Project: Movie Recommendation with MLlib - Collaborative Filtering

Student :

Presented by MANICKAM RAVISEKAR ,
Master of Science in Computer Science, 19599 , Fall Semester 2022

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ACKNOWLEDGEMENT

One of our master's degree Project for Machine Learning using,

Colab notebooks which allows us to combine executable code and rich text in a single document and saving same cells from ipynb to py (python).

Is an Interesting, which made me to learn new things, it is useful in designing and applying on Google Cloud Platform.

Using MLlib (**machine learning library**) is built on top of Spark as part of the Spark package.

For deploying this project, I would like to thank Dr. Henry Chang an TA Liang for providing all the required input .

Also, for all I would like to always pray to Almighty for giving us wisdom and power to understand things.

Content

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Abstract

MovieLens is a recommender system and virtual community website that recommends movies for its users to watch, based on their film preferences using collaborative filtering. MovieLens 100M datatset is taken from the MovieLens website, which customizes user recommendation based on the ratings given by the user. To understand the concept of recommendation system better, we will work with this dataset.

Collaborative filtering **uses similarities between users and items simultaneously to provide recommendations**.

I would like thank Dr Henry chung for providing the guidance and assigning this project .

Recommender System is an information filtering tool that seeks to predict which product a user will like, and based on that, recommends a few products to the users. For example, Amazon can recommend new shopping items to buy, Netflix can recommend new movies to watch, and Google can recommend news that a user might be interested in. The two widely used approaches for building a recommender system are content-based filtering (CBF) and collaborative filtering (CF).

To understand the concept of recommender systems, let us look at an example. The below table shows the user-item *utility matrix* Y where the value Rui denotes how item i has been rated by user u on a scale of 1–5. The missing entries (shown **?** in Table) are the items that have not been rated by the respective user.

	Item 1	Item 2	Item 3	Item 4
User 1	2	5	1	3
User 2	4	?	?	1
User 3	?	4	2	?
User 4	2	4	3	1
User 5	1	3	2	?

Explicit v.s. Implicit ratings

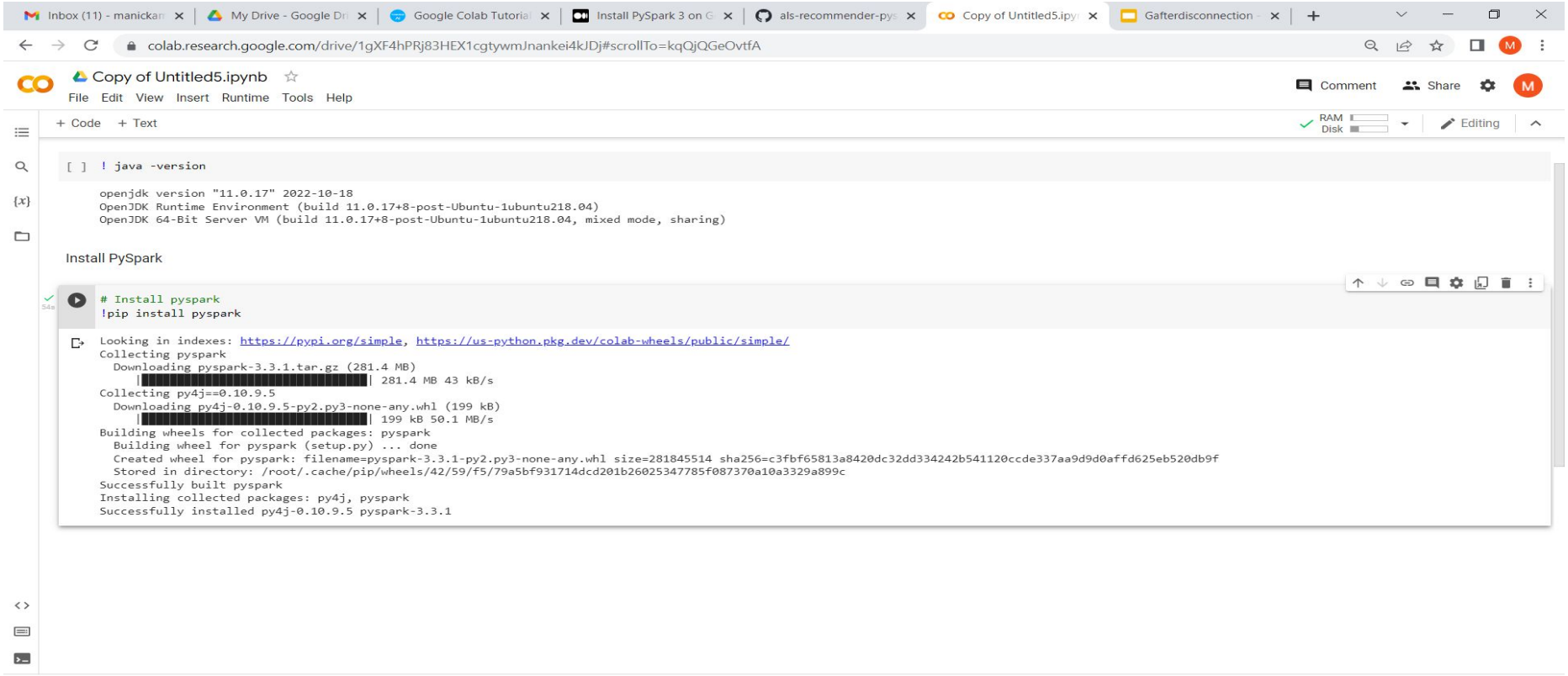
There are two ways to gather user preference data to recommend items, the first method is to ask for **explicit ratings** from a user, typically on a concrete rating scale (such as rating a movie from one to five stars) making it easier to make extrapolations from data to predict future ratings. However, the drawback with explicit data is that it puts the responsibility of data collection on the user, who may not want to take the time to enter ratings. On the other hand, **implicit data** is easy to collect in large quantities without any extra effort on the part of the user. Unfortunately, it is much more difficult to work with.

Data Sparsity and Cold Start

In real world problems, the utility matrix is expected to be very sparse, as each user only encounters a small fraction of items among the vast pool of options available. The cold-start problem can arise during the addition of a new user or a new item where both do not have a history in terms of ratings. Sparsity can be calculated using the below function.def get_mat_sparsity(ratings):

```
def get_mat_sparsity(ratings):
    # Count the total number of ratings in the dataset
    count_nonzero = ratings.select("rating").count()
    # Count the number of distinct userIds and distinct movieIds
    total_elements = ratings.select("userId").distinct().count() * ratings.select("movieId").distinct().count()
    # Divide the numerator by the denominator
    sparsity = (1.0 - (count_nonzero *1.0)/total_elements)*100
    print("The ratings dataframe is ", "%.2f" % sparsity + "% sparse.")
get_mat_sparsity(ratings)
```

Colab Cells Steps to Find the best model and recommendations



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After installation, we can create a Spark session and check its information.

```
[3] # Import SparkSession
    from pyspark.sql import SparkSession
```

```
[4] # Create a Spark Session
    spark = SparkSession.builder.master("local[*]").getOrCreate()
```

```
# Check Spark Session Information
spark
```

SparkSession - in-memory

SparkContext

Spark UI

Version
v3.3.1
Master
local[*]
AppName
pyspark-shell

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We can also test the installation by importing a Spark library.

Double-click (or enter) to edit

```
[6] # Import a Spark function from library
    from pyspark.sql.functions import col
```

Import libraries

```
[7] #https://grouplens.org/datasets/movielens/
```

```
[8] import pandas as pd
    from pyspark.sql.functions import col, explode
    from pyspark import SparkContext
```

Initiate spark session

```
from pyspark.sql import SparkSession
sc = SparkContext
# sc.setCheckpointDir('checkpoint')
spark = SparkSession.builder.appName('Recommendations').getOrCreate()
```

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RAM Disk Editing

1. Load data

```
[10] from google.colab import drive
     drive.mount('/content/drive')
```

```
Mounted at /content/drive
```

```
!ls -l /content/drive/MyDrive/
```

```
total 3035
drwx------ 2 root root    4096 Nov 16 15:31 'Colab Notebooks'
-rw------- 1 root root     143 Mar 23  2022 'Copy of CS540 - Project Group List.gsheet'
-rw------- 1 root root     143 Nov 17 04:08  Gafterdisconnection.gslides
drwx------ 2 root root    4096 Nov 17 00:16  GCollaborative-filtering
-rw------- 1 root root  494429 Nov 16 02:42  gmovies.csv
-rw------- 1 root root 2483721 Nov 16 02:45  gratings.csv
-rw------- 1 root root  118658 Nov 16 02:48  gtags.csv
-rw------- 1 root root     143 Nov 17 03:07  GWeek9-HW.gslides
```

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1. Dataset with Explicit Ratings (MovieLens)

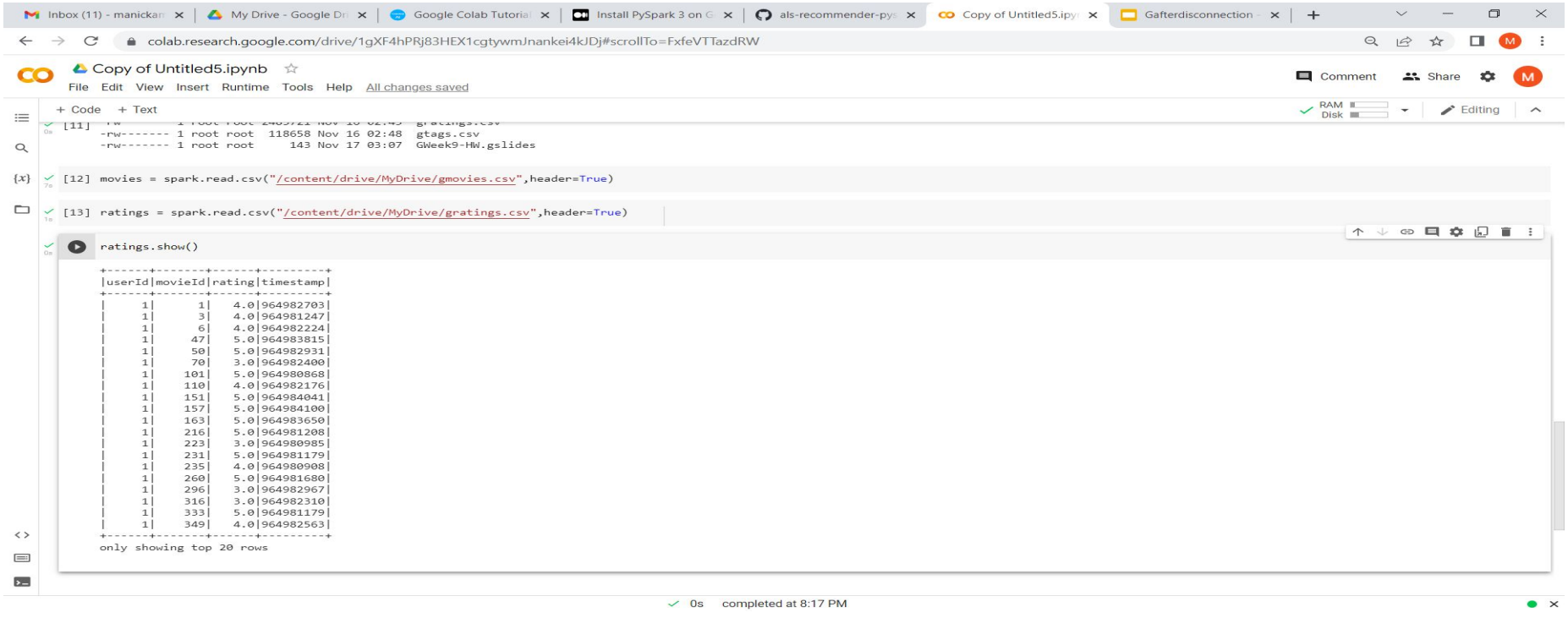
MovieLens is a recommender system and virtual community website that recommends movies for its users to watch, based on their film preferences using collaborative filtering. MovieLens 100M datatset is taken from the MovieLens website, which customizes user recommendation based on the ratings given by the user. To understand the concept of recommendation system better, we will work with this dataset. This dataset can be downloaded from here.

There are 2 tuples, movies and ratings which contains variables such as MovieID::Genre::Title and UserID::MovieID::Rating::Timestamp respectively.

Let's load the data and explore the data. To load the data as a spark dataframe, import pyspark and instantiate a spark session.

As show in the next slide

```
from pyspark.sql import SparkSessionspark =
SparkSession.builder.appName('Recommendations').getOrCreate()
movies = spark.read.csv("movies.csv",header=True)
ratings = spark.read.csv("ratings.csv",header=True)
ratings.show()
```



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RAM Disk Editing

```
[15] ratings.printSchema()
```

```
root
 |-- userId: string (nullable = true)
 |-- movieId: string (nullable = true)
 |-- rating: string (nullable = true)
 |-- timestamp: string (nullable = true)
```

```
ratings = ratings.\
    withColumn('userId', col('userId').cast('integer')).\
    withColumn('movieId', col('movieId').cast('integer')).\
    withColumn('rating', col('rating').cast('float')).\
    drop('timestamp')
ratings.show()
```

```
+------+-------+------+
|userId|movieId|rating|
+------+-------+------+
|     1|      1|   4.0|
|     1|      3|   4.0|
|     1|      6|   4.0|
|     1|     47|   5.0|
|     1|     50|   5.0|
|     1|     70|   3.0|
|     1|    101|   5.0|
|     1|    110|   4.0|
|     1|    151|   5.0|
|     1|    157|   5.0|
|     1|    163|   5.0|
|     1|    216|   5.0|
|     1|    223|   3.0|
|     1|    231|   5.0|
|     1|    235|   4.0|
|     1|    260|   5.0|
|     1|    296|   3.0|
|     1|    316|   3.0|
```

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```
ratings = ratings.\
    withColumn('userId', col('userId').cast('integer')).\
    withColumn('movieId', col('movieId').cast('integer')).\
    withColumn('rating', col('rating').cast('float')).\
    drop('timestamp')
ratings.show()
```

