Big Data Parallel Programming

Final Project Report

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Contents

1 State of Problem 2
2 Introduction 2
3 Discussion 3
3.1 Google Cloud Platform 3
3.1.1 Creating Cluster 3
3.1.2 Creating Firewall Rule 3
3.1.3 Static ip address 4
3.1.4 Storage Bucket 4
3.2 Configure Jupyter Notebook 5
3.3 Pyspark 5
3.4 Exploratory Analysis 5
3.4.1 Showing The Data 6
3.4.2 Missing Values 6
3.4.3 Statistics of Data 7
3.4.4 Data filtering 7
3.4.5 Graphical representation 8
..... 8
3.4.6 String Indexer 8
3.4.7 Vector Assembler 9
3.4.8 Stand Scaler 9
3.4.9 Split the dataset 10
3.4.10 Data Balancing 10
3.5 Machine Learning 11
3.5.1 Logistic Regression 11
3.5.2 Decision Tree 12
3.5.3 Random Forest 12
3.5.4 Gradient Boost Tree Classifier 13
3.5.5 Linear SVS 14
3.6 Model Selection 15
3.7 Creating Output Link on Jupyter Notebook 17
3.8 Saving output on GCP Bucket 17
3.9 Job submission 17
4 Problems and solution on GCP 18
5 Conclusion 19

1 State of Problem

In This project we have to predict whether an individual's income will be greater than $50,000 per year or less than $50000 per year based on several attributes from the census data that is collected from Kaggle US adult census dataset.

Keywords: Google cloud platform, Machine learning, Decision Tree, Gradient Boos Tree Classification, Logistic Regression, Random Forest,

2 Introduction

The obvious difference of wealth and income is a huge concern, especially in the United States. The principle of universal moral equality guarantees the improvement of the financial stability and sustainable development. The different countries are trying their best way to overcome on this problem and giving an optimal solution. I will contribute to this problem by performing some machine learning algorithm.

This is a supervised machine learning classification task. In supervised Machine learning we have given data attribute with labeled class and we have to train a model by using different algorithms and predict the data that may have lack of class label. In This task we have a census income dataset with several attributes. The dataset contains 48,842 entries and 14 attributes. Each entry contains the information about an individual. This task is done by using pyspark on GCP. I used cluster with one master node and 2 worker nodes. A firewall also created to use the ip address and port number 8888 to access the cluster node with specific ip address and port number. the cluster node uses the static ip address rather than the dynamic. After this loaded the data from gcp bucket with pyspark and perform some exploratory analysis on the data. To be very first I check the schema of the data with print schema and then check the missing or unknown value in the data. I drop out the unknown value and then perform the filtering on the data to check the association of the attribute with income. There are some categorical attributes that are converted to numerical by using string indexer. After this I used the vector assembler to put all the numeric attribute into one column is call features. In addition, I used the stand scaler to scale all the values in features column and saved output in scaled features column. Then created the pipeline that means how the stages will be performed on the previous steps and prepared a data pipeline. After the pipeline, the data is ready for machine learning algorithms. I performed five different algorithm that are Logistic Regression, Decision Tree, Random Forest, Gradient Boost Tree Classifier and Linear SVC.I used these algorithms and perform the hyper parameter tuning of each algorithm. Each algorithm gives the different accuracy and based on accuracy I evaluated the algorithm and choose a best model to predict the test data. After this the output of the test data saved in a csv file on GCP bucket that user can download the output file as well. I also generated the http link on the jupyter notebook the user can also download the file directly from the notebook. After completing the code in notebook, I created a pyspark job on GCP cluster with my python file and submit the job successfully. The output can be seen on the GCP and, we can monitor the job as well as can see the log of the job. I have also tried the IBM Watson for this project but according to some limitation I switch on to GCP rather than IBM Watson. One of the major problems of IBM Watson is that We can perform limited prediction on IBM Watson. In the next session I will briefly explain the methodology, discussion and results as well .

3 Discussion

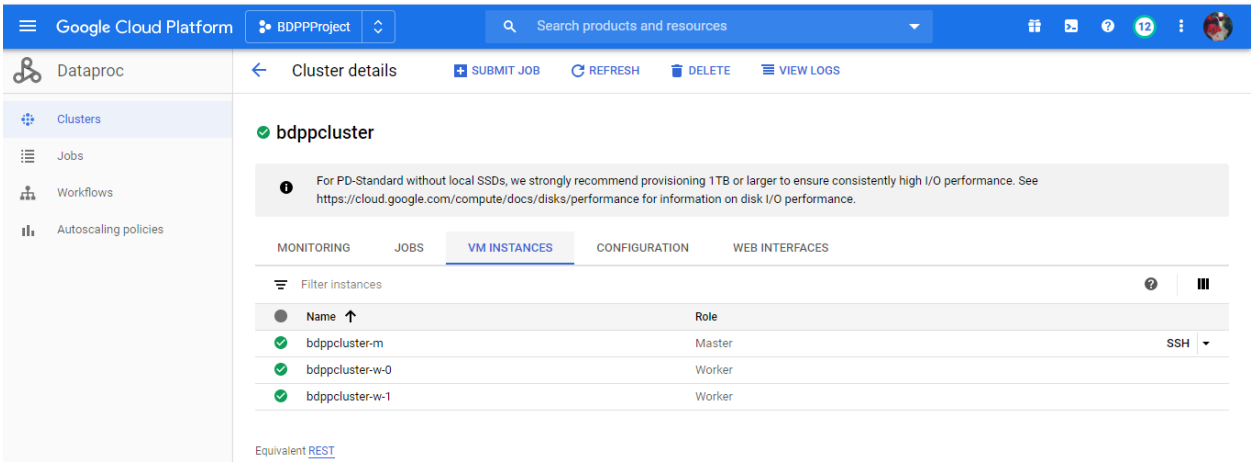
In this part the whole project methodology will be explained that means the flow of project including GCP cluster ,configuration ,creating firewall rule, set the static ip address, the data exploratory analysis , Statistics ,Data cleaning, Data filtering , String indexer, Vector assembler, Stand scaler, Data pipeline and train model with five different binomial classification algorithm and measure the accuracy . All algorithm evaluated on the base of ROC and select the best model and make prediction with these model and then submit a pyspark job then save the output file on GCP Bucket that user can download the output file as well .

3.1 Google Cloud Platform

GCP provide different features like clustering, creating VM instance, storage, private network, firewall rule and much other features. I am using the GCP for creating cluster, private network, firewall rule, storage and job submission

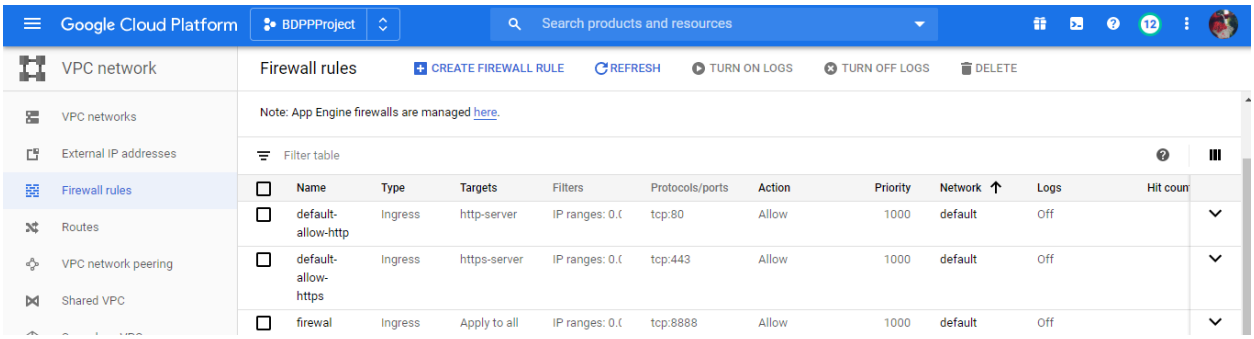
3.1.1 Creating Cluster

To be very first I created the GCP account with 300$ free credit with 365 days. After this I created a project with the name of BDPPProject .In addition, I click on menu on dashboard and go to Dataproc and click on cluster for creating the cluster with one master node and 2 worker node with name of bdppcluster .the following screenshot can be seen what I have created :-



