \###|       AL2 End of Life is 2026-06-30.
  ~~       \#/ ___
   ~~       V~' '->
    ~~~         /    A newer version of Amazon Linux is available!
      ~~._.   _/
         _/ _/       Amazon Linux 2023, GA and supported until 2028-03-15.
       _/m/'           https://aws.amazon.com/linux/amazon-linux-2023/

EEEEEEEEEEEEEEEEEEEE MMMMMMMM           MMMMMMMM RRRRRRRRRRRRRRR
E::::::::::::::::::E M:::::::M         M:::::::M R::::::::::::::R
EE::::::EEEEEEEEE:::E M::::::::M       M::::::::M R::::::RRRRRR::::::R
  E::::E       EEEEE M:::::::::M     M:::::::::M RR::::R      R::::R
  E::::E             M::::::M:::M   M:::M::::::M   R::::R      R::::R
  E::::E             M::::::M:::M   M:::M::::::M   R::::R      R::::R
  E::::::::::::::::E M::::::M  M:::M:::M  M::::::M   R::::::::::::RR
  E::::::EEEEEEEEEE  M::::::M   M::::M   M::::::M   R::::RRRRRR::::R
  E::::E             M::::::M    M:::M    M::::::M   R::::R      R::::R
  E::::E       EEEEE M::::::M     MMM     M::::::M   R::::R      R::::R
EE::::::EEEEEEEE:::E M::::::M             M::::::M   R::::R      R::::R
E::::::::::::::::::E M::::::M             M::::::M RR::::R      R::::R
EEEEEEEEEEEEEEEEEEEE MMMMMMMM             MMMMMMMM RRRRRRR      RRRRRR

[ec2-user@ip-172-31-48-14 ~]$
```

Switch to Hadoop user

command : sudo su – hadoop

```
For more details see su(1).
[ec2-user@ip-172-31-48-14 ~]$ sudo su - hadoop
Last login: Wed Apr 30 20:51:38 UTC 2025

EEEEEEEEEEEEEEEEEEEE MMMMMMMM           MMMMMMMM RRRRRRRRRRRRRRR
E::::::::::::::::::E M:::::::M         M:::::::M R::::::::::::::R
EE::::::EEEEEEEEE:::E M::::::::M       M::::::::M R::::::RRRRRR::::::R
  E::::E       EEEEE M:::::::::M     M:::::::::M RR::::R      R::::R
  E::::E             M::::::M:::M   M:::M::::::M   R::::R      R::::R
  E::::::EEEEEEEEEE  M::::::M M:::M M:::M M::::::M   R::::RRRRRR::::R
  E::::::::::::::::E M::::::M  M:::M:::M  M::::::M   R::::::::::::RR
  E::::::EEEEEEEEEE  M::::::M   M::::::M   M::::::M   R::::RRRRRR::::R
  E::::E             M::::::M    M:::M    M::::::M   R::::R      R::::R
  E::::E       EEEEE M::::::M     MMM     M::::::M   R::::R      R::::R
EE::::::EEEEEEEE:::E M::::::M             M::::::M   R::::R      R::::R
E::::::::::::::::::E M::::::M             M::::::M RR::::R      R::::R
EEEEEEEEEEEEEEEEEEEE MMMMMMMM             MMMMMMMM RRRRRRR      RRRRRR

[hadoop@ip-172-31-48-14 ~]$
```

Change directory

command :cd CC-CS643-Prgm-Assgn-2-/

Now run the Prediction using JAR file locally without docker

Command:

```
spark-submit \
 --class com.wine.WinePredictApp \
 --master yarn \
 target/wine-ml-spark-1.0-SNAPSHOT.jar
```

Snippet:

```
[hadoop@ip-172-31-48-14 CC-CS643-Prgm-Assgn-2-]$ aws s3 ls s3://wine-ml-bucket-vk722/
                           PRE wine_quality_model/
2025-04-28 03:50:38      68804 TrainingDataset.csv
2025-04-28 03:50:57       8760 ValidationDataset.csv
2025-04-28 21:44:21       6541 wine-ml-spark-1.0-SNAPSHOT.jar
[hadoop@ip-172-31-48-14 CC-CS643-Prgm-Assgn-2-]$ spark-submit \
>   --class com.wine.WinePredictApp \
>   --master yarn \
>   target/wine-ml-spark-1.0-SNAPSHOT.jar