```
+------+-------+------+
|userId|movieId|rating|
+------+-------+------+
|     1|      1|   4.0|
|     1|      3|   4.0|
|     1|      6|   4.0|
|     1|     47|   5.0|
|     1|     50|   5.0|
|     1|     70|   3.0|
|     1|    101|   5.0|
|     1|    110|   4.0|
|     1|    151|   5.0|
|     1|    157|   5.0|
|     1|    163|   5.0|
|     1|    216|   5.0|
|     1|    223|   3.0|
|     1|    231|   5.0|
|     1|    235|   4.0|
|     1|    260|   5.0|
|     1|    296|   3.0|
|     1|    316|   3.0|
|     1|    333|   5.0|
|     1|    349|   4.0|
+------+-------+------+
only showing top 20 rows
```

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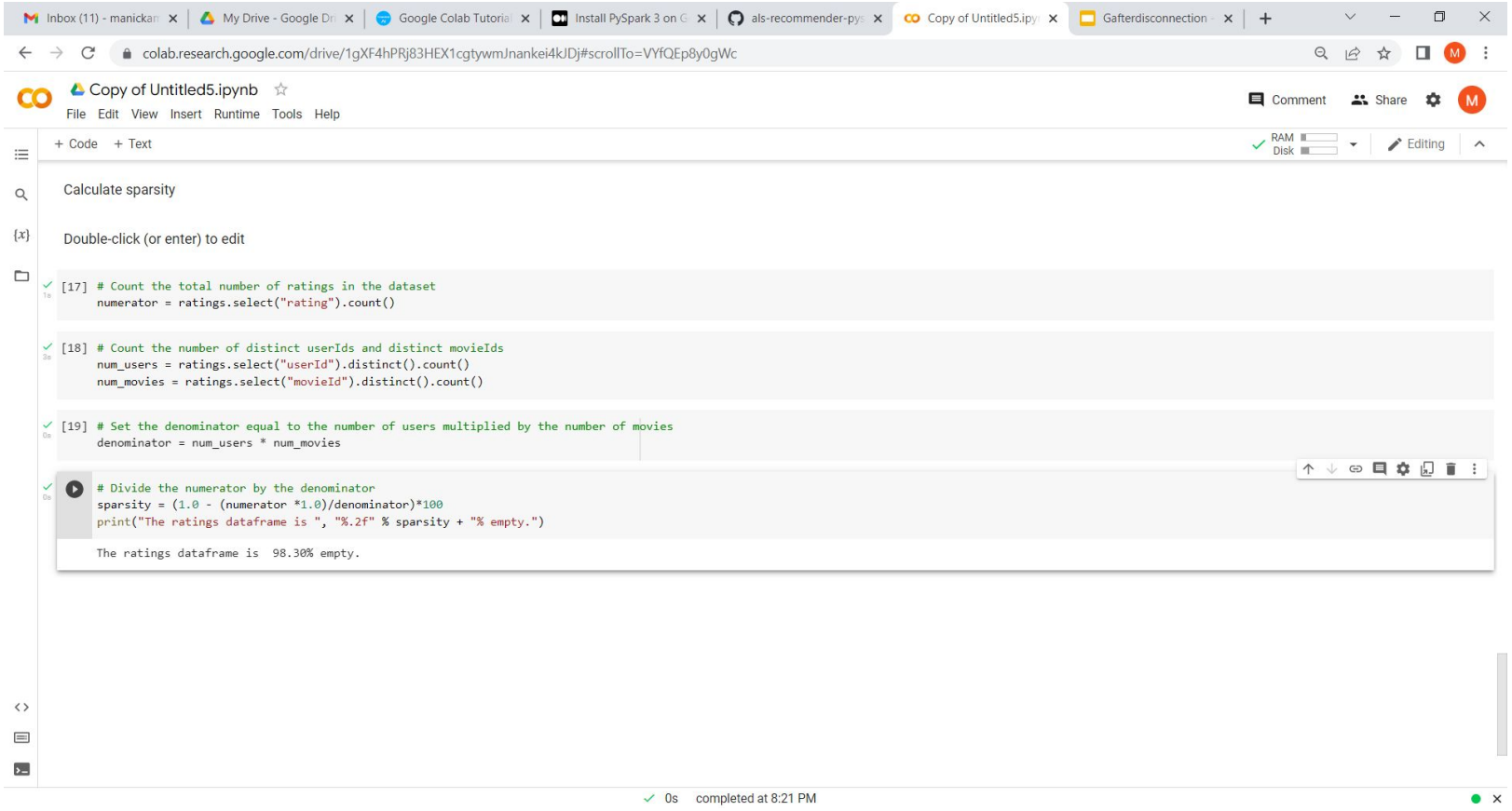
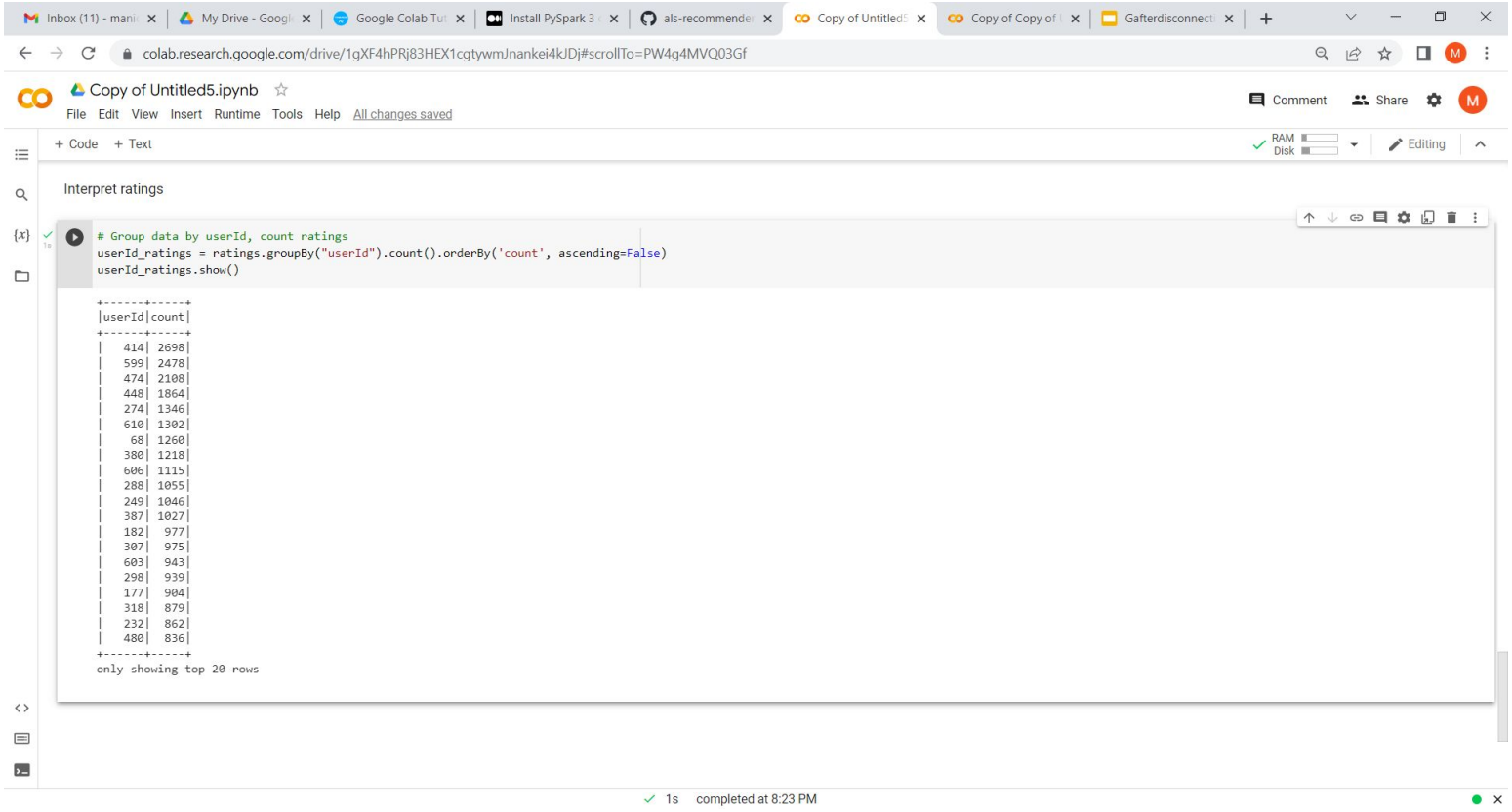
Calculate sparsity



Interpret ratings



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RAM Disk Editing

```
[21] |   480|  836|
     +------+-----+
     only showing top 20 rows
```

```
# Group data by userId, count ratings
movieId_ratings = ratings.groupBy("movieId").count().orderBy('count', ascending=False)
movieId_ratings.show()
```