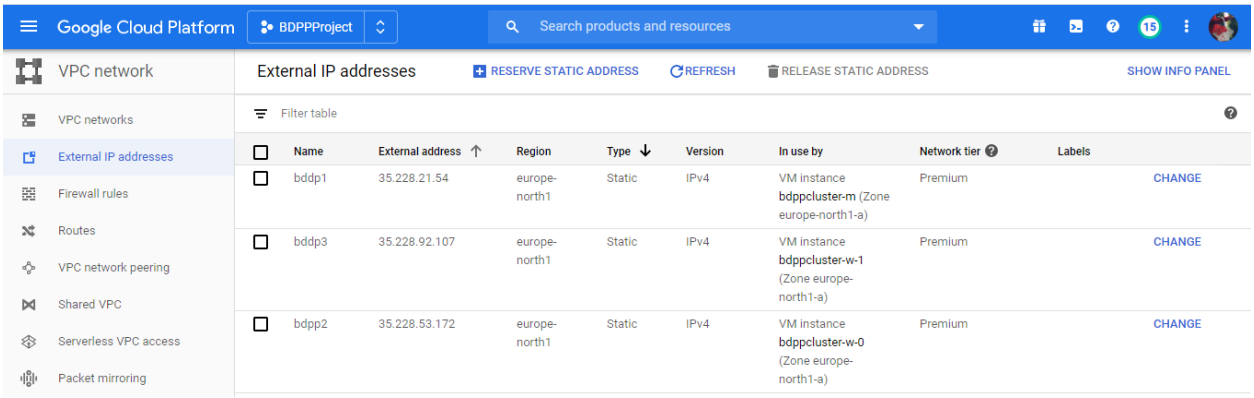
3.1.2 Creating Firewall Rule

After completed the cluster creation I need to create a firewall rule. I click on option and go the vps network then click on firewall rule and create a firewall rule with name of firewal for setting up the specific tcp port number 8888 and set the ip address range 0.0.0.0/0.So I can access my virtual machine instance with ip address and specific port number. I also allow the http traffic and allow the access to all project .following is the screen shot of firewall rule you can see there are some default firewall rule but I created a firewall rule with the name of firewall



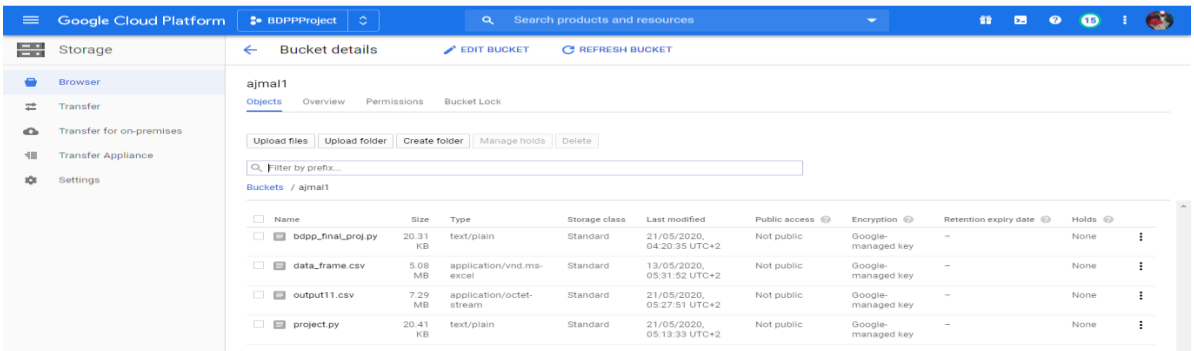
3.1.3 Static ip address

After the creation of cluster and firewall rule I click on external ip address where I have to set the ip address static so I can reserve the external ip address for my virtual machine instances if don't set it to static then may the ip address change after some while and I need to access with new ip address so that's why I set the ip address static and it will reserve for my VM instances. You can see the following screen shot with all three instances that mean one master node and 2 worker nodes with their ip static ip address:



3.1.4 Storage Bucket

Now I created a bucket on google cloud platform with the name of ajmal1 where I can upload my dataset and store the output file on bucket where a user can download the output file as well. The following screen shot contain the information of storage bucket where you can see the dataset and other file as well

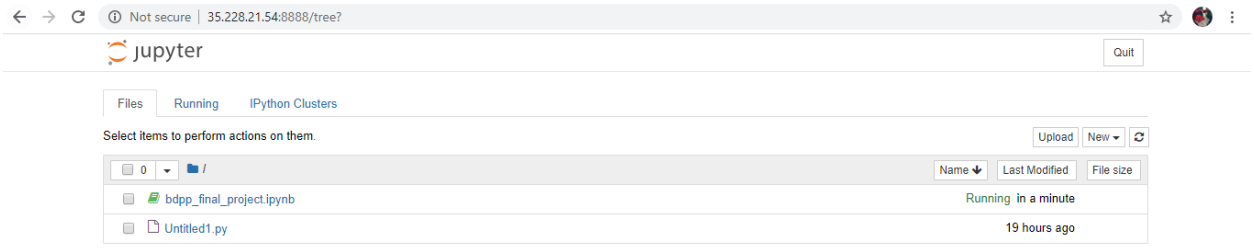


3.2 Configure Jupyter Notebook

After setting up the cluster ,firewall rule, external ip address and storage bucket. I configure the jupyter notebook with the top port number on master node . I opened the jupyter configuration file and set the required field as ip address and port number. I give the command " vi ~/.jupyter/jupyter_notebook_config.py"

```
# Configuration file for jupyter-notebook.
c = get_config()
c.NotebookApp.ip = '*'
c.NotebookApp.open_browser = False
c.NotebookApp.port = 8888
#------------------------------------------------------------------------------
# Application(SingletonConfigurable) configuration
#------------------------------------------------------------------------------
```

After setting up the configuration I run the command "jupyter notebook " on master node and access the jupyter notebook with external ip address and tcp port 8888 write down the 35.228.21.54:8888 and You can access the jupyter notebook

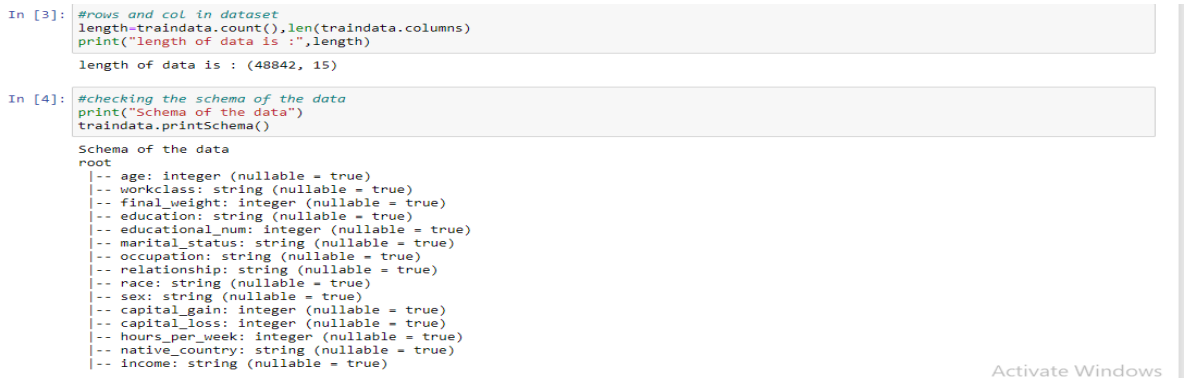


3.3 Pyspark

To be very first in jupyter notebook I created a pyspark session and load the data from the GCP bucket into the jupter notebook " traindata = spark.read.load("gs://ajmal1/data_frame.csv",format="csv", sep=",", inferSchema=True,schema=schema, header=True) "

3.4 Exploratory Analysis

Firstly, I check out the length of data which is 48842 rows and 15 columns. I also check the schema of the data with the command of printSchema. You can see the following screen shot



```
In [3]: #rows and col in dataset
        length=traindata.count(),len(traindata.columns)
        print("length of data is :",length)

        length of data is : (48842, 15)

In [4]: #checking the schema of the data
        print("Schema of the data")
        traindata.printSchema()

        Schema of the data
        root
         |-- age: integer (nullable = true)
         |-- workclass: string (nullable = true)
         |-- final_weight: integer (nullable = true)
         |-- education: string (nullable = true)
         |-- educational_num: integer (nullable = true)
         |-- marital_status: string (nullable = true)
         |-- occupation: string (nullable = true)
         |-- relationship: string (nullable = true)
         |-- race: string (nullable = true)
         |-- sex: string (nullable = true)
         |-- capital_gain: integer (nullable = true)
         |-- capital_loss: integer (nullable = true)
         |-- hours_per_week: integer (nullable = true)
         |-- native_country: string (nullable = true)
         |-- income: string (nullable = true)
```

Here we can see that there are 15 columns and 48842 rows in the datasets The Dataset the Census Income dataset has 48,842 entries. Each entry contains the following information about an individual:

- age: the age of an individual
- workclass: a general term to represent the employment status of an individual
- fnlwgt: final weight. In other words, this is the number of people the census believes the entry represents
- education: the highest level of education achieved by an individual.
- education_num: the highest level of education achieved in numerical form
- maritalstatus: marital status of an individual
- occupation: the general type of occupation of an individual
- relationship: represents what this individual is relative to others.
- race: Descriptions of an individual's race
- sex: the biological sex of the individual
- capitalgain: capital gains for an individual
- capitalloss: capital loss for an individual
- hoursperweek: the hours an individual has reported to work per week
- nativecountry: country of origin for an individual
- the label: whether or not an individual makes more than $50,000 annually.