25/04/30 21:02:56 INFO SparkContext: Running Spark version 3.4.1-amzn-2
25/04/30 21:02:56 INFO ResourceUtils: ==============================================================
25/04/30 21:02:56 INFO ResourceUtils: No custom resources configured for spark.driver.
25/04/30 21:02:56 INFO ResourceUtils: ==============================================================
25/04/30 21:02:56 INFO SparkContext: Submitted application: Wine Quality Prediction - Prediction Phase
25/04/30 21:02:56 INFO ResourceProfile: Default ResourceProfile created, executor resources: Map(cores -> name: cores, amount: 4,
t: 4269, script: , vendor: , offHeap -> name: offHeap, amount: 0, script: , vendor: ), task resources: Map(cpus -> name: cpus, am
25/04/30 21:02:56 INFO ResourceProfile: Limiting resource is cpus at 4 tasks per executor
25/04/30 21:02:56 INFO ResourceProfileManager: Added ResourceProfile id: 0
25/04/30 21:02:56 INFO SecurityManager: Changing view acls to: hadoop
25/04/30 21:02:56 INFO SecurityManager: Changing modify acls to: hadoop
25/04/30 21:02:56 INFO SecurityManager: Changing view acls groups to:
25/04/30 21:02:56 INFO SecurityManager: Changing modify acls groups to:
25/04/30 21:02:56 INFO SecurityManager: SecurityManager: authentication disabled; ui acls disabled; users with view permissions:
 with modify permissions: hadoop; groups with modify permissions: EMPTY
25/04/30 21:02:56 INFO Utils: Successfully started service 'sparkDriver' on port 46067.
25/04/30 21:02:57 INFO SparkEnv: Registering MapOutputTracker
25/04/30 21:02:57 INFO SparkEnv: Registering BlockManagerMaster
25/04/30 21:02:57 INFO BlockManagerMasterEndpoint: Using org.apache.spark.storage.DefaultTopologyMapper for getting topology info
25/04/30 21:02:57 INFO BlockManagerMasterEndpoint: BlockManagerMasterEndpoint up
```

Confirm the prediction:

```
s Vector(0))
25/04/30 21:03:58 INFO YarnScheduler: Adding task set 6.0 with 1 tasks resource profile 0
25/04/30 21:03:58 INFO TaskSetManager: Starting task 0.0 in stage 6.0 (TID 6) (ip-172-31-50-248.ec2.internal, executor 2, p
25/04/30 21:03:58 INFO BlockManagerInfo: Added broadcast_12_piece0 in memory on ip-172-31-50-248.ec2.internal:43791 (size:
25/04/30 21:03:58 INFO MapOutputTrackerMasterEndpoint: Asked to send map output locations for shuffle 0 to 172.31.50.248:51
25/04/30 21:03:58 INFO TaskSetManager: Finished task 0.0 in stage 6.0 (TID 6) in 166 ms on ip-172-31-50-248.ec2.internal (e
25/04/30 21:03:58 INFO YarnScheduler: Removed TaskSet 6.0, whose tasks have all completed, from pool
25/04/30 21:03:58 INFO DAGScheduler: ResultStage 6 (collectAsMap at MulticlassMetrics.scala:61) finished in 0.189 s
25/04/30 21:03:58 INFO DAGScheduler: Job 5 is finished. Cancelling potential speculative or zombie tasks for this job
25/04/30 21:03:58 INFO YarnScheduler: Killing all running tasks in stage 6: Stage finished
25/04/30 21:03:58 INFO DAGScheduler: Job 5 finished: collectAsMap at MulticlassMetrics.scala:61, took 1.808258 s
F1 Score on Validation Data = 0.5625522927084354
25/04/30 21:03:58 INFO SparkContext: SparkContext is stopping with exitCode 0.
25/04/30 21:03:58 INFO SparkUI: Stopped Spark web UI at http://ip-172-31-48-14.ec2.internal:4040
25/04/30 21:03:58 INFO YarnClientSchedulerBackend: Interrupting monitor thread
25/04/30 21:03:58 INFO YarnClientSchedulerBackend: Shutting down all executors
25/04/30 21:03:58 INFO YarnSchedulerBackend$YarnDriverEndpoint: Asking each executor to shut down
25/04/30 21:03:58 INFO YarnClientSchedulerBackend: YARN client scheduler backend Stopped
25/04/30 21:03:58 INFO MapOutputTrackerMasterEndpoint: MapOutputTrackerMasterEndpoint stopped!
25/04/30 21:03:58 INFO MemoryStore: MemoryStore cleared
25/04/30 21:03:58 INFO BlockManager: BlockManager stopped
25/04/30 21:03:58 INFO BlockManagerMaster: BlockManagerMaster stopped
```

Now to Run Prediction with Docker, Lets set up Docker Setup:

1. **Build Docker Image:**

   Command: sudo docker build -t wine-predictor:v3 .

   Snippet:

```
[hadoop@ip-172-31-63-75 CC-CS643-Prgm-Assgn-2-]$ sudo docker build -t wine-predictor:v3 .
[+] Building 0.3s (8/8) FINISHED
 => [internal] load build definition from Dockerfile
 => => transferring dockerfile: 385B
 => [internal] load metadata for docker.io/bitnami/spark:3.3.0
 => [internal] load .dockerignore
 => => transferring context: 2B
 => [1/3] FROM docker.io/bitnami/spark:3.3.0@sha256:b4e81939f1606b1f039bea1b86145317ae38c5803a6b6895b38961a4b1213c7c
 => [internal] load build context
 => => transferring context: 85B
 => CACHED [2/3] WORKDIR /app
 => CACHED [3/3] COPY target/wine-ml-spark-1.0-SNAPSHOT.jar /app/app.jar
 => exporting to image
 => => exporting layers
 => => writing image sha256:05a344e7d1ebb4274c3ef18daa0b488ffc1edc68181ff5d14af0113b3921102f
 => => naming to docker.io/library/wine-predictor:v3
[hadoop@ip-172-31-63-75 CC-CS643-Prgm-Assgn-2-]$
```

Verify Docker Image

- sudo docker images

```
[hadoop@ip-172-31-63-75 CC-CS643-Prgm-Assgn-2-]$ ^C
[hadoop@ip-172-31-63-75 CC-CS643-Prgm-Assgn-2-]$ sudo docker images
REPOSITORY                TAG       IMAGE ID       CREATED              SIZE
wine-predictor            v1        05a344e7d1eb   About a minute ago   1.25GB
wine-predictor            v3        05a344e7d1eb   About a minute ago   1.25GB
vishalk722/wine-ml-app    v2        6bbeea84c4dc   2 hours ago          1.25GB
[hadoop@ip-172-31-63-75 CC-CS643-Prgm-Assgn-2-]$
```

2. **Now Tag the Docker Images:**
   - sudo docker tag wine-predictor:v3 vishalk722/wine-ml-app:v3

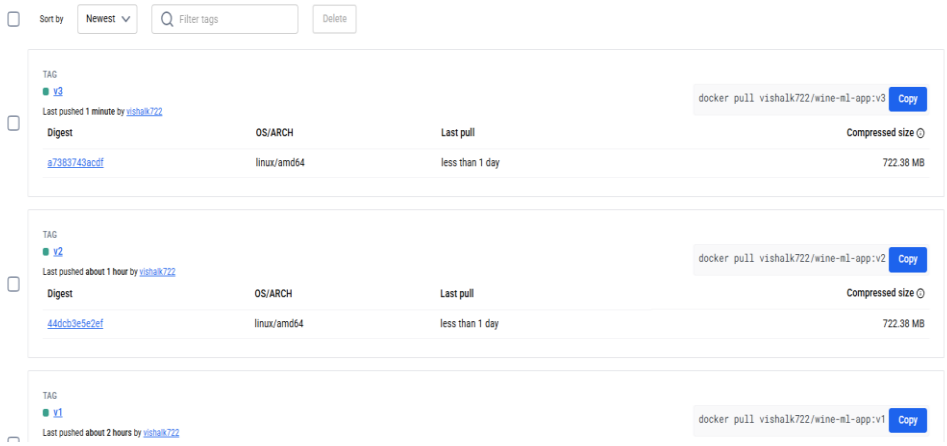
```
[hadoop@ip-172-31-63-75 CC-CS643-Prgm-Assgn-2-]$
[hadoop@ip-172-31-63-75 CC-CS643-Prgm-Assgn-2-]$ sudo docker tag wine-predictor:v3 vishalk722/wine-ml-app:v3
[hadoop@ip-172-31-63-75 CC-CS643-Prgm-Assgn-2-]$ sudo docker images
REPOSITORY                TAG       IMAGE ID       CREATED          SIZE
wine-predictor            v1        05a344e7d1eb   4 minutes ago    1.25GB
wine-predictor            v3        05a344e7d1eb   4 minutes ago    1.25GB
vishalk722/wine-ml-app    v3        05a344e7d1eb   4 minutes ago    1.25GB
vishalk722/wine-ml-app    v2        6bbeea84c4dc   2 hours ago      1.25GB
[hadoop@ip-172-31-63-75 CC-CS643-Prgm-Assgn-2-]$
```

3. **Push the docker Image to Docker Hub**
   - sudo docker push vishalk722/wine-ml-app:v3