```
+-------+-----+
|movieId|count|
+-------+-----+
|    356|  329|
|    318|  317|
|    296|  307|
|    593|  279|
|   2571|  278|
|    260|  251|
|    480|  238|
|    110|  237|
|    589|  224|
|    527|  220|
|   2959|  218|
|      1|  215|
|   1196|  211|
|   2858|  204|
|     50|  204|
|     47|  203|
|    780|  202|
|    150|  201|
|   1198|  200|
|   4993|  198|
+-------+-----+
only showing top 20 rows
```

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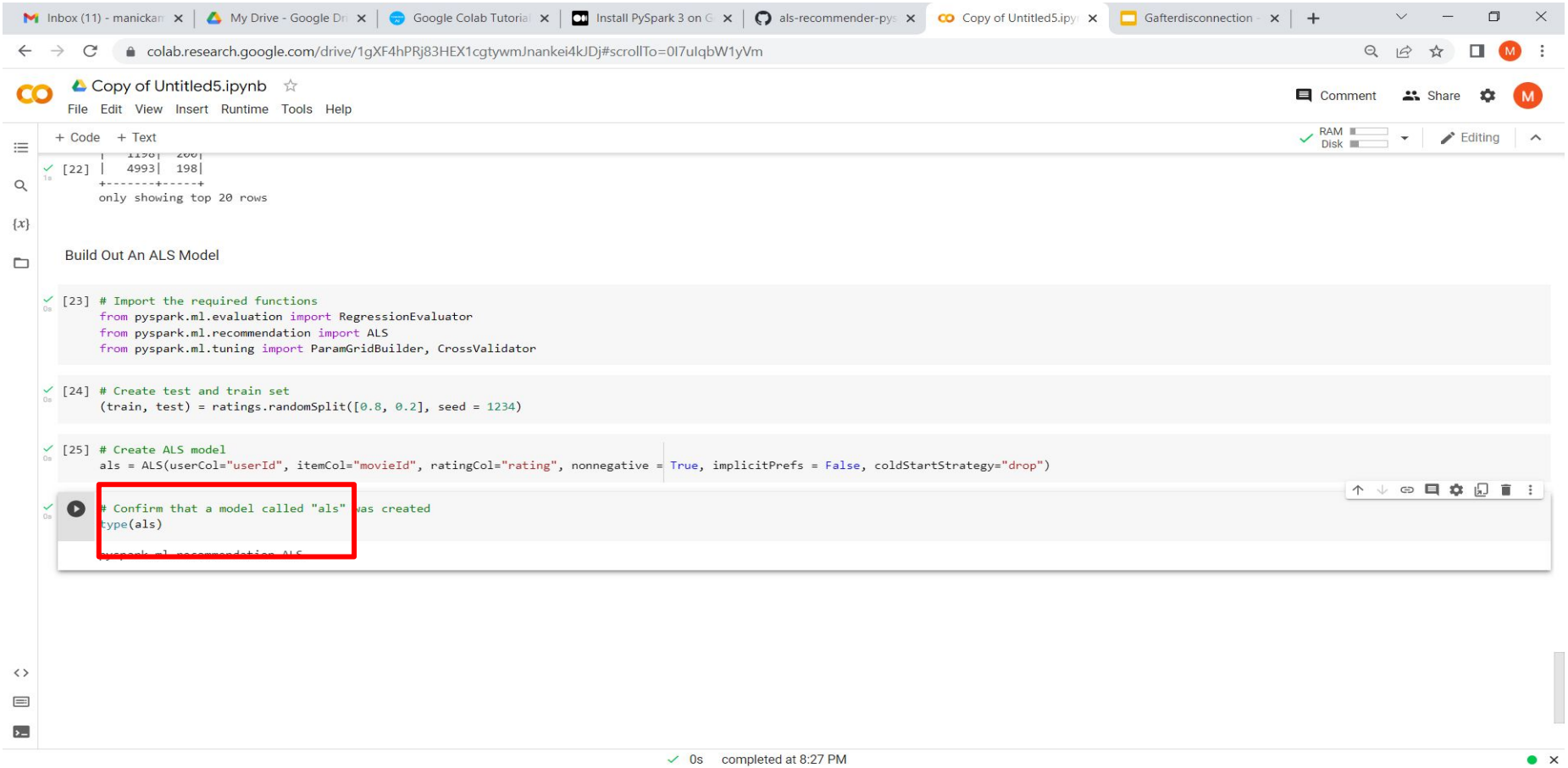
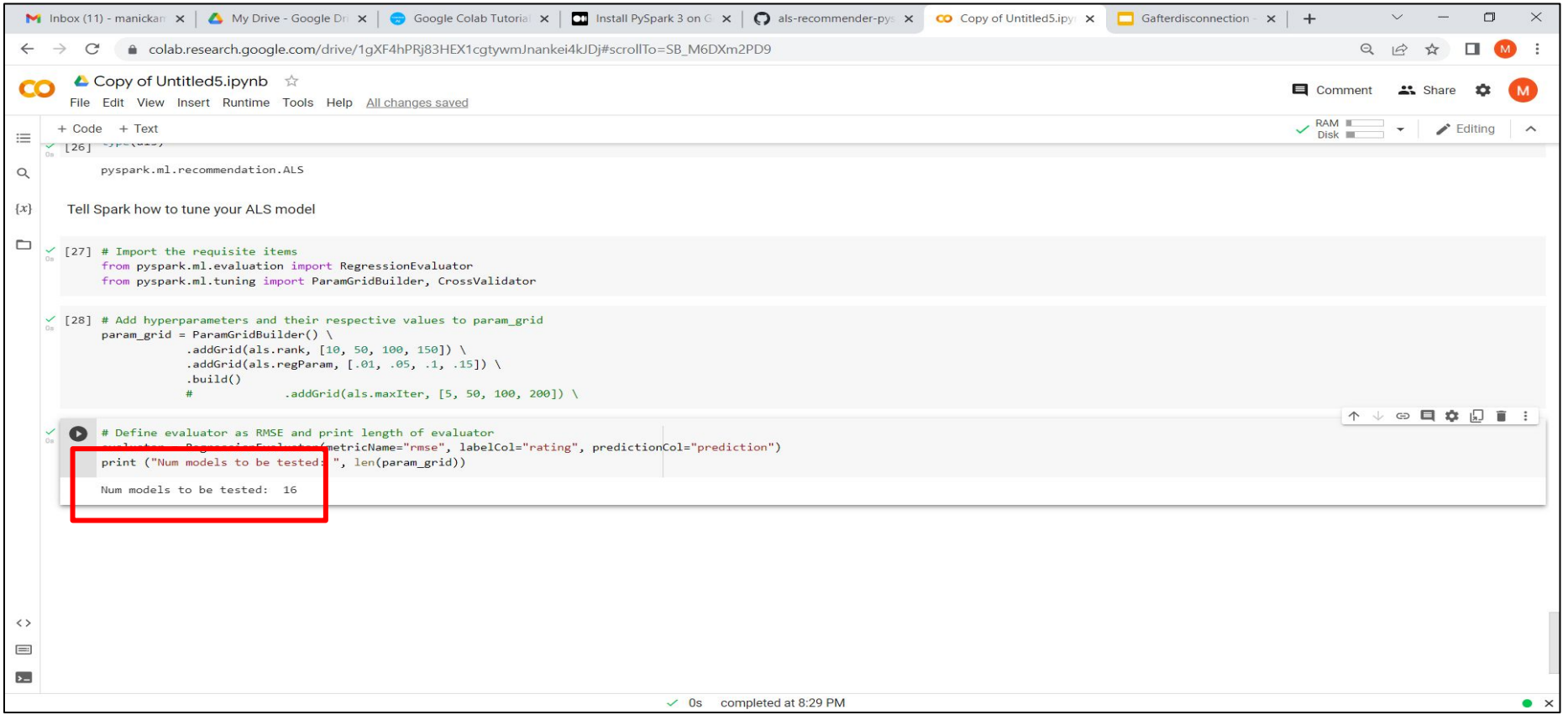
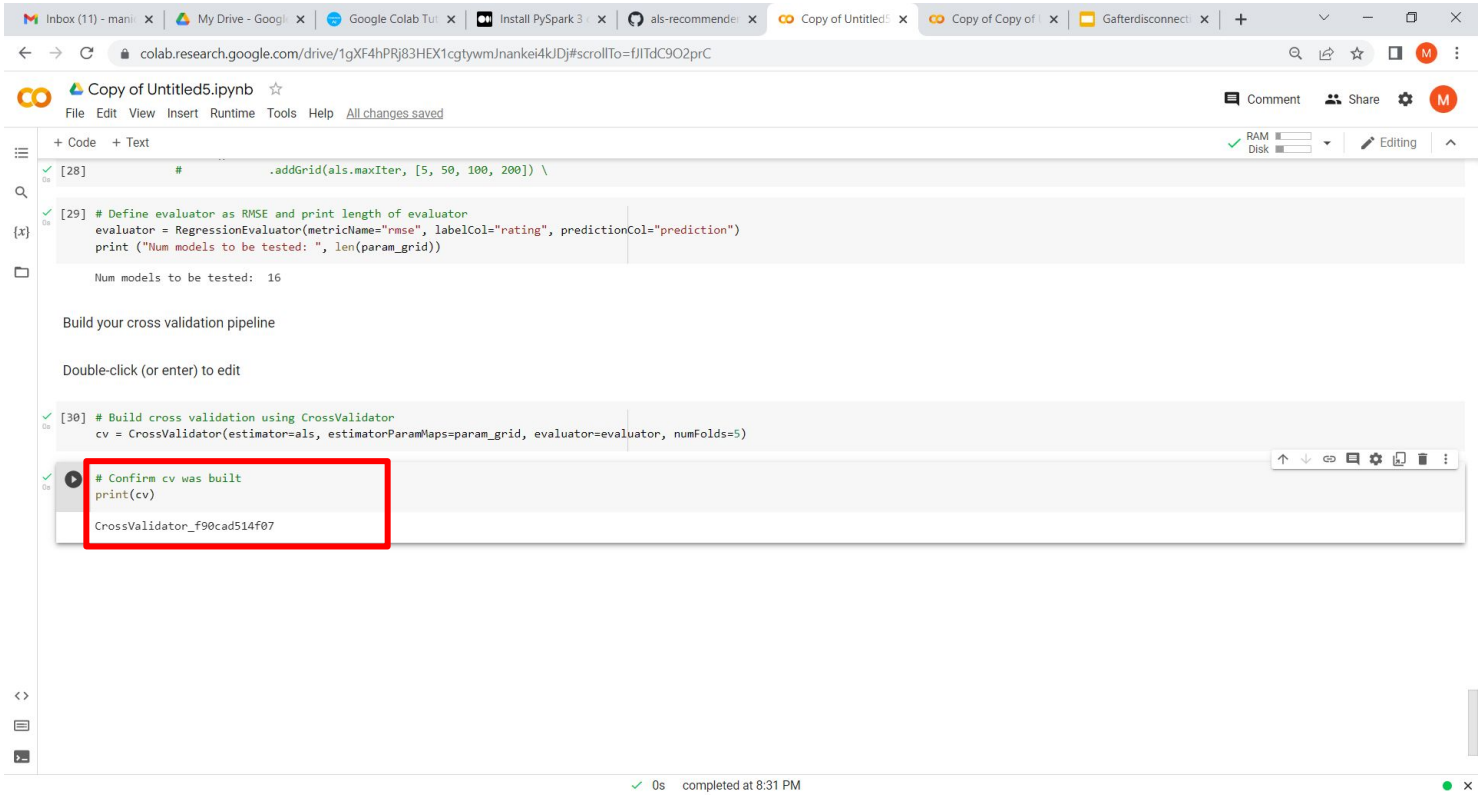
Build Out An ALS Model



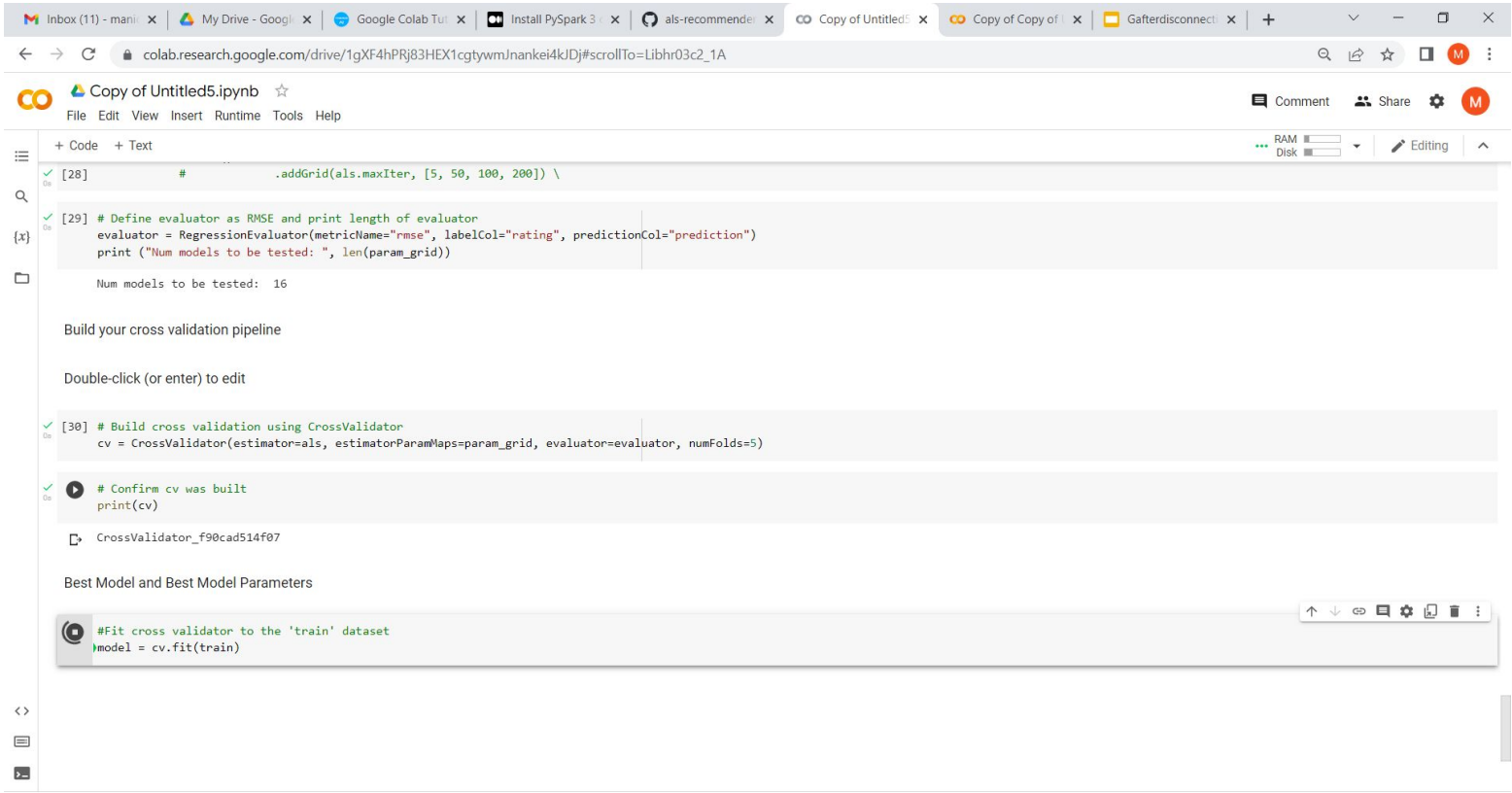
Tell Spark how to tune your ALS model



Build your cross validation pipeline



Best Model and Best Model Parameters



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RAM Disk Editing

```
[28]            #             .addGrid(als.maxIter, [5, 50, 100, 200]) \
```

```
[29] # Define evaluator as RMSE and print length of evaluator
     evaluator = RegressionEvaluator(metricName="rmse", labelCol="rating", predictionCol="prediction")
     print ("Num models to be tested: ", len(param_grid))
```

```
Num models to be tested:  16
```

Build your cross validation pipeline

Double-click (or enter) to edit

```
[30] # Build cross validation using CrossValidator
     cv = CrossValidator(estimator=als, estimatorParamMaps=param_grid, evaluator=evaluator, numFolds=5)
```

```
[31] # Confirm cv was built
     print(cv)
```

```
CrossValidator_f90cad514f07
```

Best Model and Best Model Parameters

```
#Fit cross validator to the 'train' dataset
model = cv.fit(train)
```

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RAM Disk Editing

```
[28]            #             .addGrid(als.maxIter, [5, 50, 100, 200]) \
```

```
[29] # Define evaluator as RMSE and print length of evaluator
     evaluator = RegressionEvaluator(metricName="rmse", labelCol="rating", predictionCol="prediction")
     print ("Num models to be tested: ", len(param_grid))
```

```
Num models to be tested:  16
```

Build your cross validation pipeline

Double-click (or enter) to edit

```
[30] # Build cross validation using CrossValidator
     cv = CrossValidator(estimator=als, estimatorParamMaps=param_grid, evaluator=evaluator, numFolds=5)
```

```
[31] # Confirm cv was built
     print(cv)
```

```
CrossValidator_f90cad514f07
```

Best Model and Best Model Parameters

```
[32] #Fit cross validator to the 'train' dataset
     model = cv.fit(train)
```

```
#Extract best model from the cv model above
best_model = model.bestModel
```

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[30]
```
# Build cross validation using CrossValidator
cv = CrossValidator(estimator=als, estimatorParamMaps=param_grid, evaluator=evaluator, numFolds=5)
```

[31]
```
# Confirm cv was built
print(cv)
```

```
CrossValidator_f90cad514f07
```

Best Model and Best Model Parameters

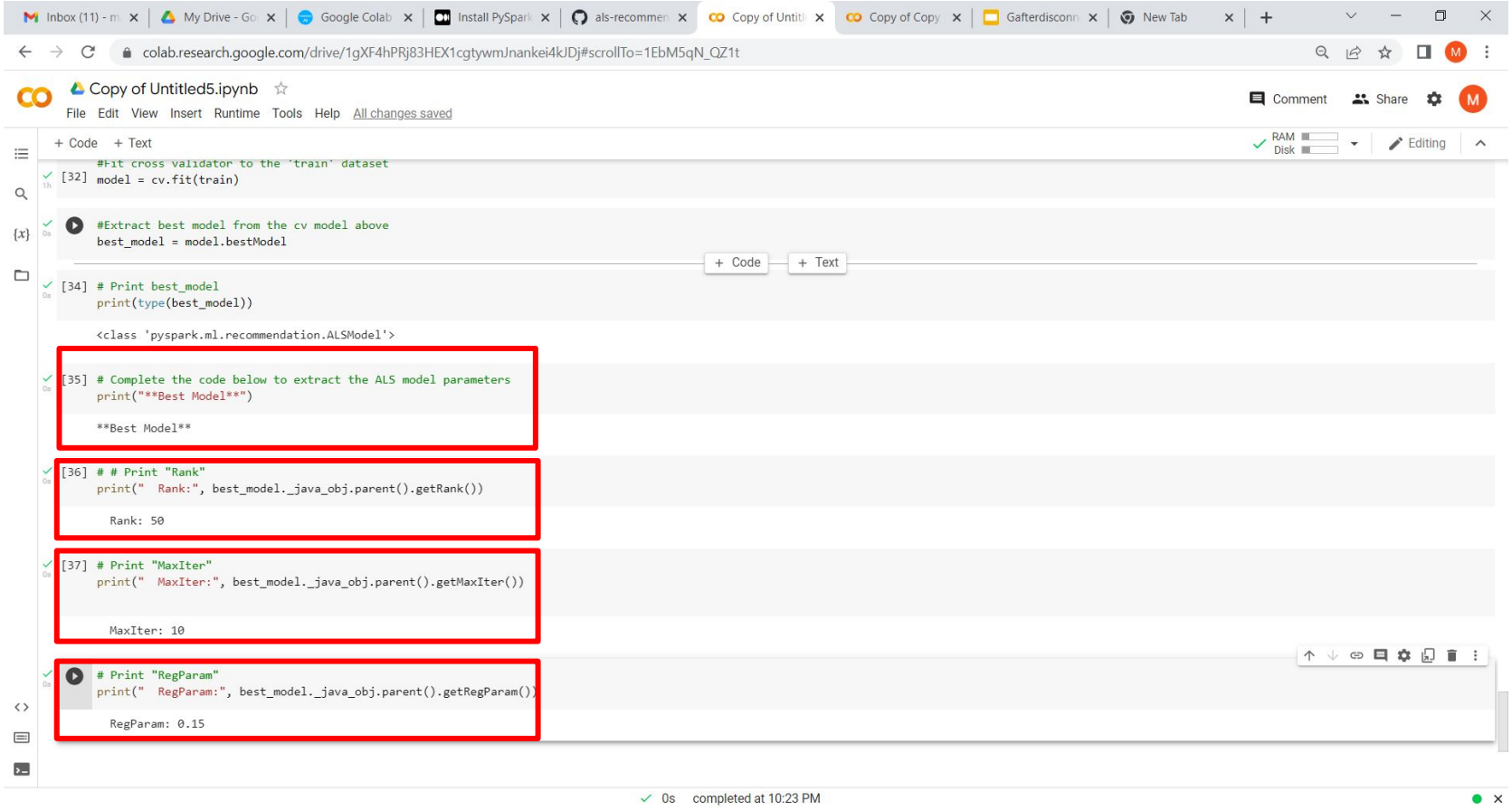
[32]
```
#Fit cross validator to the 'train' dataset
model = cv.fit(train)
```

[33]
```
#Extract best model from the cv model above
best_model = model.bestModel
```