3.4.1 Showing The Data

From the following screenshot you can see the first 5 rows of dataset.

```
#showing the first 5 rows of Data
print("First five rows of data")
traindata.show(5)
```

```
First five rows of data
+---+---------+------------+------------+--------------+------------------+-----------------+------------+-----+------+-------
-----+------------+-------------+-------------+------+
|age|workclass|final_weight|   education|educational_num|    marital_status|       occupation|relationship| race|   sex|capital
_gain|capital_loss|hours_per_week|native_country|income|
+---+---------+------------+------------+--------------+------------------+-----------------+------------+-----+------+-------
-----+------------+-------------+-------------+------+
| 25|  Private|      226802|        11th|             7|     Never-married|Machine-op-inspct|   Own-child|Black|  Male|
0|           0|           40| United-States| <=50K|
| 38|  Private|       89814|     HS-grad|             9|Married-civ-spouse|  Farming-fishing|     Husband|White|  Male|
0|           0|           50| United-States| <=50K|
| 28|Local-gov|      336951|  Assoc-acdm|            12|Married-civ-spouse|  Protective-serv|     Husband|White|  Male|
0|           0|           40| United-States|  >50K|
| 44|  Private|      160323|Some-college|            10|Married-civ-spouse|Machine-op-inspct|     Husband|Black|  Male|
7688|          0|           40| United-States|  >50K|
| 18|        ?|      103497|Some-college|            10|     Never-married|                ?|   Own-child|White|Female|
0|           0|           30| United-States| <=50K|
+---+---------+------------+------------+--------------+------------------+-----------------+------------+-----+------+-------
-----+------------+-------------+-------------+------+
only showing top 5 rows
```

3.4.2 Missing Values

The dataset contain "?" value which means the null value are unknown value I drop out these rows that contain "? "value. here you can show the data without "?" value .

```
#dropout the unknown value
new_df = traindata.filter((traindata.workclass != '?') & (traindata.occupation != '?') & (traindata.native_country != '?'))
new_df.show(5)
```

```
+---+---------+------------+------------+--------------+------------------+-----------------+-------------+-----+----+--------
----+------------+--------------+--------------+------+
|age|workclass|final_weight|   education|educational_num|    marital_status|       occupation| relationship| race| sex|capital_
gain|capital_loss|hours_per_week|native_country|income|
+---+---------+------------+------------+--------------+------------------+-----------------+-------------+-----+----+--------
----+------------+--------------+--------------+------+
| 25|  Private|      226802|        11th|             7|     Never-married|Machine-op-inspct|    Own-child|Black|Male|
0|           0|            40| United-States| <=50K|
| 38|  Private|       89814|     HS-grad|             9|Married-civ-spouse|  Farming-fishing|      Husband|White|Male|
0|           0|            50| United-States| <=50K|
| 28|Local-gov|      336951|  Assoc-acdm|            12|Married-civ-spouse|  Protective-serv|      Husband|White|Male|
0|           0|            40| United-States|  >50K|
| 44|  Private|      160323|Some-college|            10|Married-civ-spouse|Machine-op-inspct|      Husband|Black|Male|
7688|           0|            40| United-States|  >50K|
| 34|  Private|      198693|        10th|             6|     Never-married|    Other-service|Not-in-family|White|Male|
0|           0|            30| United-States| <=50K|
+---+---------+------------+------------+--------------+------------------+-----------------+-------------+-----+----+--------
----+------------+--------------+--------------+------+
only showing top 5 rows
```

3.4.3 Statistics of Data

Here you can see the statistics of some attribute that mean the count ,minimum , maximum , mean standard deviation .

```
#statestics of data
new_df.describe(['age','capital_gain','hours_per_week','capital_loss','final_weight']).show()
```

```
+-------+------------------+------------------+------------------+------------------+------------------+
|summary|               age|      capital_gain|    hours_per_week|      capital_loss|      final_weight|
+-------+------------------+------------------+------------------+------------------+------------------+
|  count|             45222|             45222|             45222|             45222|             45222|
|   mean|38.547941267524656|1101.4303436380524| 40.93801689443191|   88.595418159303| 189734.7343107337|
| stddev|13.217870219055532|  7506.43008374525|12.007508230033423|404.95609205896506|105639.19513422064|
|    min|                17|                 0|                 1|                 0|             13492|
|    max|                90|             99999|                99|              4356|           1490400|
+-------+------------------+------------------+------------------+------------------+------------------+
```

3.4.4 Data filtering

Here you can see the different filter data.

>50k $ income grouped by occupation

```
+-----------------+-----+
|       occupation|count|
+-----------------+-----+
|  Exec-managerial| 2867|
|   Prof-specialty| 2704|
|            Sales| 1455|
|     Craft-repair| 1355|
|     Adm-clerical|  756|
| Transport-moving|  478|
|     Tech-support|  411|
|Machine-op-inspct|  365|
|  Protective-serv|  307|
|    Other-service|  196|
|  Farming-fishing|  172|
|Handlers-cleaners|  135|
|     Armed-Forces|    4|
|  Priv-house-serv|    3|
+-----------------+-----+
```

```
+-----------------+-----+
|       occupation|count|
+-----------------+-----+
|     Craft-repair|  204|
|     Adm-clerical|  185|
|   Prof-specialty|  164|
|  Exec-managerial|  143|
|            Sales|  142|
|    Other-service|  118|
|Machine-op-inspct|  112|
| Transport-moving|   73|
|Handlers-cleaners|   58|
|  Farming-fishing|   57|
|     Tech-support|   55|
|  Protective-serv|   30|
|  Priv-house-serv|    8|
+-----------------+-----+
```

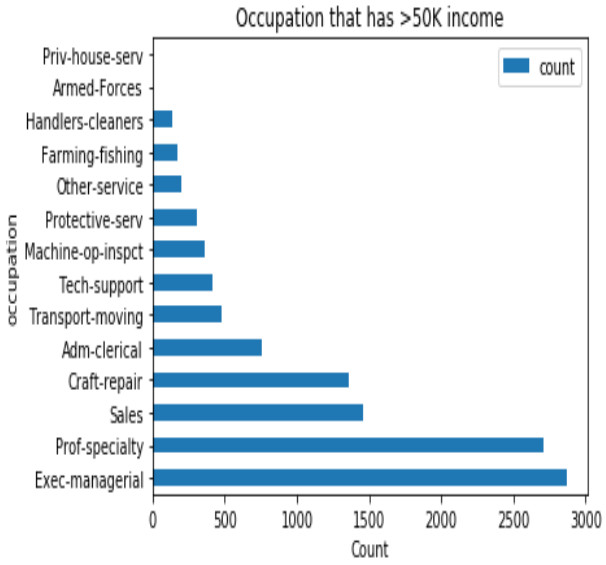
<50K $ income and capital gain >100K and age >30