```
Upload an image to a registry
[hadoop@ip-172-31-63-75 CC-CS643-Prgm-Assgn-2-]$ sudo docker push vishalk722/wine-ml-app:v3
The push refers to repository [docker.io/vishalk722/wine-ml-app]
81d37d4f1692: Pushed
7643bc492431: Layer already exists
c0c1eb24d971: Layer already exists
877c59cba308: Layer already exists
v3: digest: sha256:a7383743acdf89ff1e850423d6d65df00ae1e5a18d15e09a1aefb852224d0f06 size: 1157
[hadoop@ip-172-31-63-75 CC-CS643-Prgm-Assgn-2-]$
```

Verify on Docker Hub if the image pushed:

Snippet:



4. **Now clean local images on EMR :**
   - sudo docker rmi -f IMAGE_ID
   - E.g: sudo docker rmi -f 6bbeea84c4dc

Snippet:

```
[hadoop@ip-172-31-63-75 ~]$ sudo docker rmi -f 05a344e7d1eb
Untagged: wine-predictor:v1
Untagged: wine-predictor:v3
Untagged: vishalk722/wine-ml-app:v3
Untagged: vishalk722/wine-ml-app@sha256:a7383743acdf89ff1e850423d6d65df00ae1e5a18d15e09a1aefb852224d0f06
Deleted: sha256:05a344e7d1ebb4274c3ef18daa0b488ffc1edc68181ff5d14af0113b3921102f
[hadoop@ip-172-31-63-75 ~]$ sudo docker rmi -f 6bbeea84c4dc
Untagged: vishalk722/wine-ml-app:v2
Untagged: vishalk722/wine-ml-app@sha256:44dcb3e5e2ef23d8f9561224080c6a2c1e183690d9268dddc8e97377201b1212
Deleted: sha256:6bbeea84c4dc3f74af2bcfc6b522e6b99556442d7e954af83a3032fde47f07cb
[hadoop@ip-172-31-63-75 ~]$ sudo docker rmi -f 05a344e7d1eb
Error response from daemon: No such image: 05a344e7d1eb:latest
[hadoop@ip-172-31-63-75 ~]$ sudo docker images
REPOSITORY   TAG       IMAGE ID   CREATED   SIZE
[hadoop@ip-172-31-63-75 ~]$
```

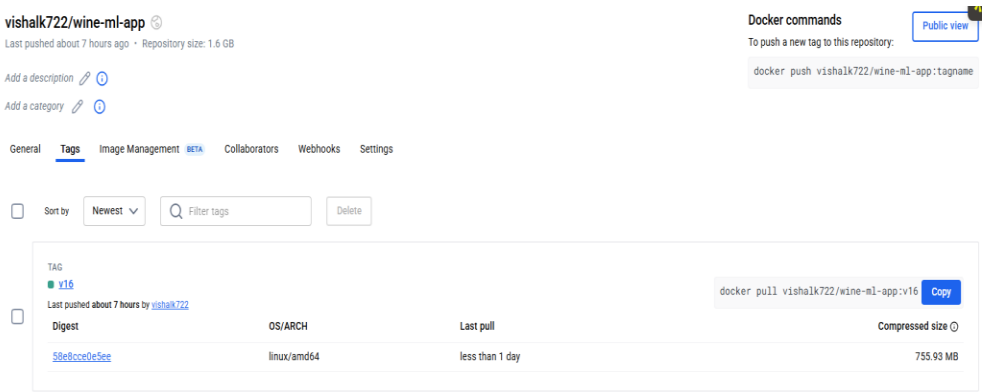
5. **Remove clone repo directory : CC-CS643-Prgm-Assgn-2-/**
   - rm -r CC-CS643-Prgm-Assgn-2-/

   Snippet:

```
[hadoop@ip-172-31-63-75 ~]$ rm -r CC-CS643-Prgm-Assgn-2-/
rm: remove write-protected regular file 'CC-CS643-Prgm-Assgn-2-/.git/objects/pack/pack-cb920cd430970530d3e80b66f94e9339b1a657c7.pack'? y
rm: remove write-protected regular file 'CC-CS643-Prgm-Assgn-2-/.git/objects/pack/pack-cb920cd430970530d3e80b66f94e9339b1a657c7.rev'? y
rm: remove write-protected regular file 'CC-CS643-Prgm-Assgn-2-/.git/objects/pack/pack-cb920cd430970530d3e80b66f94e9339b1a657c7.idx'? y
[hadoop@ip-172-31-63-75 ~]$ ls
[hadoop@ip-172-31-63-75 ~]$
```

6. **Now Pull Image from docker hub and verify its available:**
   - Copy command from docker Hub :
   - docker pull vishalk722/wine-ml-app:v16

   Snippet:



Run the command on EMR Cluster

```
[hadoop@ip-172-31-52-39 ~]$ docker pull vishalk722/wine-ml-app:v16
v16: Pulling from vishalk722/wine-ml-app
001c52e26ad5: Already exists
d9d4b9b6e964: Already exists
2068746827ec: Already exists
9daef329d350: Already exists
d85151f15b66: Already exists
52a8c426d30b: Already exists
8754a66e0050: Already exists
bddc7b093fe0: Already exists
987e953de113: Already exists
3db0f77b3231: Already exists
d2f77dd03f9e: Already exists
c632c60fa4e8: Already exists
4c2bf67b1d55: Already exists
Digest: sha256:58e8cce0e5ee3e368115a757a4360e233b6f65912806439b2677650350a48850
Status: Downloaded newer image for vishalk722/wine-ml-app:v16
docker.io/vishalk722/wine-ml-app:v16
[hadoop@ip-172-31-52-39 ~]$ sudo docker images
REPOSITORY                TAG       IMAGE ID       CREATED          SIZE
vishalk722/wine-ml-app    v16       9430a7864634   12 minutes ago   1.15GB
```

7. Running Prediction with Docker image on EMR Cluster:

Command: sudo docker run --rm -v $HOME/.ivy2:/root/.ivy2 -v $HOME:/root -e HOME=/root -e SPARK_SUBMIT_OPTS="-Divy.cache.dir=/root/.ivy2/cache -Divy.home=/root/.ivy2" --user root vishalk722/wine-ml-app:v16

Snippet:

```
[hadoop@ip-172-31-52-39 ~]$ sudo docker run --rm  -v $HOME/.ivy2:/root/.ivy2  -v $HOME:/root  -e HOME=/root  -e SPARK_SUBMIT_OPTS="-Divy.cache.dir=/root/.ivy2/cache -Divy.home=/root/.ivy2"  --user r
shalk722/wine-ml-app:v16
25/04/30 12:14:57 INFO SparkContext: Running Spark version 3.3.3
25/04/30 12:14:57 WARN NativeCodeLoader: Unable to load native-hadoop library for your platform... using builtin-java classes where applicable
25/04/30 12:14:57 INFO ResourceUtils: ==============================================================
25/04/30 12:14:57 INFO ResourceUtils: No custom resources configured for spark.driver.
25/04/30 12:14:57 INFO ResourceUtils: ==============================================================
25/04/30 12:14:57 INFO SparkContext: Submitted application: Wine Quality Prediction - Prediction Phase
25/04/30 12:14:57 INFO ResourceProfile: Default ResourceProfile created, executor resources: Map(cores -> name: cores, amount: 1, script: , vendor: , memory -> name: memory, amount: 1024, script: , vendo
offheap -> name: offheap, amount: 0, script: , vendor: ), task resources: Map(cpus -> name: cpus, amount: 1.0)
25/04/30 12:14:57 INFO ResourceProfile: Limiting resource is cpu
25/04/30 12:14:57 INFO ResourceProfileManager: Added ResourceProfile id: 0
25/04/30 12:14:57 INFO SecurityManager: Changing view acls to: root
25/04/30 12:14:57 INFO SecurityManager: Changing modify acls to: root
25/04/30 12:14:57 INFO SecurityManager: Changing view acls groups to:
25/04/30 12:14:57 INFO SecurityManager: Changing modify acls groups to:
25/04/30 12:14:57 INFO SecurityManager: SecurityManager: authentication disabled; ui acls disabled; users  with view permissions: Set(root); groups with view permissions: Set(); users  with modify permis
s(root); groups with modify permissions: Set()
```

8. Confirm the result with F1 score printed on validation data.

Snippet:

```
25/04/30 12:14:31 INFO MemoryStore: Block broadcast_11_piece0 stored as bytes in memory (estimated size 2.8 KiB, free 365.8 MiB)
25/04/30 12:14:31 INFO BlockManagerInfo: Added broadcast_11_piece0 in memory on 61b7169ae867:44583 (size: 2.8 KiB, free: 366.2 MiB)
25/04/30 12:14:31 INFO SparkContext: Created broadcast 11 from broadcast at DAGScheduler.scala:1509
25/04/30 12:14:31 INFO DAGScheduler: Submitting 1 missing tasks from ResultStage 6 (ShuffledRDD[25] at reduceByKey at MulticlassMetrics.
25/04/30 12:14:31 INFO TaskSchedulerImpl: Adding task set 6.0 with 1 tasks resource profile 0
25/04/30 12:14:31 INFO TaskSetManager: Starting task 0.0 in stage 6.0 (TID 6) (61b7169ae867, executor driver, partition 0, NODE_LOCAL, 4
25/04/30 12:14:31 INFO Executor: Running task 0.0 in stage 6.0 (TID 6)
25/04/30 12:14:31 INFO ShuffleBlockFetcherIterator: Getting 1 (490.0 B) non-empty blocks including 1 (490.0 B) local and 0 (0.0 B) host-
25/04/30 12:14:31 INFO ShuffleBlockFetcherIterator: Started 0 remote fetches in 14 ms
25/04/30 12:14:31 INFO Executor: Finished task 0.0 in stage 6.0 (TID 6). 2162 bytes result sent to driver
25/04/30 12:14:31 INFO TaskSetManager: Finished task 0.0 in stage 6.0 (TID 6) in 88 ms on 61b7169ae867 (executor driver) (1/1)
25/04/30 12:14:31 INFO TaskSchedulerImpl: Removed TaskSet 6.0, whose tasks have all completed, from pool
25/04/30 12:14:31 INFO DAGScheduler: ResultStage 6 (collectAsMap at MulticlassMetrics.scala:61) finished in 0.110 s
25/04/30 12:14:31 INFO DAGScheduler: Job 5 is finished. Cancelling potential speculative or zombie tasks for this job
25/04/30 12:14:31 INFO TaskSchedulerImpl: Killing all running tasks in stage 6: Stage finished
25/04/30 12:14:31 INFO DAGScheduler: Job 5 finished: collectAsMap at MulticlassMetrics.scala:61, took 1.413798 s
F1 Score on Validation Data = 0.5625522927084354
25/04/30 12:14:31 INFO SparkUI: Stopped Spark web UI at http://61b7169ae867:4040
25/04/30 12:14:31 INFO MapOutputTrackerMasterEndpoint: MapOutputTrackerMasterEndpoint stopped!
25/04/30 12:14:31 INFO MemoryStore: MemoryStore cleared
25/04/30 12:14:31 INFO BlockManager: BlockManager stopped
25/04/30 12:14:31 INFO BlockManagerMaster: BlockManagerMaster stopped
25/04/30 12:14:31 INFO OutputCommitCoordinator$OutputCommitCoordinatorEndpoint: OutputCommitCoordinator stopped!
25/04/30 12:14:31 INFO SparkContext: Successfully stopped SparkContext
25/04/30 12:14:31 INFO ShutdownHookManager: Shutdown hook called
25/04/30 12:14:31 INFO ShutdownHookManager: Deleting directory /tmp/spark-c14c0a41-ade7-4409-b263-66ddbf15127b
25/04/30 12:14:31 INFO ShutdownHookManager: Deleting directory /tmp/spark-f295550c-59af-488c-b30c-6205d577478e
25/04/30 12:14:31 INFO MetricsSystemImpl: Stopping s3a-file-system metrics system...
```

9. Running Prediction with Docker image single cluster:

- **Pull docker image from Docker Hub on primary EC2 which we connected on CMD**

  Command : docker pull vishalk722/wine-ml-app:v16

  Snippet:

```
Login Succeeded
[hadoop@ip-172-31-48-14 ~]$ sudo docker pull vishalk722/wine-ml-app:v16
v16: Pulling from vishalk722/wine-ml-app
001c52e26ad5: Extracting [>                                                  ]  557.1kB/55MB
d9d4b9b6e964: Download complete
2068746827ec: Download complete
9daef329d350: Download complete
d85151f15b66: Download complete
52a8c426d30b: Download complete
8754a66e0050: Downloading [==================>                            ]  39.39MB/105.9MB
bddc7b093fe0: Download complete
987e953de113: Waiting
3db0f77b3231: Waiting
d2f77dd03f9e: Waiting
c632c60fa4e8: Waiting
4c2bf67b1d55: Waiting
```

Now run the docker image on cluster :

Command : sudo docker run --rm -v $HOME/.ivy2:/root/.ivy2 -v $HOME:/root -e HOME=/root -e SPARK_SUBMIT_OPTS="-Divy.cache.dir=/root/.ivy2/cache -Divy.home=/root/.ivy2" --user root vishalk722/wine-ml-app:v16

Snippet:

```
docker.io/vishalk722/wine-ml-app:v16
[hadoop@ip-172-31-48-14 ~]$ sudo docker run --rm  -v $HOME/.ivy2:/root/.ivy2  -v $HOME:/root  -e HOME=/root  -e SPARK_SUBMIT_OPTS="-Divy.cache.dir=/root/.ivy2/cache -Divy.home
=/root/.ivy2"  --user root  vishalk722/wine-ml-app:v16
```

```
25/04/30 21:34:38 INFO TaskSchedulerImpl: Adding task set 6.0 with 1 tasks resource profile 0
25/04/30 21:34:38 INFO TaskSetManager: Starting task 0.0 in stage 6.0 (TID 6) (602a44af77ce, executor driver, partition 0, NODE_
25/04/30 21:34:38 INFO Executor: Running task 0.0 in stage 6.0 (TID 6)
25/04/30 21:34:38 INFO ShuffleBlockFetcherIterator: Getting 1 (490.0 B) non-empty blocks including 1 (490.0 B) local and 0 (0.0
 (0.0 B) remote blocks
25/04/30 21:34:38 INFO ShuffleBlockFetcherIterator: Started 0 remote fetches in 32 ms
25/04/30 21:34:38 INFO Executor: Finished task 0.0 in stage 6.0 (TID 6). 2162 bytes result sent to driver
25/04/30 21:34:38 INFO TaskSetManager: Finished task 0.0 in stage 6.0 (TID 6) in 115 ms on 602a44af77ce (executor driver) (1/1)
25/04/30 21:34:38 INFO TaskSchedulerImpl: Removed TaskSet 6.0, whose tasks have all completed, from pool
25/04/30 21:34:38 INFO DAGScheduler: ResultStage 6 (collectAsMap at MulticlassMetrics.scala:61) finished in 0.140 s
25/04/30 21:34:38 INFO DAGScheduler: Job 5 is finished. Cancelling potential speculative or zombie tasks for this job
25/04/30 21:34:38 INFO TaskSchedulerImpl: Killing all running tasks in stage 6: Stage finished
25/04/30 21:34:38 INFO DAGScheduler: Job 5 finished: collectAsMap at MulticlassMetrics.scala:61, took 1.382377 s
F1 Score on Validation Data = 0.5625522927084354
25/04/30 21:34:38 INFO SparkUI: Stopped Spark web UI at http://602a44af77ce:4040
25/04/30 21:34:38 INFO MapOutputTrackerMasterEndpoint: MapOutputTrackerMasterEndpoint stopped!
25/04/30 21:34:38 INFO MemoryStore: MemoryStore cleared
25/04/30 21:34:38 INFO BlockManager: BlockManager stopped
25/04/30 21:34:38 INFO BlockManagerMaster: BlockManagerMaster stopped
25/04/30 21:34:38 INFO OutputCommitCoordinator$OutputCommitCoordinatorEndpoint: OutputCommitCoordinator stopped!
25/04/30 21:34:38 INFO SparkContext: Successfully stopped SparkContext
25/04/30 21:34:38 INFO ShutdownHookManager: Shutdown hook called
25/04/30 21:34:38 INFO ShutdownHookManager: Deleting directory /tmp/spark-4bc402fa-76b6-4f91-b2ad-a03c9756925c
```