```
# Print best_model
print(type(best_model))
```

```
<class 'pyspark.ml.recommendation.ALSModel'>
```

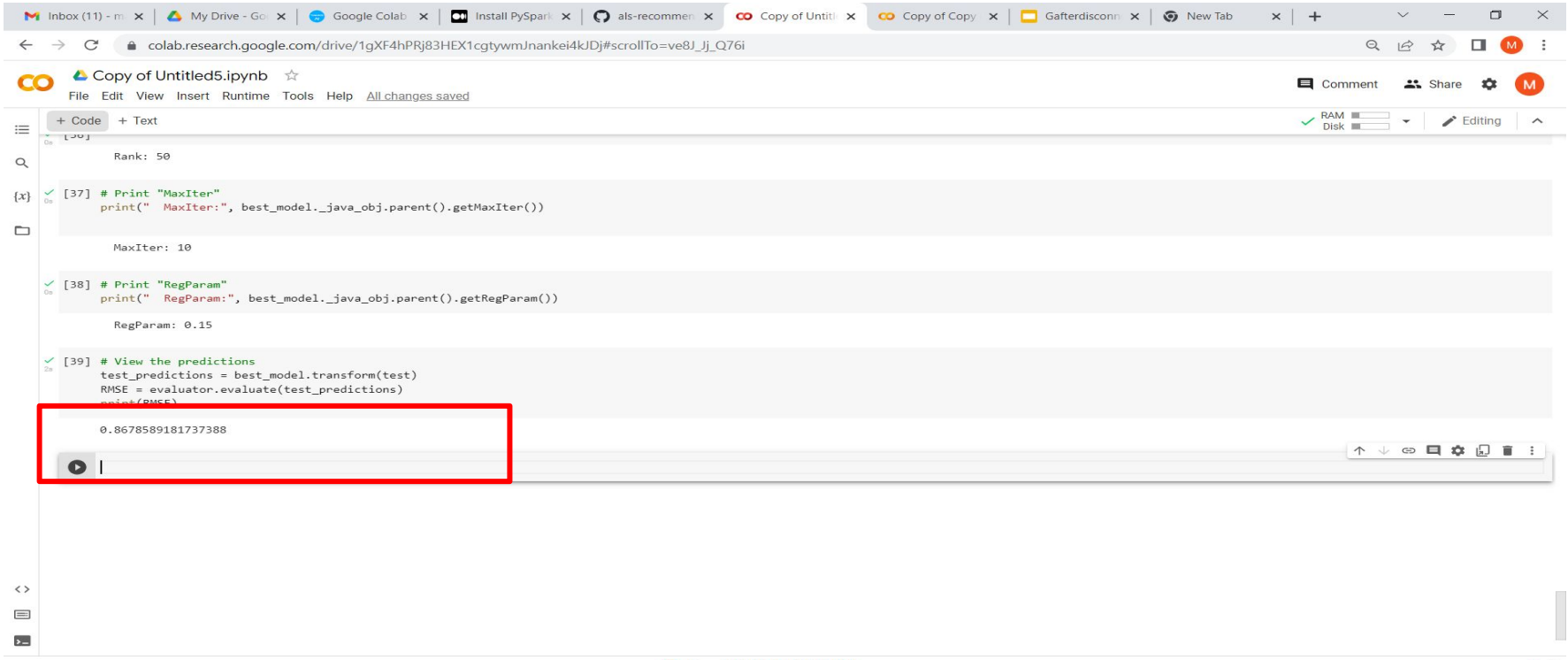
Print best model



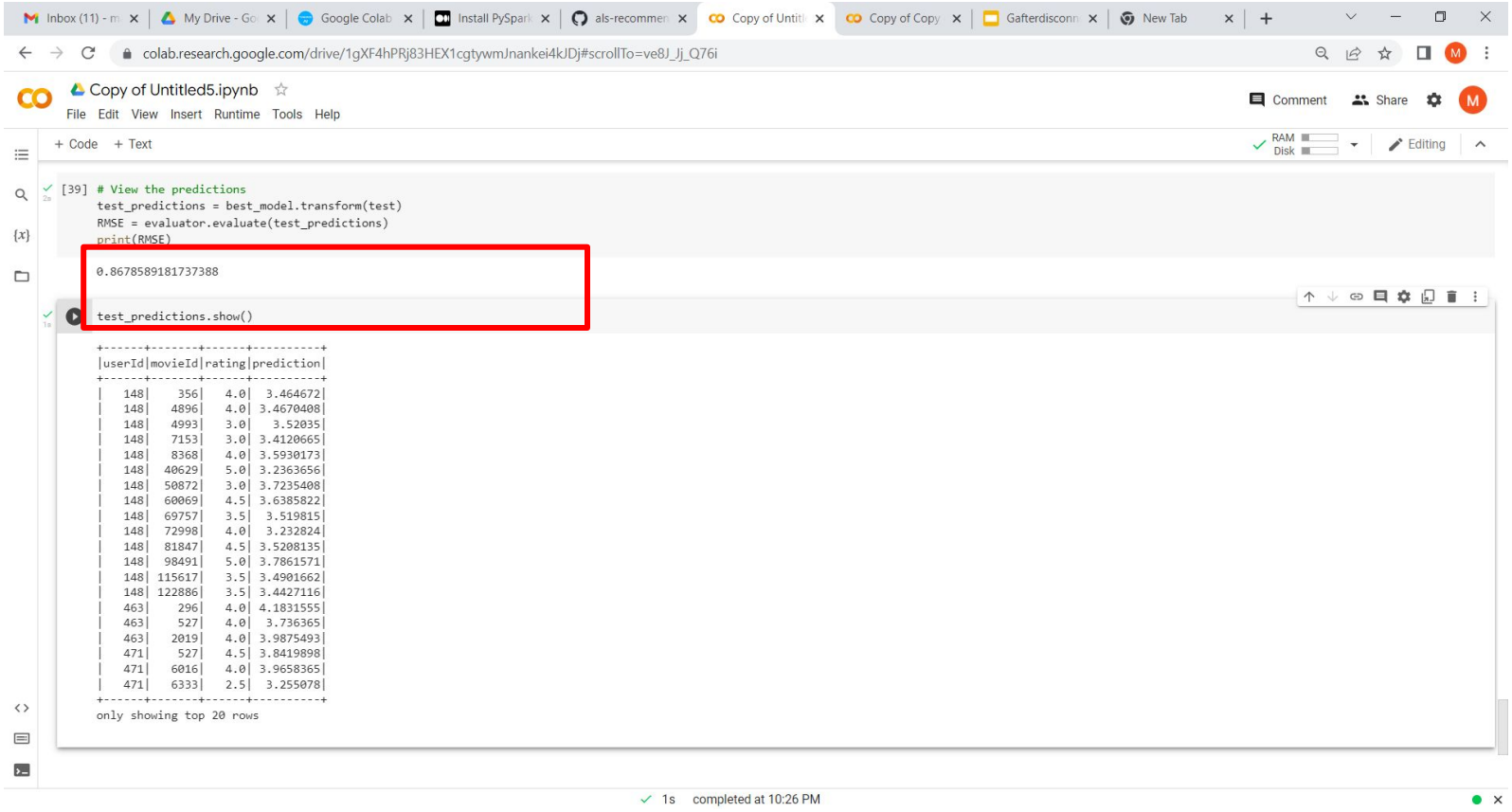
Print best model

```
**Best Model**
  Rank: 50
  MaxIter: 10
  RegParam: 0.15
```

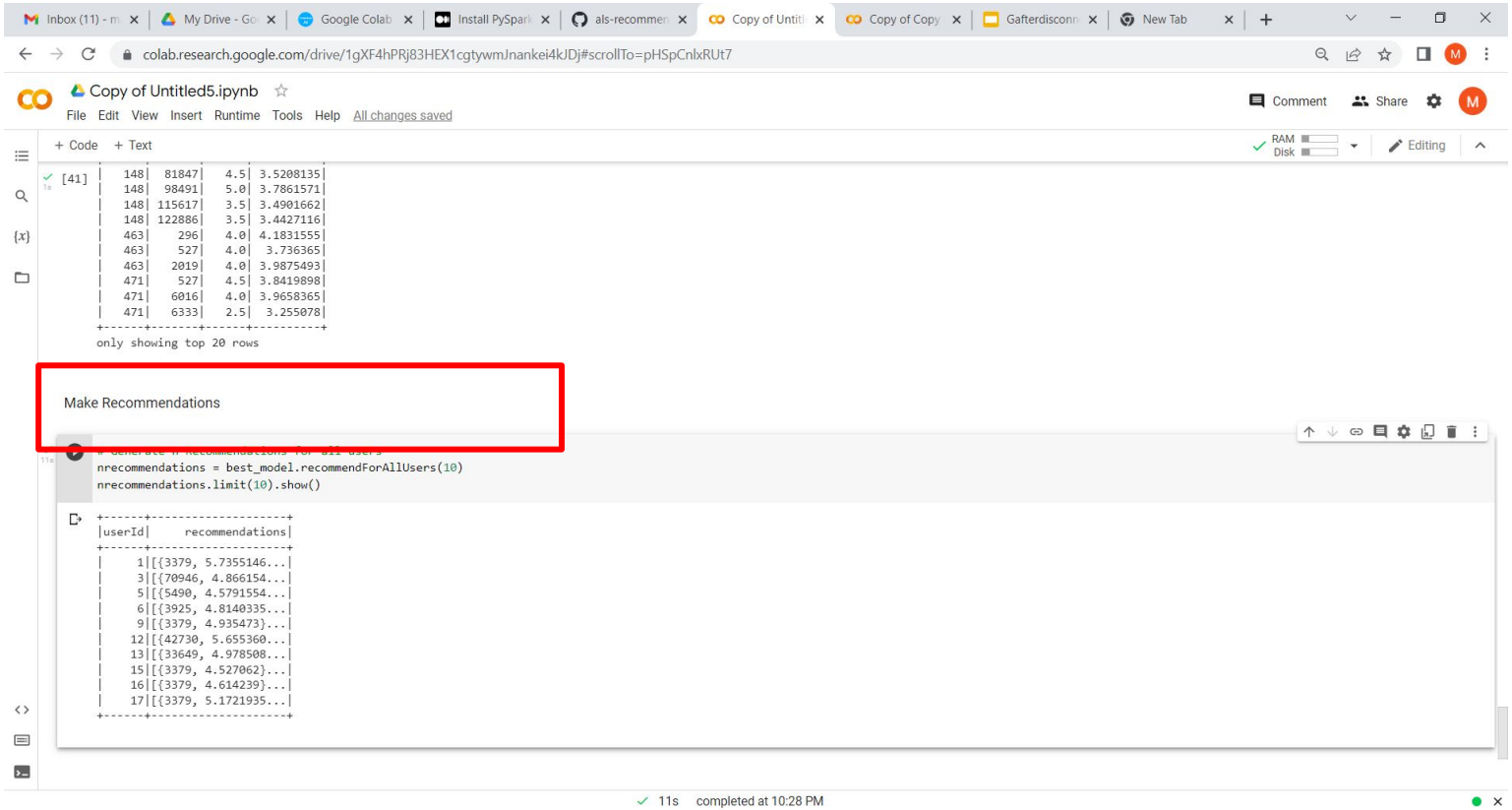
View the predictions



Test predictions



Make Recommendations



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[42]
```
nrecommendations = best_model.recommendForAllUsers(10)
nrecommendations.limit(10).show()
```

```
+------+--------------------+
|userId|     recommendations|
+------+--------------------+
|     1|[{3379, 5.7355146...|
|     3|[{70946, 4.866154...|
|     5|[{5490, 4.5791554...|
|     6|[{3925, 4.8140335...|
|     9|[{3379, 4.935473}...|
|    12|[{42730, 5.655360...|
|    13|[{33649, 4.978508...|
|    15|[{3379, 4.527062}...|
|    16|[{3379, 4.614239}...|
|    17|[{3379, 5.1721935...|
+------+--------------------+
```

```
nrecommendations = nrecommendations\
    .withColumn("rec_exp", explode("recommendations"))\
    .select('userId', col("rec_exp.movieId"), col("rec_exp.rating"))

nrecommendations.limit(10).show()
```

```
+------+-------+---------+
|userId|movieId|   rating|
+------+-------+---------+
|     1|   3379|5.7355146|
|     1|  33649|5.5564117|
|     1|   5490|  5.47559|
|     1| 171495|5.4036317|
|     1|   5328| 5.361952|
|     1|   5416| 5.361952|
|     1|   3951| 5.361952|
|     1|  78836|5.3408904|
|     1|   5915| 5.309985|
|     1|   8477|5.3042073|
+------+-------+---------+
```

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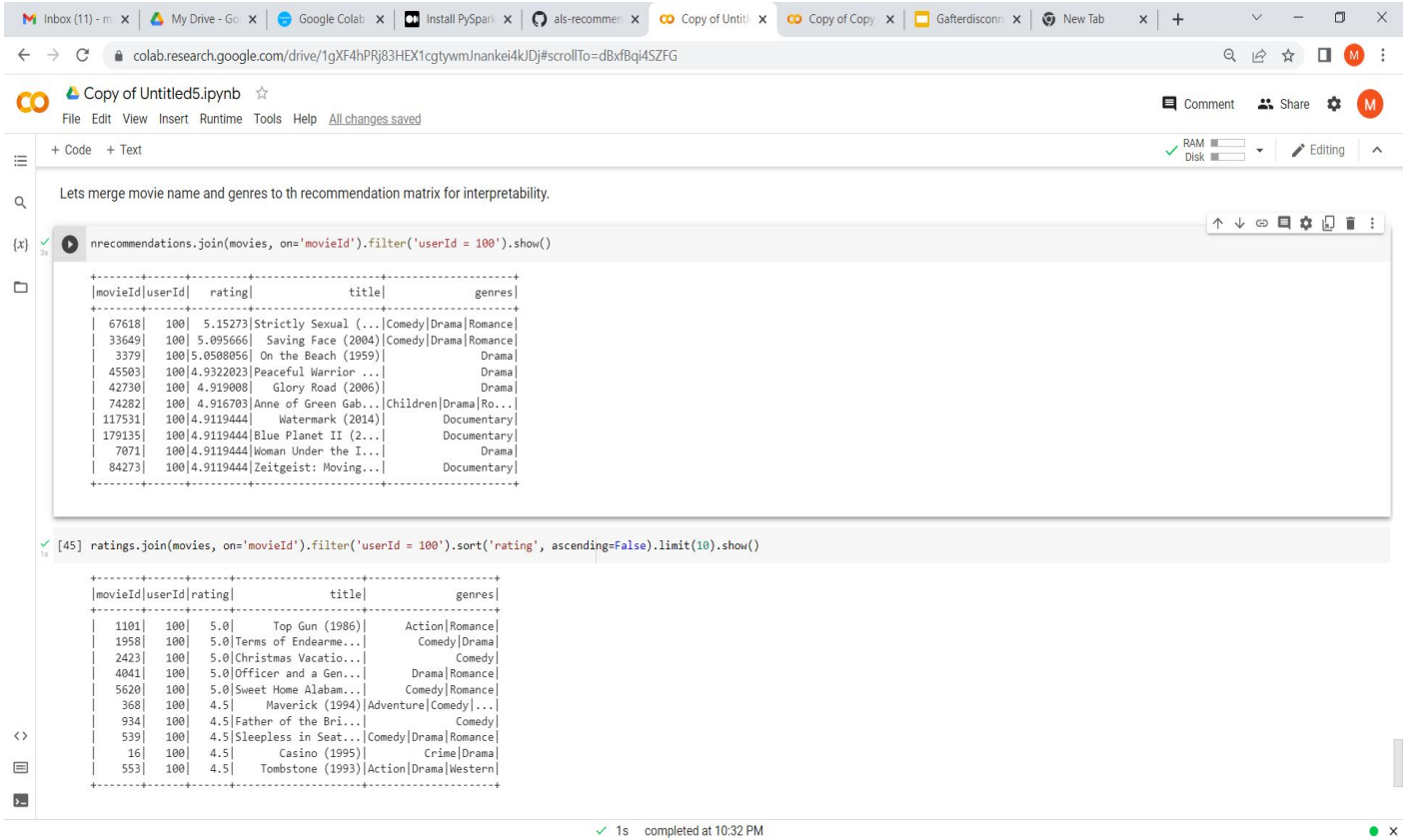
Do the recommendations make sense?Lets merge movie name and genres to th recommendation matrix for interpretability.



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RAM Disk Editing