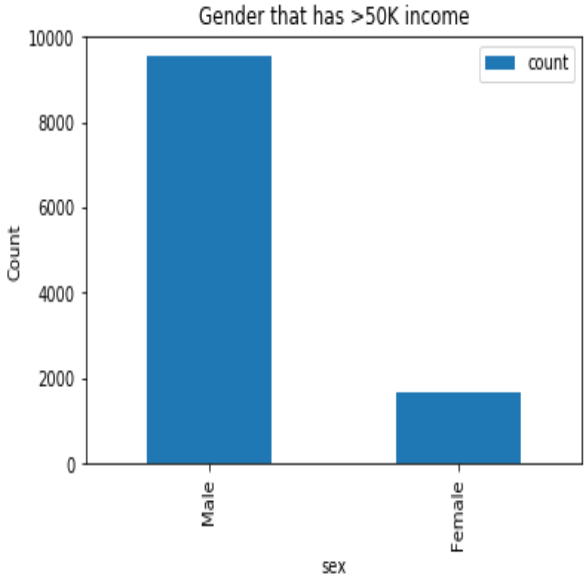
```
+-----------------+-----+
|       occupation|count|
+-----------------+-----+
|     Craft-repair|  204|
|     Adm-clerical|  185|
|   Prof-specialty|  164|
|  Exec-managerial|  143|
|            Sales|  142|
|    Other-service|  118|
|Machine-op-inspct|  112|
| Transport-moving|   73|
|Handlers-cleaners|   58|
|  Farming-fishing|   57|
|     Tech-support|   55|
|  Protective-serv|   30|
|  Priv-house-serv|    8|
+-----------------+-----+
```

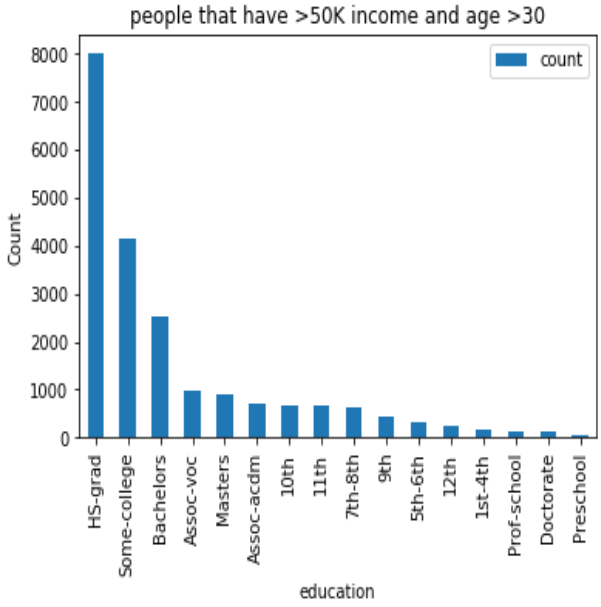
>50k $ income

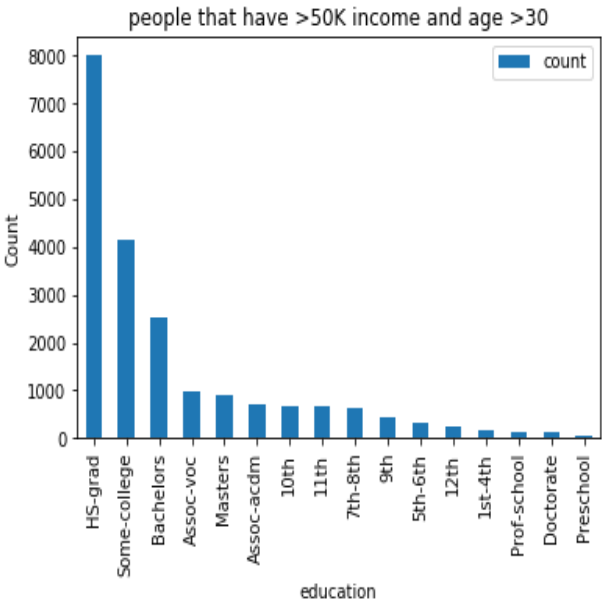
```
+------+-----+
|   sex|count|
+------+-----+
|  Male| 9539|
|Female| 1669|
+------+-----+
```

3.4.5 Graphical representation









3.4.6 String Indexer

I have categorical attributes in dataset I have to convert it into the numerical form by string indexer .the String indexer is used to convert the categorical col to numerical col.i have categorical columns are "workclass", "marital_status", "occupation", "relationship", "race", "sex", "native_country" and incom .the following screen shot is creating the numerical col from categorical col .

```
from pyspark.ml.feature import StringIndexer
from pyspark.ml.feature import OneHotEncoderEstimator
categoricalColumns = ["workclass", "marital_status", "occupation", "relationship", "race", "sex", "native_country"]
stages = [] # stages in our Pipeline
for categoricalCol in categoricalColumns:
    # Category Indexing with StringIndexer
    stringIndexer = StringIndexer(inputCol=categoricalCol, outputCol=categoricalCol + "Index")
    stages += [stringIndexer]
#stages
#stringIndexer.show(5)
```

```
#convert the label into numeric
label_stringIdx = StringIndexer(inputCol="income", outputCol="label")
#new_df = label_stringIdx.fit(new_df).transform(new_df)

stages += [label_stringIdx]
#new_df.show(1)
```

3.4.7 Vector Assembler

Vector assembler is used to combine all the attributes in one feature col and this feature or scaled features col is used for training the model as well. you can see the following output of col feature

```
showing dataset with feature col after assembler
+--------------------+-----+---+------------+---------------+------------+------------+--------------+---------+--------------
---+-----------------+-------------+-----+----+--------------+------+
|            features|label|age|final_weight|educational_num|capital_gain|capital_loss|hours_per_week|workclass|    marital_sta
tus|       occupation| relationship| race| sex|native_country|income|
+--------------------+-----+---+------------+---------------+------------+------------+--------------+---------+--------------
---+-----------------+-------------+-----+----+--------------+------+
|[0.0,1.0,6.0,2.0,...|  0.0| 25|      226802|              7|           0|           0|            40|  Private|     Never-marr
ied|Machine-op-inspct|    Own-child|Black|Male| United-States| <=50K|
|(13,[2,7,8,9,12],...|  0.0| 38|       89814|              9|           0|           0|            50|  Private|Married-civ-spo
use|  Farming-fishing|      Husband|White|Male| United-States| <=50K|
|(13,[0,2,7,8,9,12...|  1.0| 28|      336951|             12|           0|           0|            40|Local-gov|Married-civ-spo
use|  Protective-serv|      Husband|White|Male| United-States|  >50K|
|(13,[2,4,7,8,9,10...|  1.0| 44|      160323|             10|        7688|           0|            40|  Private|Married-civ-spo
use|Machine-op-inspct|      Husband|Black|Male| United-States|  >50K|
|(13,[1,2,3,7,8,9,...|  0.0| 34|      198693|              6|           0|           0|            30|  Private|     Never-marr
ied|    Other-service|Not-in-family|White|Male| United-States| <=50K|
+--------------------+-----+---+------------+---------------+------------+------------+--------------+---------+--------------
---+-----------------+-------------+-----+----+--------------+------+
only showing top 5 rows
```

3.4.8 Stand Scaler

Stand scaler is used for scale the values in feature col. If there are values that have much difference then the stand scaler scale all the values and generate scaled features col . You can see the following snap

```
showing dataset with scaled feature after scalling
+--------------------+--------------------+
|            features|      scaledFeatures|
+--------------------+--------------------+
|[0.0,1.0,6.0,2.0,...|[-0.5024394581349...|
|(13,[2,7,8,9,12],...|[-0.5024394581349...|
|(13,[0,2,7,8,9,12...|[1.03413436858976...|
|(13,[2,4,7,8,9,10...|[-0.5024394581349...|
|(13,[1,2,3,7,8,9,...|[-0.5024394581349...|
+--------------------+--------------------+
only showing top 5 rows
```

3.4.9 Split the dataset

Now the data is almost ready here we will check that split data count that how much is data for testing and how much data for training you can se the following screen shot to see the size of test and train data

```
#split the data
### Randomly split data into training and test sets. set seed for reproducibility
(trainingData, testData) = testing.randomSplit([0.7, 0.3], seed=100)
print("Training Data",trainingData.count())
print("Testing Data",testData.count())
```

```
Training Data 31676
Testing Data 13546
```

Here we can see that 31676 for training and 13546 for testing the data i.e 70% for training and 30% for testing now we will check that data is balance or not

```
#people that have $>50k incom and <=50k
higher=trainingData.filter(trainingData['income']=='>50K').count()
lower=trainingData.filter(trainingData['income']=='<=50K').count()
#trainingData.groupBy("income").count().show()
print("people that have the income >50k per year:",higher)
print("people that have the income <=50k per year:",lower)
print("Data is imbalance so we need to balance the data")
```

```
people that have the income >50k per year: 7887
people that have the income <=50k per year: 23789
Data is imbalance so we need to balance the data
```

I have 7887 people that have >$50000 and 23789 have <=$500000 which mean data is imbalanced so I need data balancing

3.4.10 Data Balancing

I need under sampling for balancing the data that mean the 7887 number of people that have >$50000 should be the around about the people 23789 that have <=$500000 .ypu can see the following screenshot of doing under sampling as well :-

```
print("After downsampling")
higher=balanced_df.filter(balanced_df['income']=='>50K').count()
lower=balanced_df.filter(balanced_df['income']=='<=50K').count()
print("people that have the income >50k per year:",higher)
print("people that have the income <=50k per year:",lower)
#print(testData.count())
```

```
After downsampling
people that have the income >50k per year: 7887
people that have the income <=50k per year: 5820
```

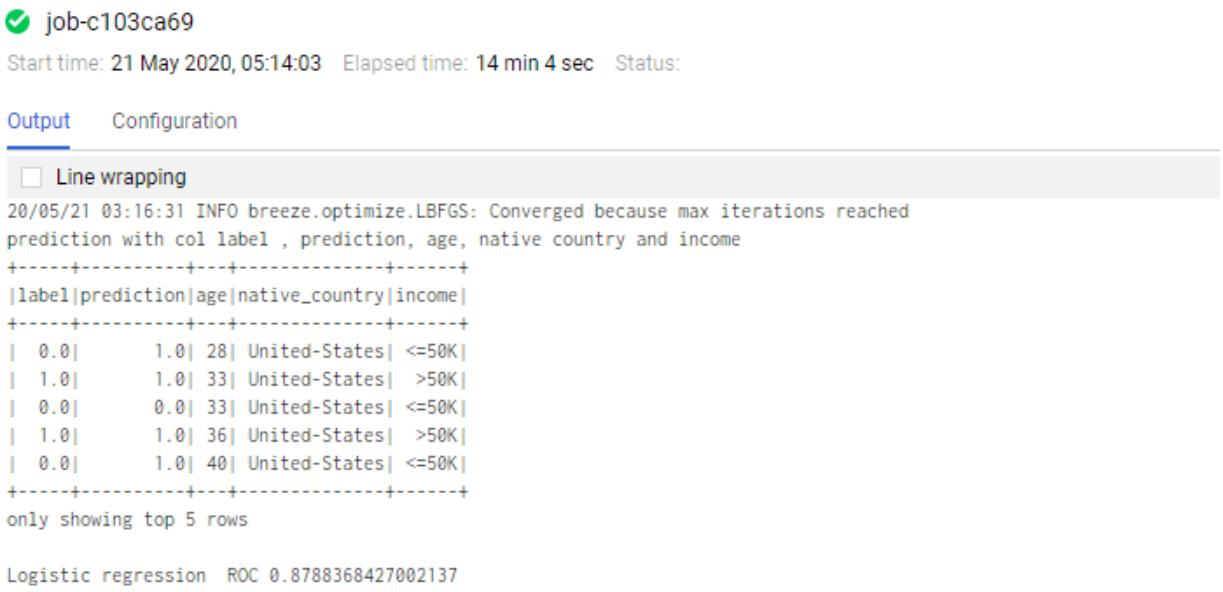
Now you can see that the data is balanced now we can train the different model and predict the data.

3.5 Machine Learning

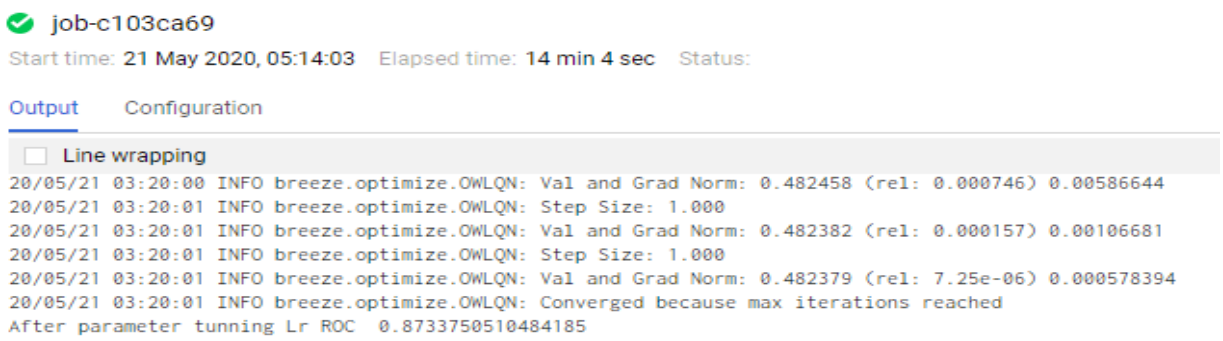
machine learning is basically performing some rules on the dataset and make prediction of test data. This is supervised machine learning task and in supervised machine learning the data set always given with the label class.so I have data and I perform some steps on data. Now the data has been ready for the processing of machine leaning. Now I will perform different number of algorithm and will find the ROC that will help to evaluate the algorithm.

3.5.1 Logistic Regression

Logistic regression is used for classification task to predict the label class by using the given information. I train the logistic regression model with training data and then predict the test data. You can see the output of logistic regression algorithm with label , prediction , income, age ,native country .we can add more feature in output if we want but now I only showing the selected attributes .the following screenshot can be seen Here you can see the accuracy of logistic regression without hyper parameter tuning

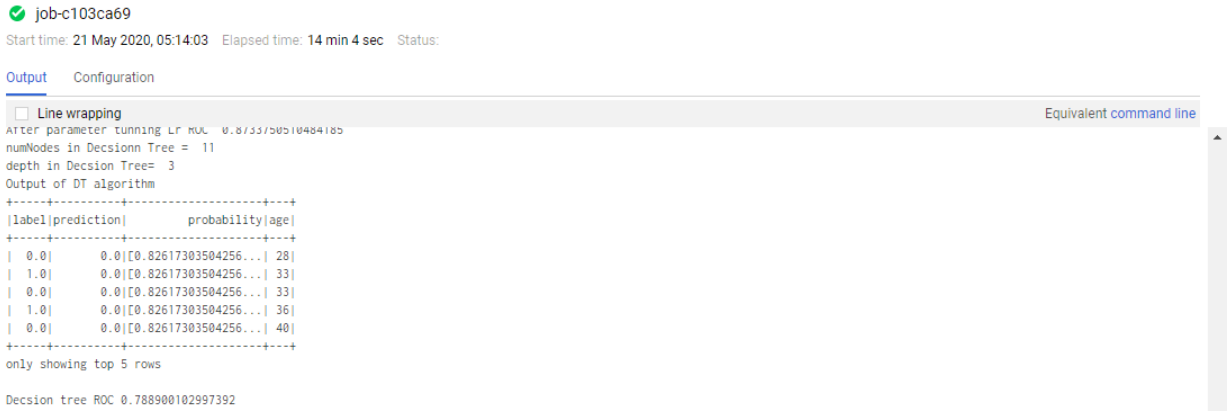


I used the ParamGridBuilder for parameter tuning.it gives me the best parameters and I trained the model with these credentials you can see there is slight difference between the accuracy. You can see the accuracy after parameter tuning following: -

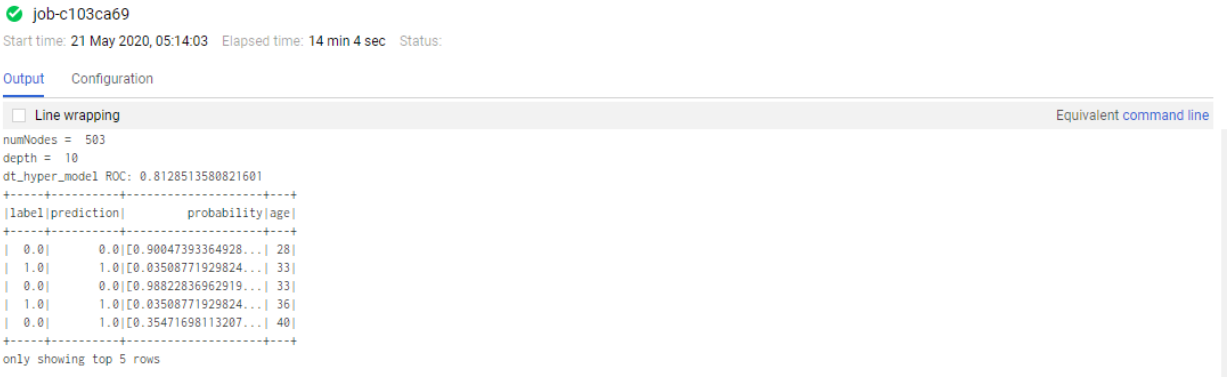


3.5.2 Decision Tree

After the Logistic regression I implemented the Decision tree and make prediction based on this model. I train this model with max depth=3 and num nodes= 11 and you can see the following screenshot for the out put of decesion tree and also you can see the ROC =0.78 of the decision tree as well