```
nrecommendations.join(movies, on='movieId').filter('userId = 100').show()
```

```
+-------+------+---------+--------------------+--------------------+
|movieId|userId|   rating|               title|              genres|
+-------+------+---------+--------------------+--------------------+
|  67618|   100|  5.15273|Strictly Sexual (...|Comedy|Drama|Romance|
|  33649|   100| 5.095666|  Saving Face (2004)|Comedy|Drama|Romance|
|   3379|   100|5.0508056| On the Beach (1959)|               Drama|
|  45503|   100|4.9322023|Peaceful Warrior ...|               Drama|
|  42730|   100| 4.919008|   Glory Road (2006)|               Drama|
|  74282|   100| 4.916703|Anne of Green Gab...|Children|Drama|Ro...|
| 117531|   100|4.9119444|    Watermark (2014)|         Documentary|
| 179135|   100|4.9119444|Blue Planet II (2...|         Documentary|
|   7071|   100|4.9119444|Woman Under the I...|               Drama|
|  84273|   100|4.9119444|Zeitgeist: Moving...|         Documentary|
+-------+------+---------+--------------------+--------------------+
```

```
[45] ratings.join(movies, on='movieId').filter('userId = 100').sort('rating', ascending=False).limit(10).show()
```

```
+-------+------+------+--------------------+--------------------+
|movieId|userId|rating|               title|              genres|
+-------+------+------+--------------------+--------------------+
|   1101|   100|   5.0|      Top Gun (1986)|      Action|Romance|
|   1958|   100|   5.0|Terms of Endearme...|        Comedy|Drama|
|   2423|   100|   5.0|Christmas Vacatio...|              Comedy|
|   4041|   100|   5.0|Officer and a Gen...|       Drama|Romance|
|   5620|   100|   5.0|Sweet Home Alabam...|      Comedy|Romance|
|    368|   100|   4.5|     Maverick (1994)|Adventure|Comedy|...|
|    934|   100|   4.5|Father of the Bri...|              Comedy|
|    539|   100|   4.5|Sleepless in Seat...|Comedy|Drama|Romance|
|     16|   100|   4.5|       Casino (1995)|         Crime|Drama|
|    553|   100|   4.5|    Tombstone (1993)|Action|Drama|Western|
+-------+------+------+--------------------+--------------------+
```

1s completed at 10:32 PM

Testing movielens.py on Google Cloud Platform

Save the colab cells notebooks program “movielens.ipynb” to python “movielens.py”
PySpark program and output screen to find the Find the best model and recommendations are enclosed in
Below slides.

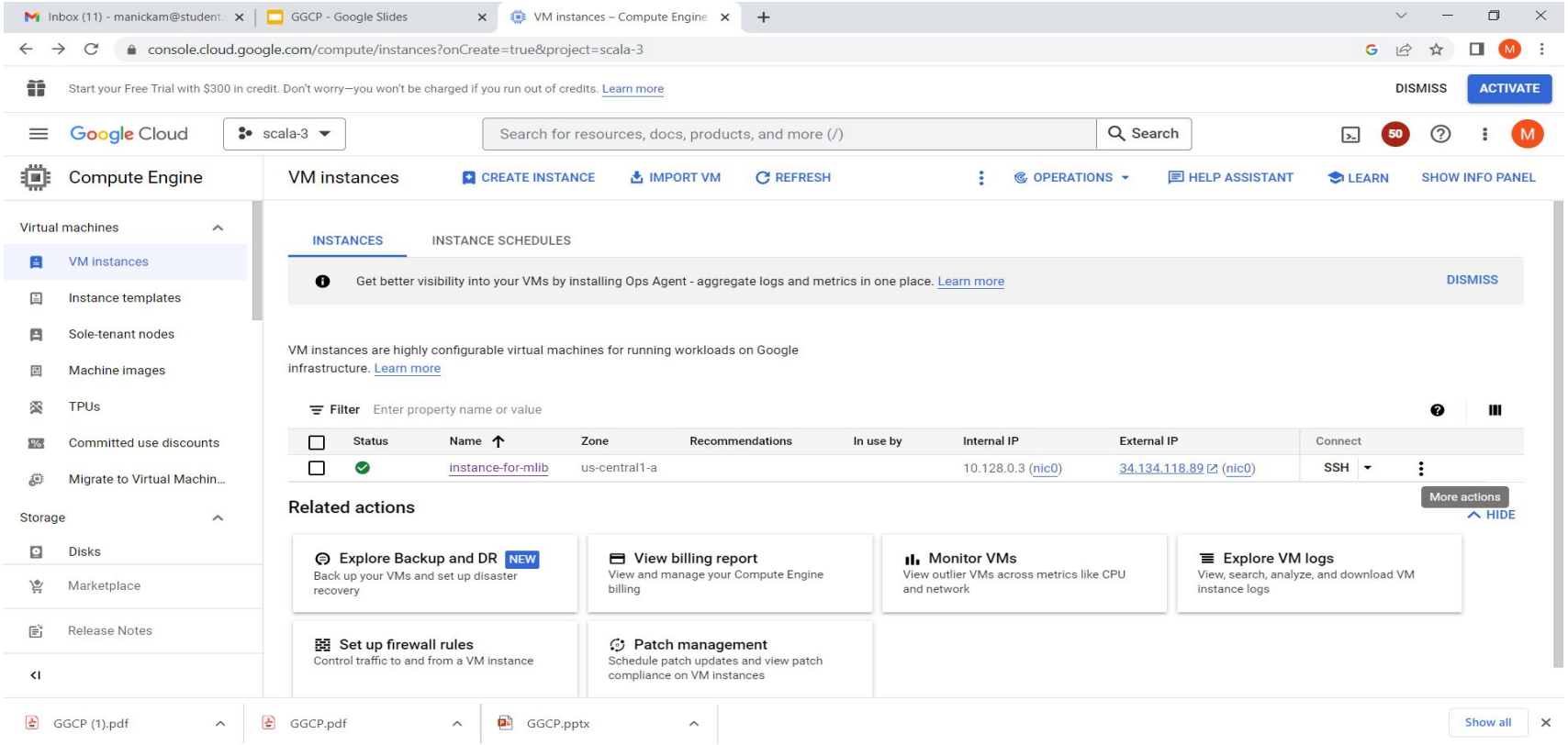
```
# Import SparkSession
from pyspark.sql import SparkSession

# Create a Spark Session
spark = SparkSession.builder.master("local[*]").getOrCreate()

# Check Spark Session Information
spark

"""We can also test the installation by importing a Spark library."""

# Import a Spark function from library
from pyspark.sql.functions import col

"""Import libraries"""

#https://grouplens.org/datasets/movielens/

import pandas as pd
from pyspark.sql.functions import col, explode
from pyspark import SparkContext

"""Initiate spark session"""

from pyspark.sql import SparkSession
sc = SparkContext
# sc.setCheckpointDir('checkpoint')
spark = SparkSession.builder.appName('Recommendations').getOrCreate()
```

```
"""1. Load data"""
from google.colab import drive
drive.mount('/content/drive')
!ls -l /content/drive/MyDrive/
movies = spark.read.csv("/content/drive/MyDrive/gmovies.csv",header=True)
ratings = spark.read.csv("/content/drive/MyDrive/gratings.csv",header=True)
ratings.show()
ratings.printSchema()
ratings = ratings.\
    withColumn('userId', col('userId').cast('integer')).\
    withColumn('movieId', col('movieId').cast('integer')).\
    withColumn('rating', col('rating').cast('float')).\
    drop('timestamp')
ratings.show()
"""Calculate sparsity"""
# Count the total number of ratings in the dataset
numerator = ratings.select("rating").count()
# Count the number of distinct userIds and distinct movieIds
num_users = ratings.select("userId").distinct().count()
num_movies = ratings.select("movieId").distinct().count()
# Set the denominator equal to the number of users multiplied by the number of movies
denominator = num_users * num_movies
# Divide the numerator by the denominator
sparsity = (1.0 - (numerator *1.0)/denominator)*100
print("The ratings dataframe is ", "%.2f" % sparsity + "% empty.")
"""Interpret ratings"""
# Group data by userId, count ratings
userId_ratings = ratings.groupBy("userId").count().orderBy('count', ascending=False)
userId_ratings.show()
# Group data by userId, count ratings
movieId_ratings = ratings.groupBy("movieId").count().orderBy('count', ascending=False)
movieId_ratings.show()
```

```
"""Build Out An ALS Model"""
# Import the required functions
from pyspark.ml.evaluation import RegressionEvaluator
from pyspark.ml.recommendation import ALS
from pyspark.ml.tuning import ParamGridBuilder, CrossValidator
# Create test and train set
(train, test) = ratings.randomSplit([0.8, 0.2], seed = 1234)
# Create ALS model
als = ALS(userCol="userId", itemCol="movieId", ratingCol="rating", nonnegative = True, implicitPrefs = False, coldStartStrategy="drop")
# Confirm that a model called "als" was created
type(als)
"""Tell Spark how to tune your ALS model"""
# Import the requisite items
from pyspark.ml.evaluation import RegressionEvaluator
from pyspark.ml.tuning import ParamGridBuilder, CrossValidator

# Add hyperparameters and their respective values to param_grid
param_grid = ParamGridBuilder() \
            .addGrid(als.rank, [10, 50, 100, 150]) \
            .addGrid(als.regParam, [.01, .05, .1, .15]) \
            .build()
            #             .addGrid(als.maxIter, [5, 50, 100, 200]) \

# Define evaluator as RMSE and print length of evaluator
evaluator = RegressionEvaluator(metricName="rmse", labelCol="rating", predictionCol="prediction")
print ("Num models to be tested: ", len(param_grid))

"""Build your cross validation pipeline"""
# Build cross validation using CrossValidator
cv = CrossValidator(estimator=als, estimatorParamMaps=param_grid, evaluator=evaluator, numFolds=5)
# Confirm cv was built
print(cv)
```