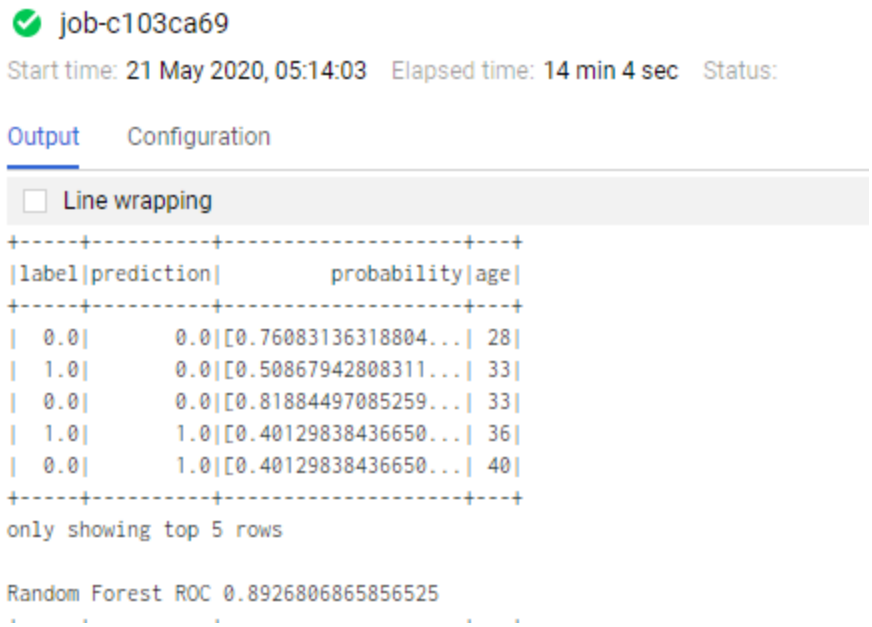


After this I used ParamGrid and Crossvalidator for parameter tuning .the param grid give me the best parameter for this model and crossvalidator slpit the data as well.now I train the model with the best parameters you can see the following screenshot the decision tree after the parameter tuning and it increase the value of ROC =0.8128 which is better the model trained before.

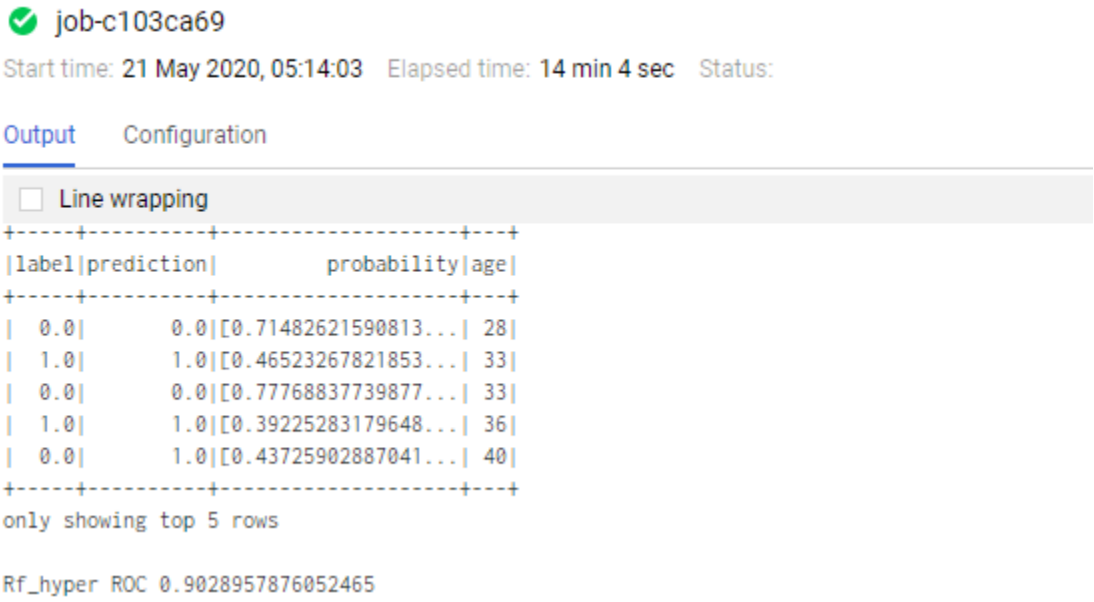


3.5.3 Random Forest

In This part I used the Random forest algorithm to train the model and make prediction based on this model. The model is evaluated by the binary classification evaluator. In the following screenshot you can see the evaluated Roc of this model

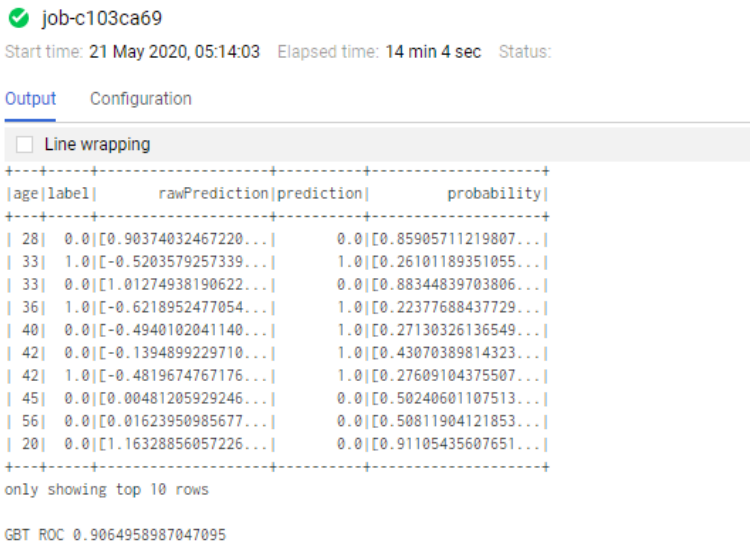


After this again I tune the parameter and made model based on these best credentials. And make prediction based on this model. You can see the out in following screenshot as well

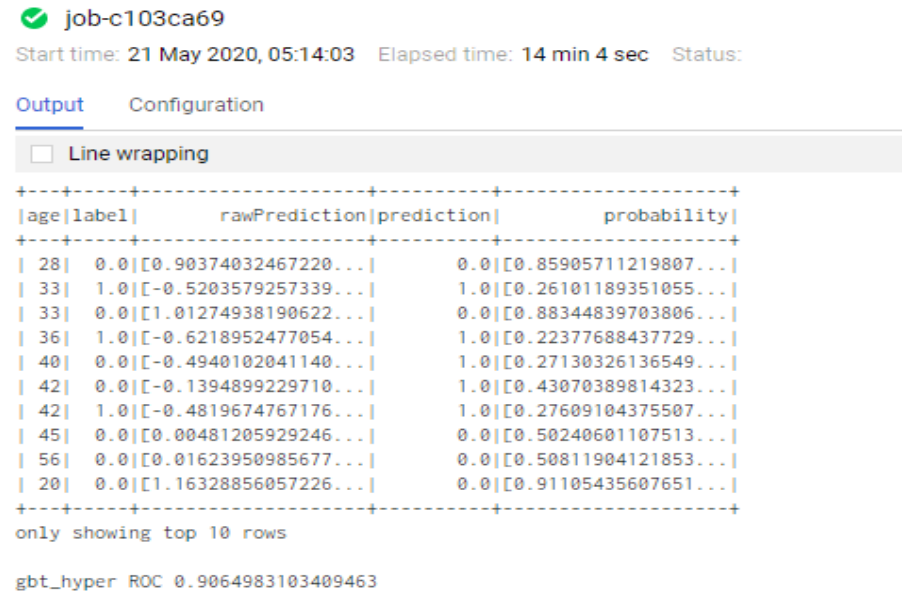


3.5.4 Gradient Boost Tree Classifier

The fourth algorithm that I have implemented on this dataset is gradient boost tree classifier. the gradient boost tree classifier is used for binomial classification and I train the model with GBTC and made prediction based on this model. I evaluated the model based on ROC you can see the following screen shot for output of the GBTC.