```
"""Best Model and Best Model Parameters"""
#Fit cross validator to the 'train' dataset
model = cv.fit(train)
#Extract best model from the cv model above
best_model = model.bestModel
# Print best_model
print(type(best_model))
# Complete the code below to extract the ALS model parameters
print("**Best Model**")
# # Print "Rank"
print("  Rank:", best_model._java_obj.parent().getRank())
# Print "MaxIter"
print("  MaxIter:", best_model._java_obj.parent().getMaxIter())
# Print "RegParam"
print("  RegParam:", best_model._java_obj.parent().getRegParam())
# View the predictions
test_predictions = best_model.transform(test)
RMSE = evaluator.evaluate(test_predictions)
print(RMSE)
test_predictions.show()
"""Make Recommendations"""
# Generate n Recommendations for all users
nrecommendations = best_model.recommendForAllUsers(10)
nrecommendations.limit(10).show()
nrecommendations = nrecommendations\
    .withColumn("rec_exp", explode("recommendations"))\
    .select('userId', col("rec_exp.movieId"), col("rec_exp.rating"))
nrecommendations.limit(10).show()
"""Do the recommendations make sense? Lets merge movie name and genres to th recommendation matrix for interpretability. """
nrecommendations.join(movies, on='movieId').filter('userId = 100').show()
ratings.join(movies, on='movieId').filter('userId = 100').sort('rating', ascending=False).limit(10).show()
```

Google Cloud Platform VM INSTANCE



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SSH CONNECT TO SERIAL CONSOLE

Connecting to serial ports is disabled

Logs

Cloud Logging
Serial port 1 (console)

SHOW MORE

Basic information

Name	instance-for-mlib
Instance Id	6631235624795226025
Description	None
Type	Instance
Status	Running
Creation time	Nov 18, 2022, 2:03:51 PM UTC-08:00
Zone	us-central1-a
Instance template	None
In use by	None

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Status	Running
Creation time	Nov 18, 2022, 2:03:51 PM UTC-08:00
Zone	us-central1-a
Instance template	None
In use by	None
Reservations	Automatically choose
Labels	None
Tags	–
Deletion protection	Disabled
Confidential VM service	Disabled
Preserved state size	0 GB

Machine configuration

Machine type	e2-medium
CPU platform	Intel Broadwell
Architecture	x86/64
vCPUs to core ratio	–
Custom visible cores	–

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Display device	Disabled Enable to use screen capturing and recording tools
GPUs	None

Networking

Public DNS PTR Record	None
Total egress bandwidth tier	–
NIC type	–

VIEW IN NETWORK TOPOLOGY

Firewalls

HTTP traffic	On
HTTPS traffic	On

Network tags

http-server https-server

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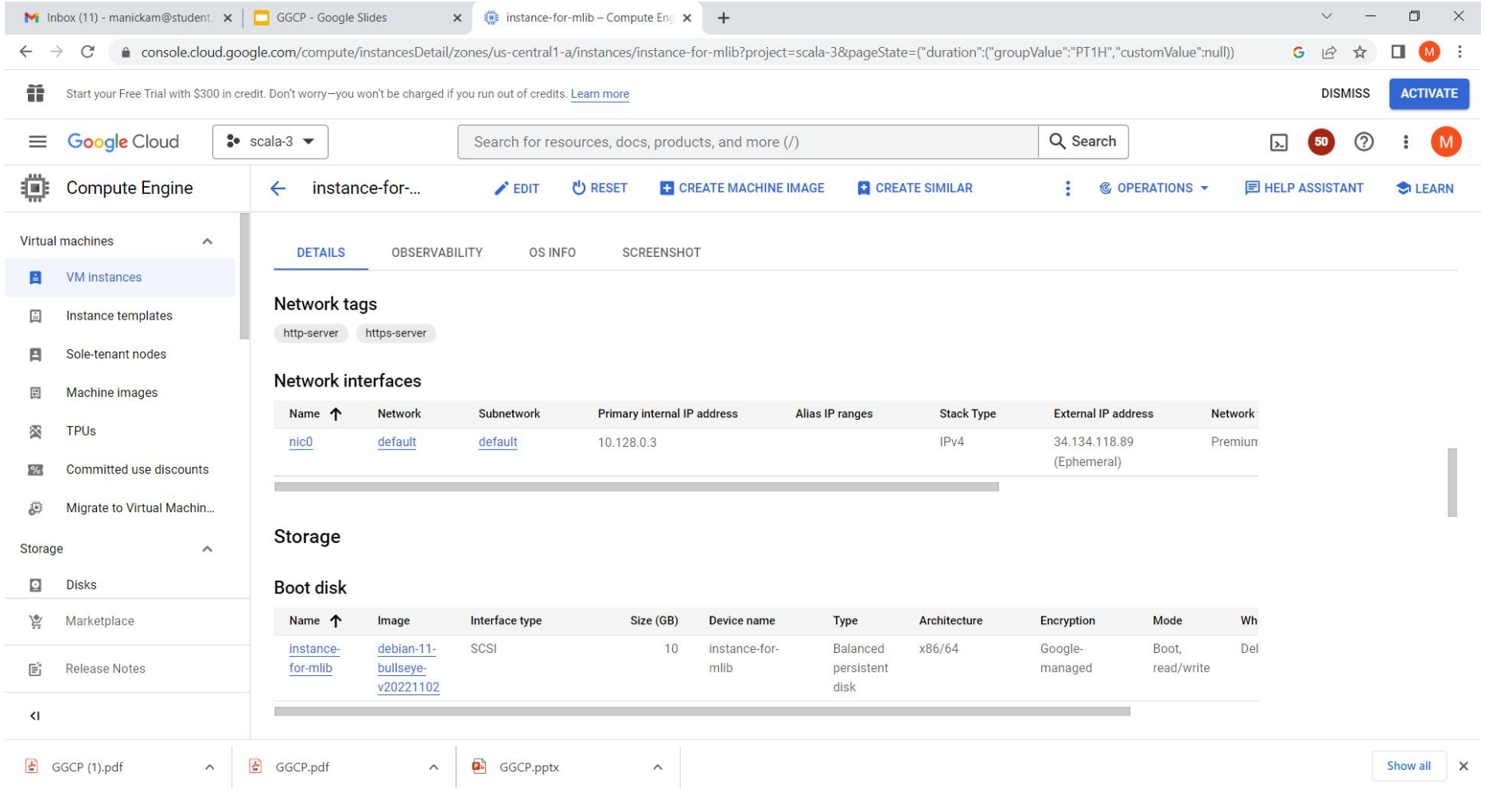
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Stack Type
External IP address
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default
default
10.128.0.3
IPv4
34.134.118.89 (Ephemeral)
Premium
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Interface type
Size (GB)
Device name
Type
Architecture
Encryption
Mode
Wh
instance-for-mlib
debian-11-bullseye-v20221102
SCSI
10
instance-for-mlib
Balanced persistent disk
x86/64
Google-managed
Boot, read/write
Del
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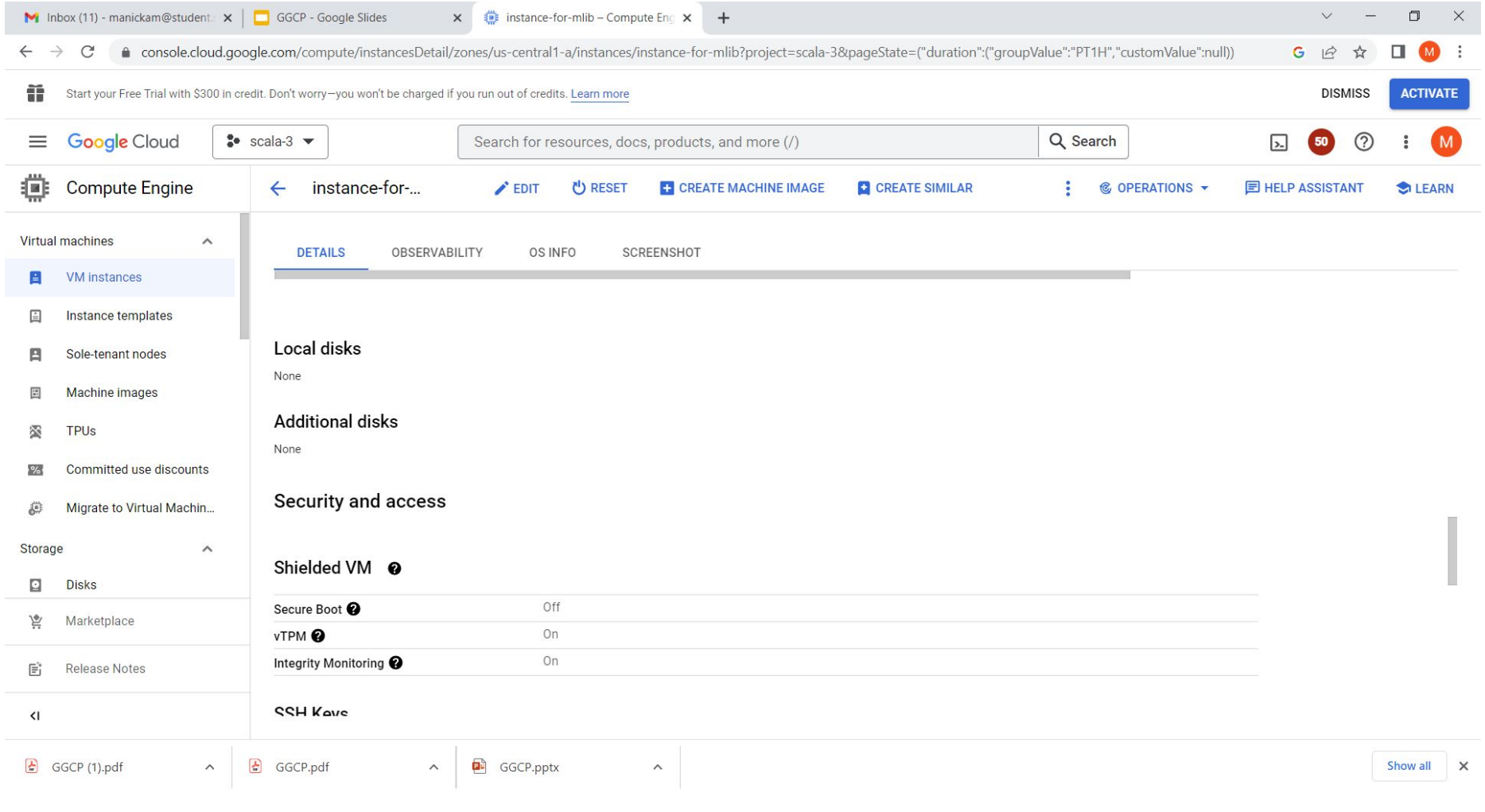
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On
SSH Keys
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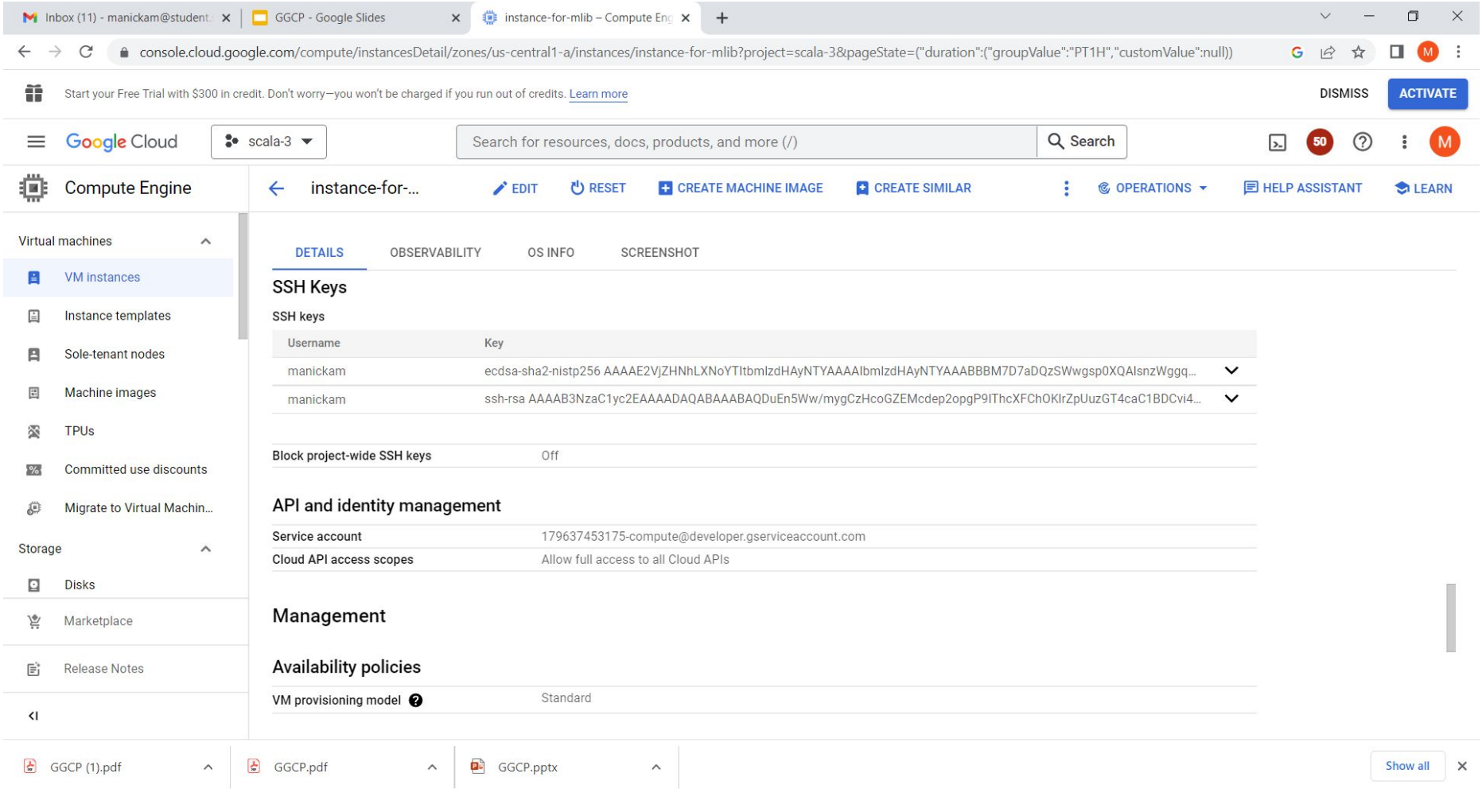
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SSH keys
Username
Key
manickam
ecdsa-sha2-nistp256 AAAAE2VjZHNhLXNoYTItbmIzdHAyNTYAAAAIbmIzdHAyNTYAAABBBM7D7aDQzSWwgsp0XQAIsnzWggq...
manickam
ssh-rsa AAAAB3NzaC1yc2EAAAADAQABAAABAQDuEn5Ww/mygCzHcoGZEMcdep2opgP9IThcXFChOKlrZpUuzGT4caC1BDCvi4...
Block project-wide SSH keys
Off
API and identity management
Service account
179637453175-compute@developer.gserviceaccount.com
Cloud API access scopes
Allow full access to all Cloud APIs
Management
Availability policies
VM provisioning model
Standard
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Management

Availability policies

VM provisioning model	Standard
Max duration	None
Preemptibility	Off (Recommended)
On VM termination	–
On host maintenance	Migrate VM instance (Recommended)
Automatic restart	On (Recommended)
Customer Managed Encryption Key (CMEK) revocation policy	Do nothing

Sole-tenancy

Affinity labels	None
CPU Overcommit	Disabled

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Availability policies

VM provisioning model	Standard
Max duration	None
Preemptibility	Off (Recommended)
On VM termination	–
On host maintenance	Migrate VM instance (Recommended)
Automatic restart	On (Recommended)
Customer Managed Encryption Key (CMEK) revocation policy	Do nothing

Sole-tenancy

Affinity labels	None
CPU Overcommit	Disabled

Custom metadata

None

EQUIVALENT REST

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http-server https-server

Network interfaces

Name	Network	Subnetwork	Primary internal IP address	Alias IP ranges	Stack Type	External IP address	Network
nic0	default	default	10.128.0.3		IPv4	Ephemeral	Premium

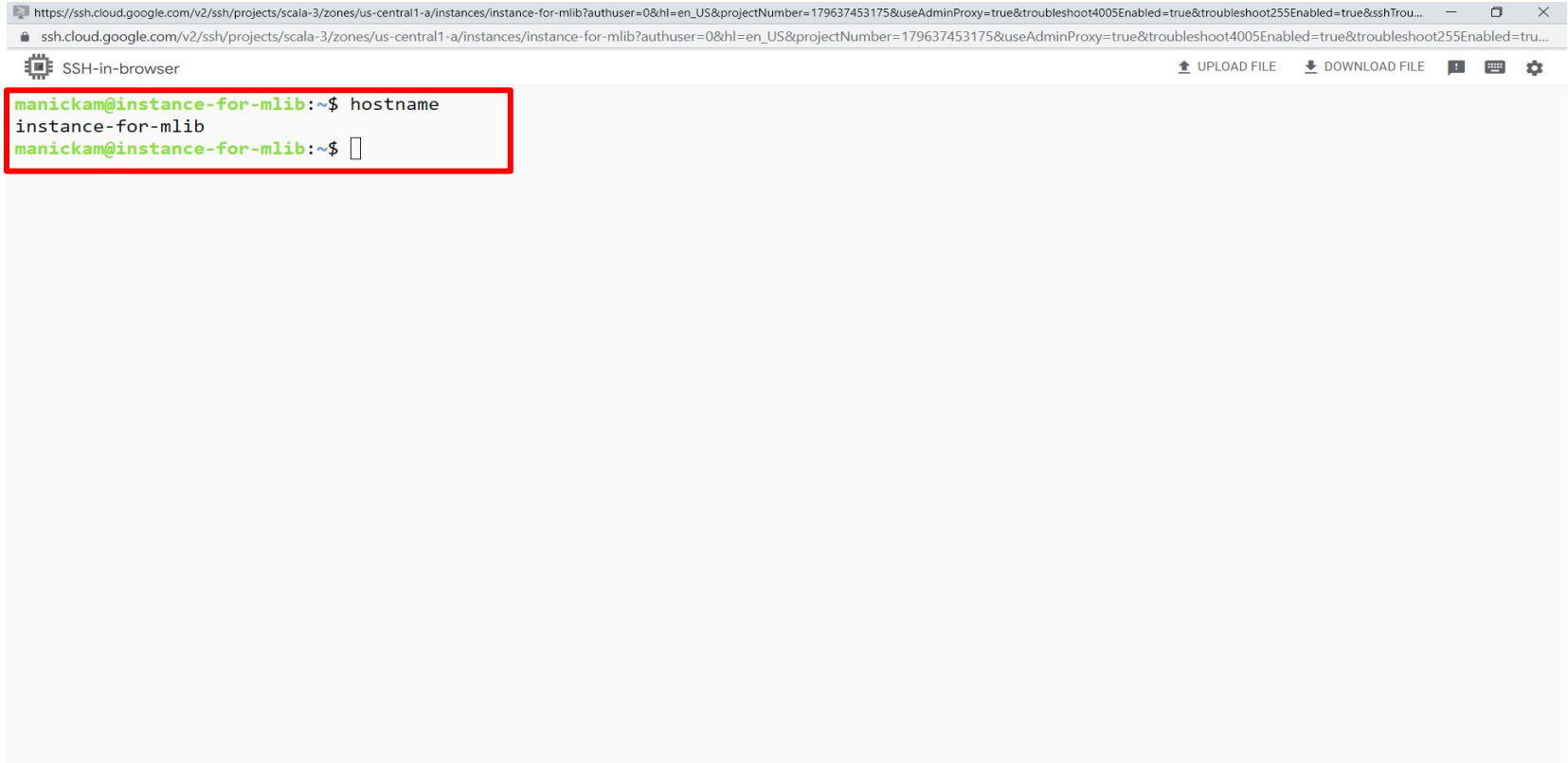
Storage

Boot disk

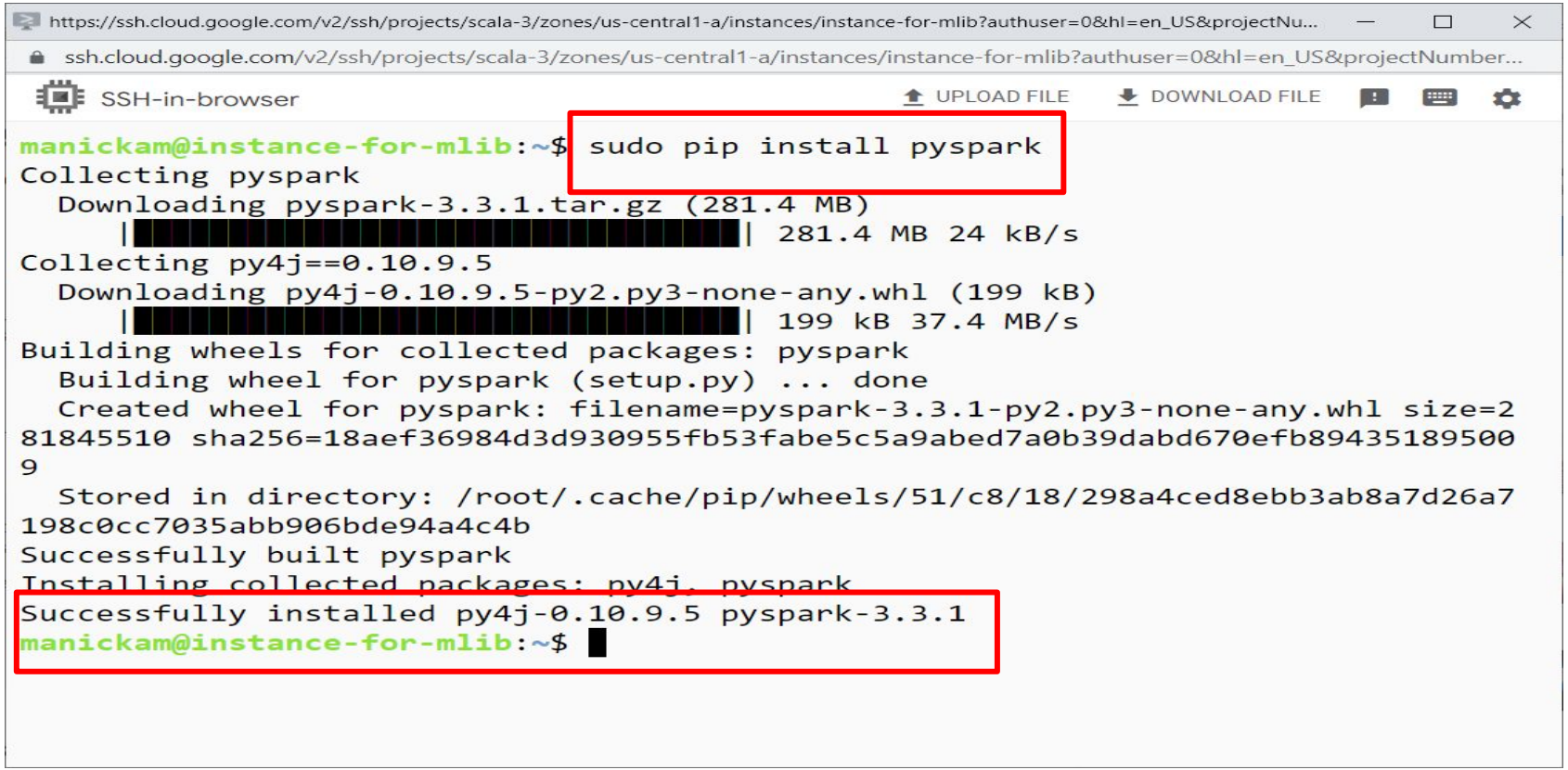
Name	Image	Interface type	Size (GB)	Device name	Type	Architecture	Encryption	Mode	Wh
instance-for-mlib	debian-11-bullseye-v20221102	SCSI	10	instance-for-mlib	Balanced persistent disk	x86/64	Google-managed	Boot, read/write	Del

Local disks

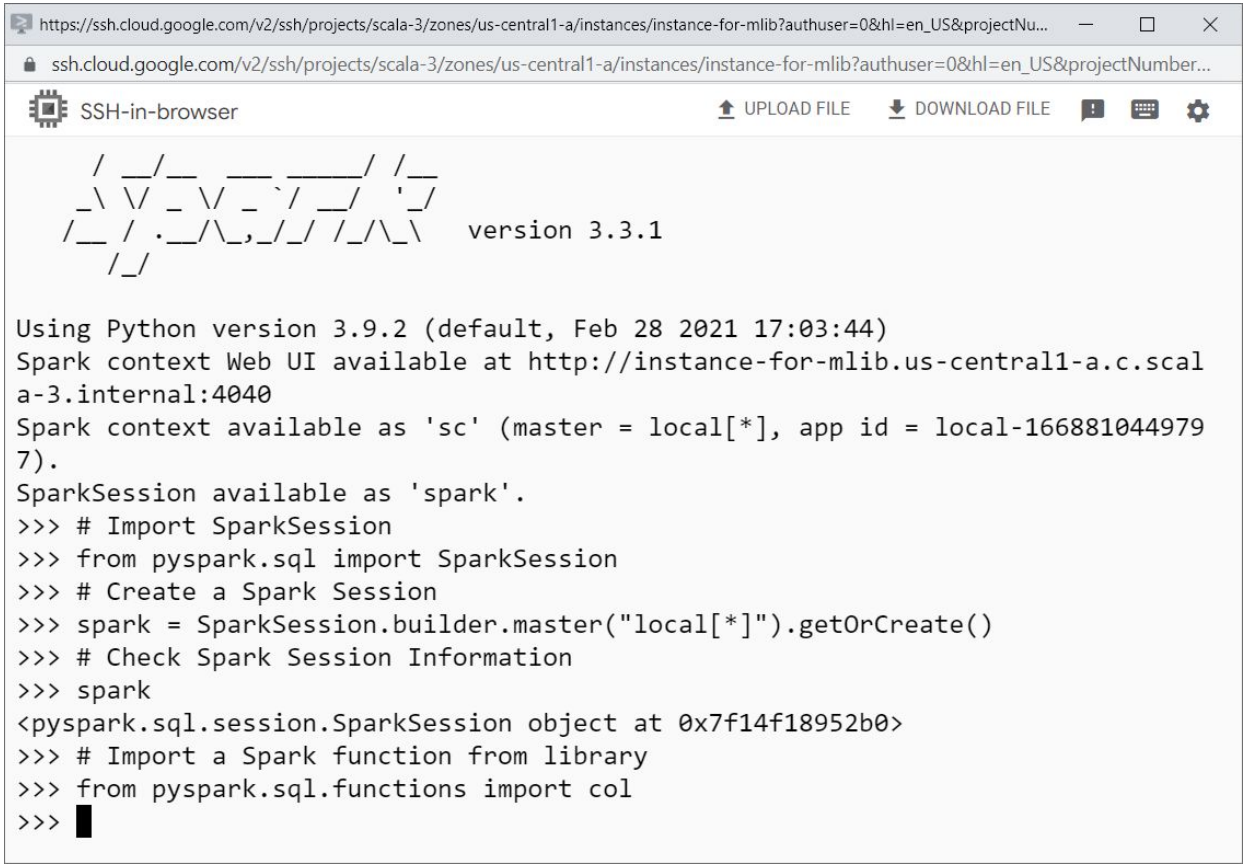
Vm instance console



Pyspark Installations



Spark installation checks



Routings.show()

Gresults-1-reference.prn - Notepad

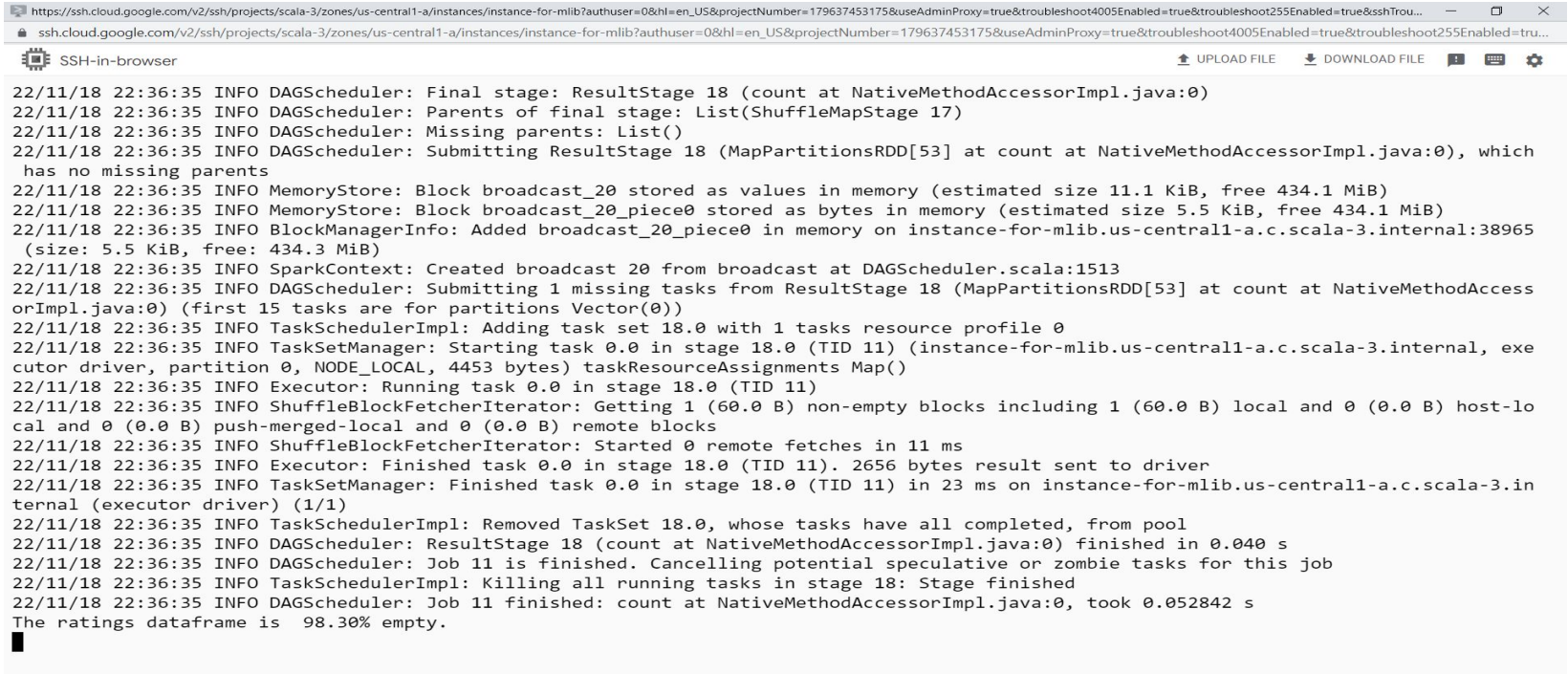
File Edit Format View Help

```
22/11/18 22:57:49 INFO TaskSchedulerImpl: Killing all running tasks in stage 2: Stage finished
22/11/18 22:57:49 INFO DAGScheduler: Job 2 finished: showString at NativeMethodAccessorImpl.java:0, took
0.281905 s
22/11/18 22:57:49 INFO CodeGenerator: Code generated in 41.783209 ms
+------+-------+------+---------+
|userId|movieId|rating|timestamp|
+------+-------+------+---------+
|     1|      1|   4.0|964982703|
|     1|      3|   4.0|964981247|
|     1|      6|   4.0|964982224|
|     1|     47|   5.0|964983815|
|     1|     50|   5.0|964982931|
|     1|     70|   3.0|964982400|
|     1|    101|   5.0|964980868|
|     1|    110|   4.0|964982176|
|     1|    151|   5.0|964984041|
|     1|    157|   5.0|964984100|
|     1|    163|   5.0|964983650|
|     1|    216|   5.0|964981208|
|     1|    223|   3.0|964980985|
|     1|    231|   5.0|964981179|
|     1|    235|   4.0|964980908|
|     1|    260|   5.0|964981680|
|     1|    296|   3.0|964982967|
|     1|    316|   3.0|964982310|
|     1|    333|   5.0|964981179|
|     1|    349|   4.0|964982563|
+------+-------+------+---------+
only showing top 20 rows
```

Ln 148, Col 1 | 100% | Unix (LF) | UTF-8

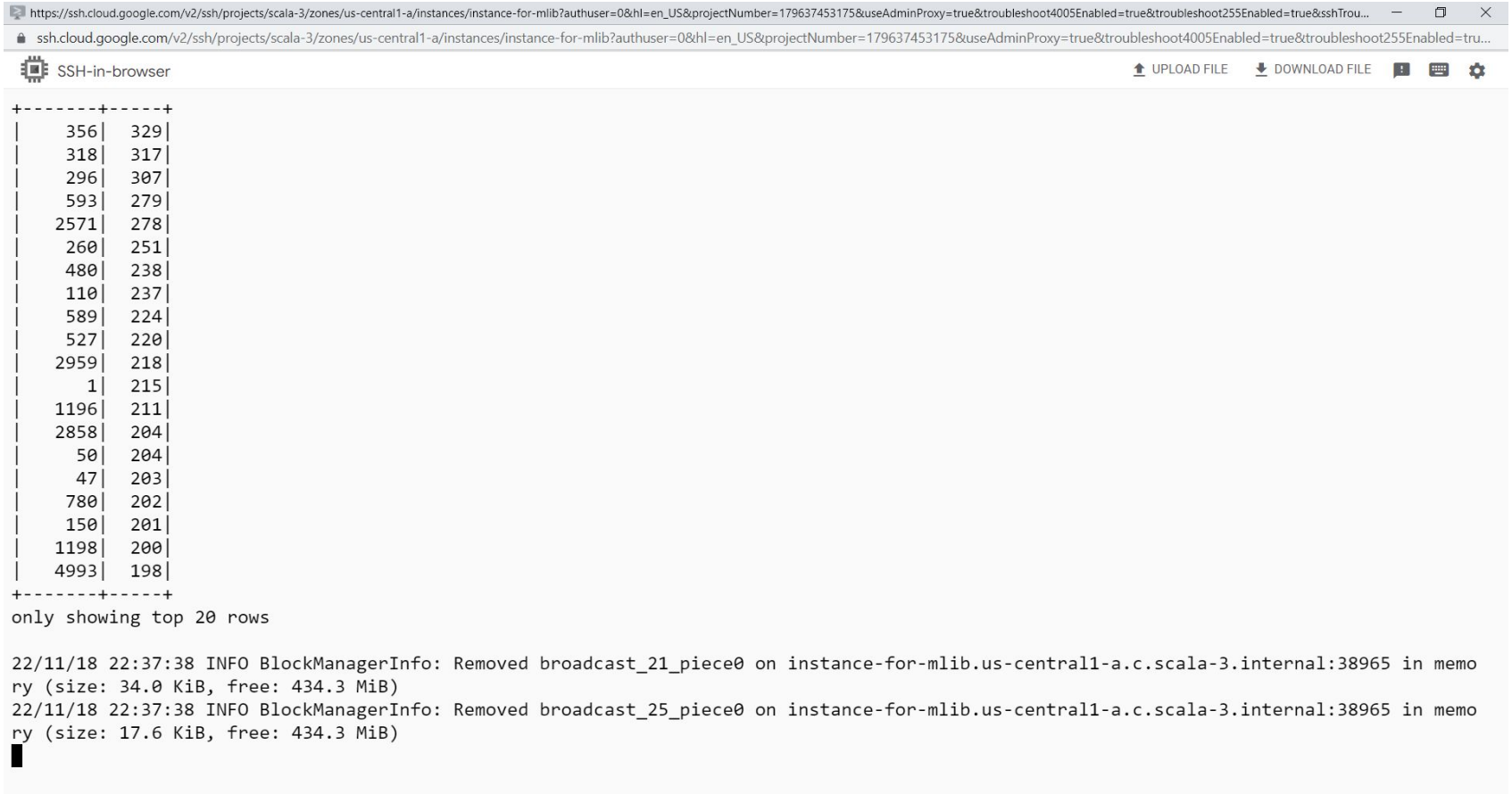
Ratings.show()

Calculate sparsity

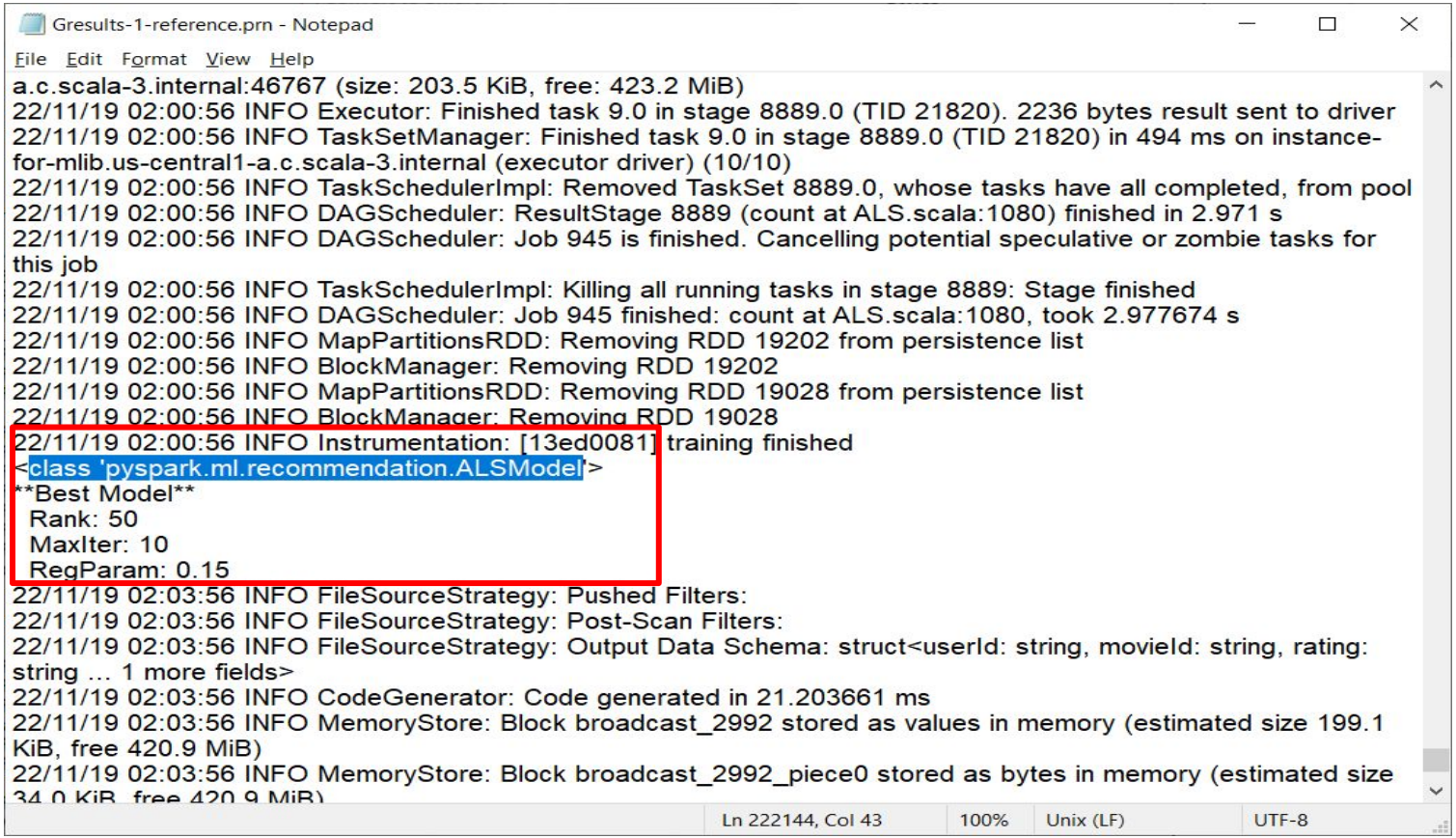


Interpret ratings

movieId_ratings.show()



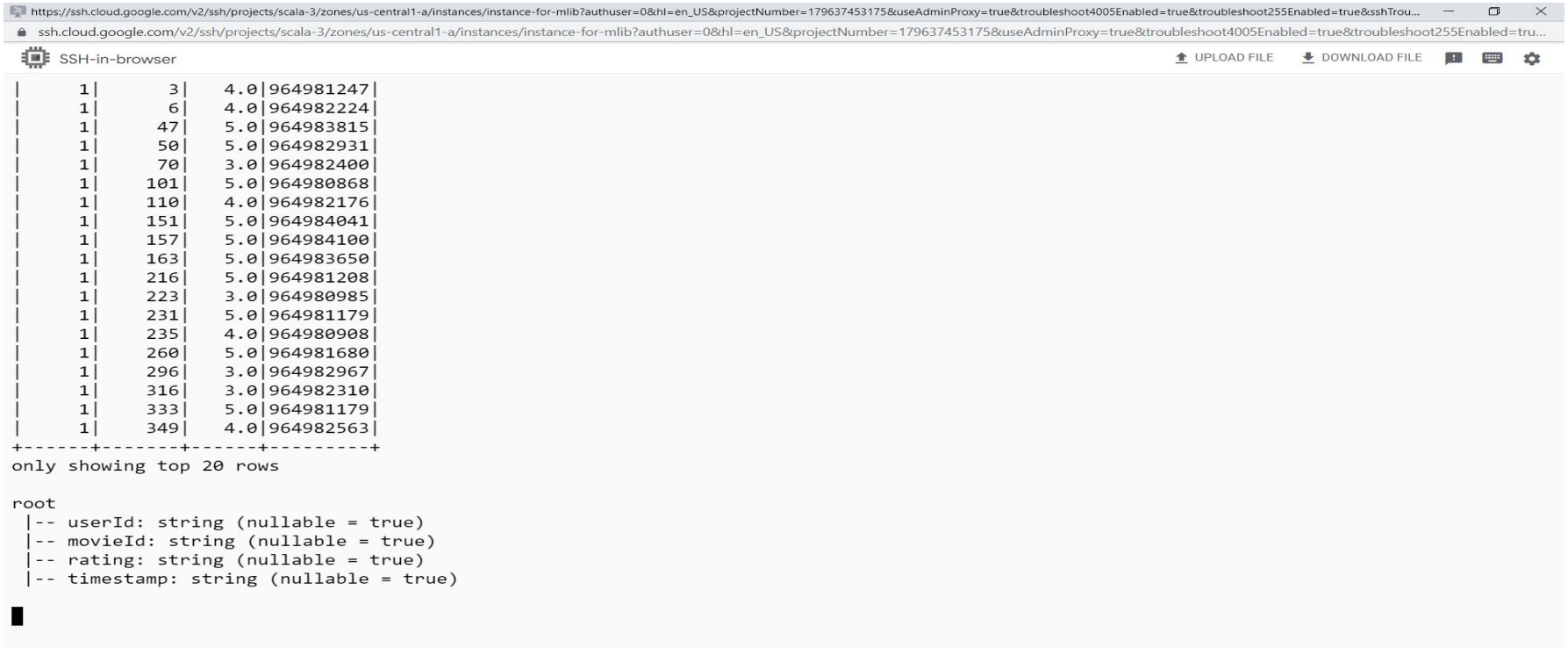
Build Out An ALS Model



Tell Spark how to tune your ALS model

Build your cross validation pipeline

Output Of Python Program on GCP