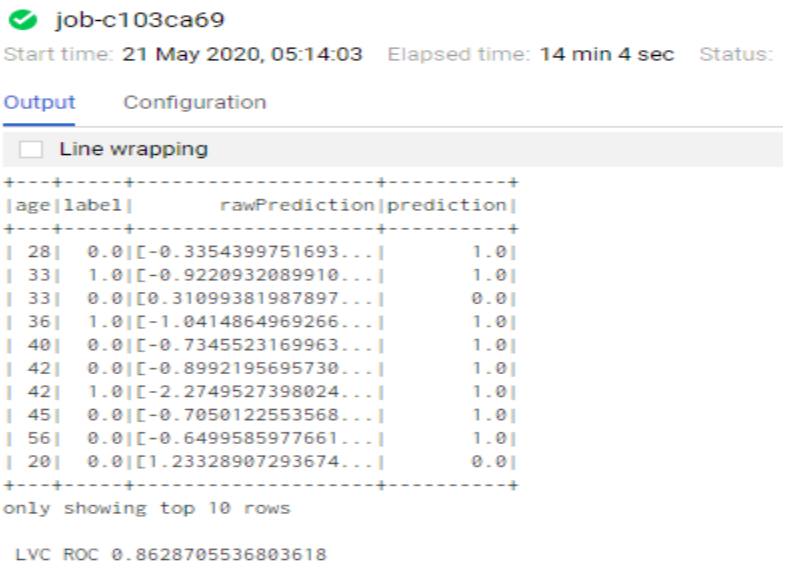


After this I have done the hyper parameter tuning and train the model based on these best parameters that is received from paramgrid and made prediction with this model. You can see the Roc of this model after parameter tuning. There is slight difference between the ROC.

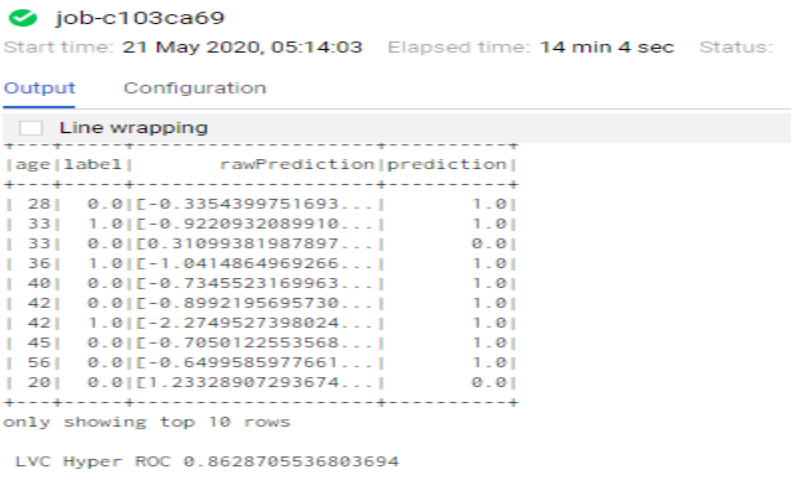


3.5.5 Linear SVS

The last algorithm I implemented on this data is linear SVS with max iteration = 10. I train the model according to the parameters and make prediction with this model. I evaluated this model based on the ROC. You can see the following screen shot for the Linear SVS output as well.



After this I have done the hyper parameter tuning with ParamGrid and Cross validator and the train model according to the credential that is received from Paramgrid and Cross validator. You can see the output of this model below as well.



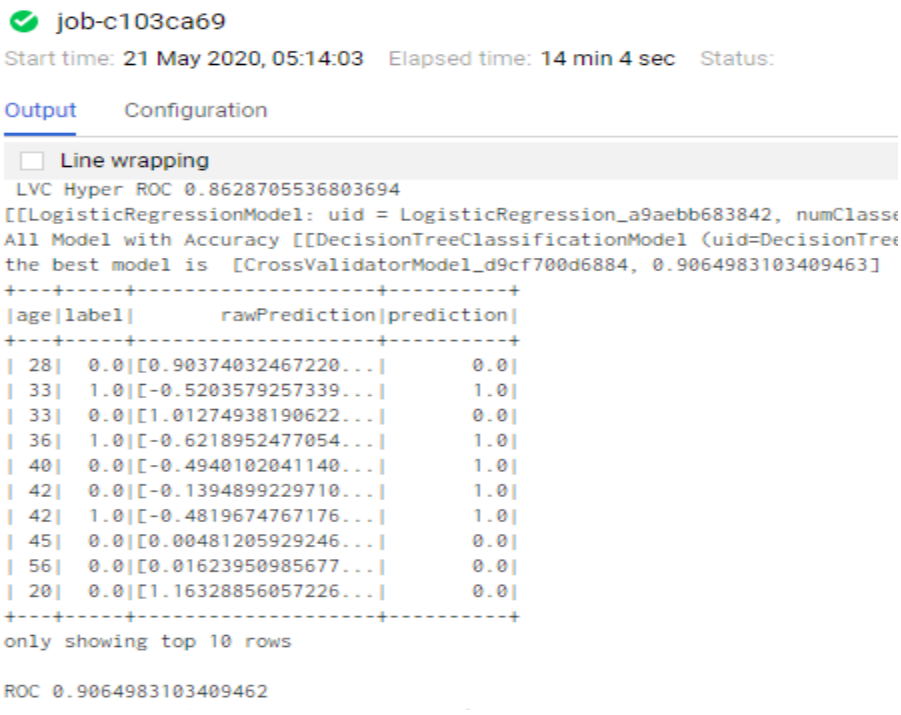
3.6 Model Selection

I have implemented the five different model on this dataset and now its time to choose the best model that have trained with different parameters. I selected the best model based on the ROC. I have the ROC of all the model so I can choose the model that have the best ROC score. Predict the test data with this best model and save the output file on GCP bucket. Following table is containing the information of all five-model including the ROC before the parameters tuning and after the parameters tuning as well and I will select the best model based on the ROC.

ROC Table of algorithms

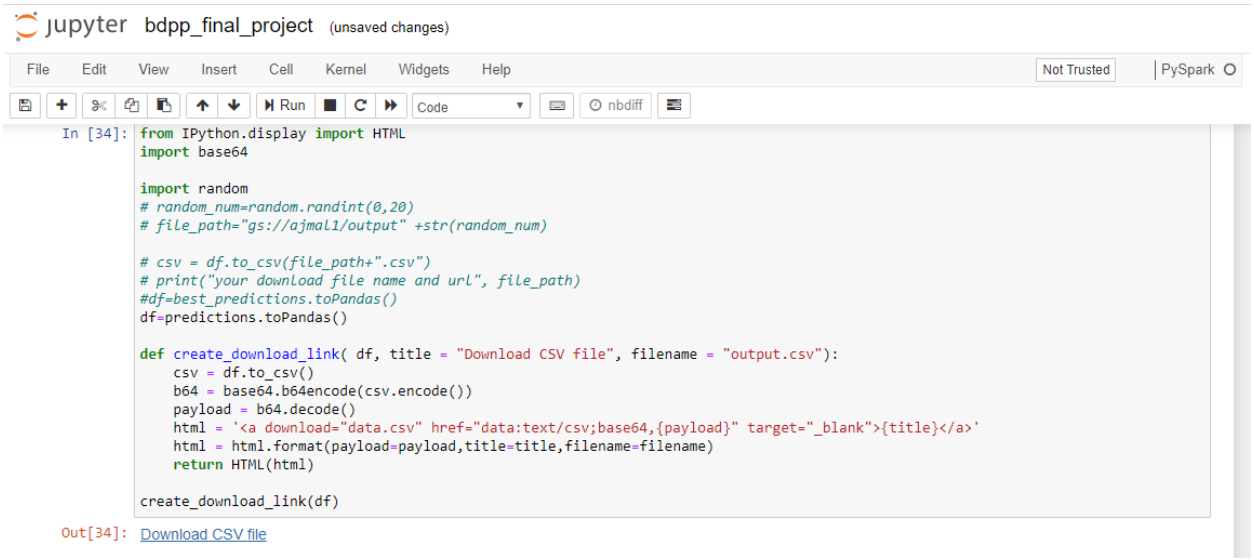
No#	Name	ROC Before Parameter Tuning	ROC After parameter tuning
1	Logistic Regression	0.8799046772930779	0.8733750510484185
2	Decision Tree	0.788900102997392	0.8128513580821601
3	Random Forest	0.8926806865856525	0.9028957876052465
4	Gradient Boost Tree Classification	0.9064958987047095	0.9064983103409463
5	Linear SVS	0.8628705536803618	0.8628705536803694

We can see that from the table that all the model has different ROC and the Gradient Boost Tree Classifier has the maximum ROC score. I chased the best model Gradient Boost Tree Classifier for the final prediction as it has the maximum score based on ROC. You can see the final prediction output with best model Gradient Boost Tree Classifier following: -



3.7 Creating Output Link on Jupyter Notebook

Finally, I have chosen the best model and made prediction with best model. Now I will create a hyper link in jupyter notebook where a user can download the output of prediction by clicking on the link on jupyter notebook. You can see the following screen shot for creating the hyper link for downloading the output file.



3.8 Saving output on GCP Bucket

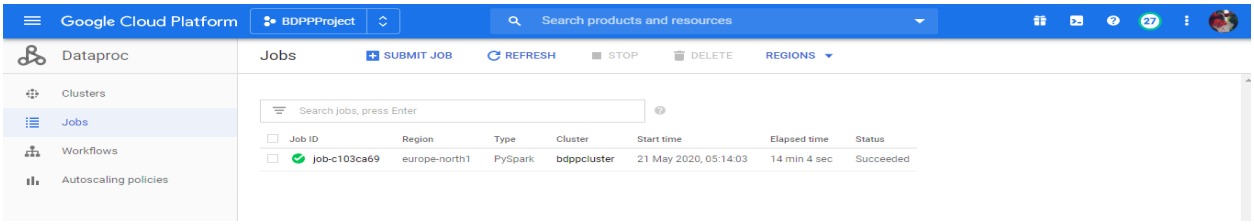
Now I will store the output file on GCP bucket storage. The user also can download the output csv file from GCP bucket .the following code will upload the output csv file on Bucket :

Uploading the output file on GCP Bucket

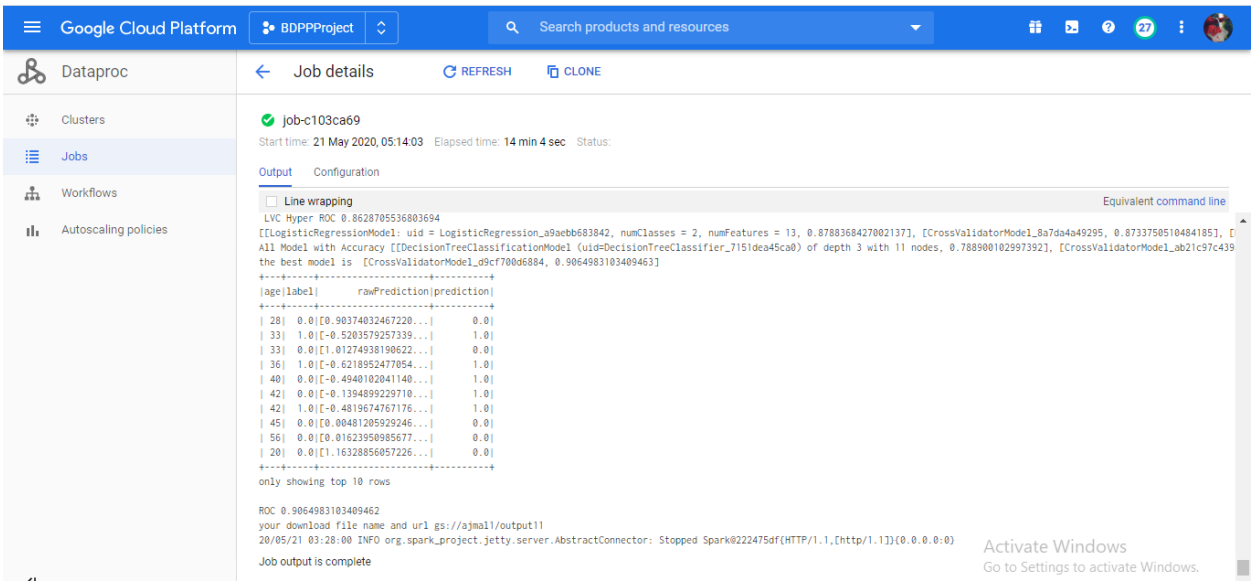
```
#Uploading the file to cloud bucket
import random
random_num=random.randint(0,20)
file_path="gs://ajmal1/output" +str(random_num)

df=best_predictions.toPandas()
csv = df.to_csv(file_path+".csv")
print("your download file name and url", file_path)
```

3.9 Job submission

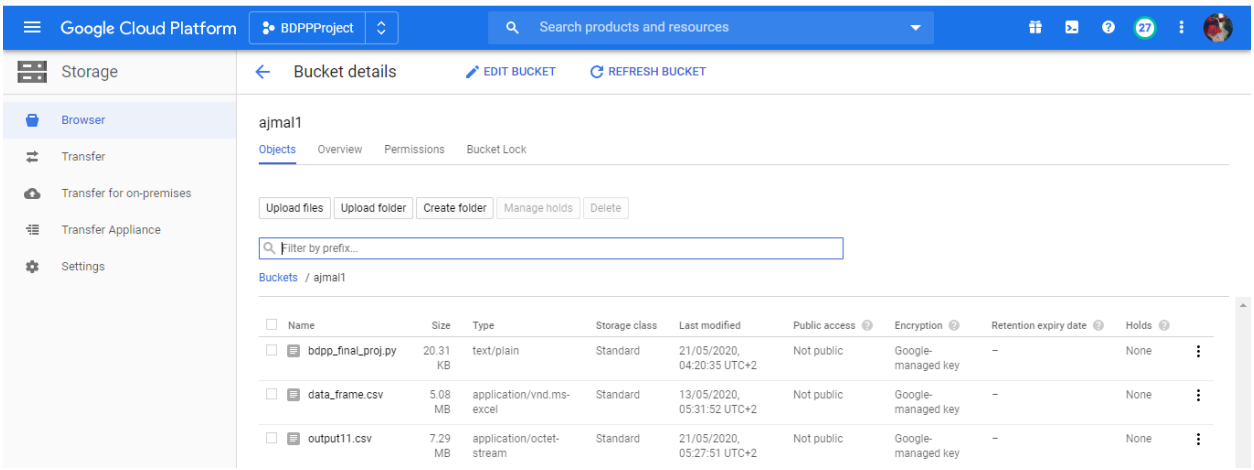
after completing the code in jupyter notebook now I must submit a cluster job with main python file and cluster will run the job on GCP we can see all the output on the GCP as well .the following screenshot containing the job status, job id and other credential :



After submitting the job, we can see the job detail which is containing the job output configuration etc. You can see the following screen shot:



After this we can see our Bucket that has output csv file on GCP bucket as well . Following screenshot containing the bucket file detail



4 Problems and solution on GCP

Problem1: pyspark did not load directly from the GCP bucket and topandas() function is not working

- ✓ Create d a cluster with spark 2.4.5 slove the problem

Problem2: Matplotlib and google.cloud libraries are not working on jupyter notebook

- ✓ Install explicitly libraries on master node with pip command

Problem:3 creating a firewall rule with ip range 0.0.0.0

- ✓ Solve it by giving the ip with subnet mask also like: 0.0.0.0/0

Problem4: Job submission with ipynb file

- ✓ Solve it by changing the file type ipynb to .py

5 Conclusion

Finally, I have done all the step with code and GCP task. I have done five different algorithms with pyspark and got the Roc of each model. Then I select the best algorithms Gradient Boost Tree Classification for census income dataset with 0.90 ROC .The Roc is depend upon the dataset that how we prepare the data for the machine learning .after this I used GCP for hosting the project as the GCP has more features than IBM Watson. GCP is realy big platform and has bigquery , storage , network , firewall and much others interesting features. The future scope of this work involves achieving an over-all better set of results by using hybrid models with inclusion of Machine Learning and Deep Learning together, or by applying many other advanced preprocessing techniques without further depletion in the accuracy.