```
22/11/18 22:58:20 INFO DAGScheduler: Job 3 finished: showString at NativeMethodAccessorImpl.java:0, took 0.197561 s
22/11/18 22:58:20 INFO CodeGenerator: Code generated in 19.586172 ms
+------+-------+------+
|userId|movieId|rating|
+------+-------+------+
|     1|      1|   4.0|
|     1|      3|   4.0|
|     1|      6|   4.0|
|     1|     47|   5.0|
|     1|     50|   5.0|
|     1|     70|   3.0|
|     1|    101|   5.0|
|     1|    110|   4.0|
|     1|    151|   5.0|
|     1|    157|   5.0|
|     1|    163|   5.0|
|     1|    216|   5.0|
|     1|    223|   3.0|
|     1|    231|   5.0|
|     1|    235|   4.0|
|     1|    260|   5.0|
|     1|    296|   3.0|
|     1|    316|   3.0|
|     1|    333|   5.0|
|     1|    349|   4.0|
+------+-------+------+
only showing top 20 rows
```

```
22/11/18 22:58:20 INFO DAGScheduler: Job 3 finished: showString at NativeMethodAccessorImpl.java:0, took 0.197561 s
22/11/18 22:58:20 INFO CodeGenerator: Code generated in 19.586172 ms
+------+-------+------+
|userId|movieId|rating|
+------+-------+------+
|     1|      1|   4.0|
|     1|      3|   4.0|
|     1|      6|   4.0|
|     1|     47|   5.0|
|     1|     50|   5.0|
|     1|     70|   3.0|
|     1|    101|   5.0|
|     1|    110|   4.0|
|     1|    151|   5.0|
|     1|    157|   5.0|
|     1|    163|   5.0|
|     1|    216|   5.0|
|     1|    223|   3.0|
|     1|    231|   5.0|
|     1|    235|   4.0|
|     1|    260|   5.0|
|     1|    296|   3.0|
|     1|    316|   3.0|
|     1|    333|   5.0|
|     1|    349|   4.0|
+------+-------+------+
only showing top 20 rows
```

```
22/11/18 22:58:55 INFO DAGScheduler: Final stage: ResultStage 18 (count at NativeMethodAccessorImpl.java:0)
22/11/18 22:58:55 INFO DAGScheduler: Parents of final stage: List(ShuffleMapStage 17)
22/11/18 22:58:55 INFO DAGScheduler: Missing parents: List()
22/11/18 22:58:55 INFO DAGScheduler: Submitting ResultStage 18 (MapPartitionsRDD[53] at count at NativeMethodAccessorImpl.java:0), which
 has no missing parents
22/11/18 22:58:55 INFO MemoryStore: Block broadcast_20 stored as values in memory (estimated size 11.1 KiB, free 434.1 MiB)
22/11/18 22:58:55 INFO MemoryStore: Block broadcast_20_piece0 stored as bytes in memory (estimated size 5.5 KiB, free 434.1 MiB)
22/11/18 22:58:55 INFO BlockManagerInfo: Added broadcast_20_piece0 in memory on instance-for-mlib.us-central1-a.c.scala-3.internal:46767
 (size: 5.5 KiB, free: 434.3 MiB)
22/11/18 22:58:55 INFO SparkContext: Created broadcast 20 from broadcast at DAGScheduler.scala:1513
22/11/18 22:58:55 INFO DAGScheduler: Submitting 1 missing tasks from ResultStage 18 (MapPartitionsRDD[53] at count at NativeMethodAccess
orImpl.java:0) (first 15 tasks are for partitions Vector(0))
22/11/18 22:58:55 INFO TaskSchedulerImpl: Adding task set 18.0 with 1 tasks resource profile 0
22/11/18 22:58:55 INFO TaskSetManager: Starting task 0.0 in stage 18.0 (TID 11) (instance-for-mlib.us-central1-a.c.scala-3.internal, exe
cutor driver, partition 0, NODE_LOCAL, 4453 bytes) taskResourceAssignments Map()
22/11/18 22:58:55 INFO Executor: Running task 0.0 in stage 18.0 (TID 11)
22/11/18 22:58:55 INFO ShuffleBlockFetcherIterator: Getting 1 (60.0 B) non-empty blocks including 1 (60.0 B) local and 0 (0.0 B) host-lo
cal and 0 (0.0 B) push-merged-local and 0 (0.0 B) remote blocks
22/11/18 22:58:55 INFO ShuffleBlockFetcherIterator: Started 0 remote fetches in 1 ms
22/11/18 22:58:55 INFO Executor: Finished task 0.0 in stage 18.0 (TID 11). 2656 bytes result sent to driver
22/11/18 22:58:55 INFO TaskSetManager: Finished task 0.0 in stage 18.0 (TID 11) in 13 ms on instance-for-mlib.us-central1-a.c.scala-3.in
ternal (executor driver) (1/1)
22/11/18 22:58:55 INFO TaskSchedulerImpl: Removed TaskSet 18.0, whose tasks have all completed, from pool
22/11/18 22:58:55 INFO DAGScheduler: ResultStage 18 (count at NativeMethodAccessorImpl.java:0) finished in 0.024 s
22/11/18 22:58:55 INFO DAGScheduler: Job 11 is finished. Cancelling potential speculative or zombie tasks for this job
22/11/18 22:58:55 INFO TaskSchedulerImpl: Killing all running tasks in stage 18: Stage finished
22/11/18 22:58:55 INFO DAGScheduler: Job 11 finished: count at NativeMethodAccessorImpl.java:0, took 0.035534 s
The ratings dataframe is  98.30% empty.
```

```
22/11/18 22:59:27 INFO CodeGenerator: Code generated in 28.59071 ms
22/11/18 22:59:27 INFO CodeGenerator: Code generated in 16.680332 ms
+------+-----+
|userId|count|
+------+-----+
|   414| 2698|
|   599| 2478|
|   474| 2108|
|   448| 1864|
|   274| 1346|
|   610| 1302|
|    68| 1260|
|   380| 1218|
|   606| 1115|
|   288| 1055|
|   249| 1046|
|   387| 1027|
|   182|  977|
|   307|  975|
|   603|  943|
|   298|  939|
|   177|  904|
|   318|  879|
|   232|  862|
|   480|  836|
+------+-----+
only showing top 20 rows
```

https://ssh.cloud.google.com/v2/ssh/projects/scala-3/zones/us-central1-a/instances/instance-for-mlib?authuser=0&hl=en_US&projectNumber=179637453175&useAdminProxy=true&troubleshoot4005Enabled=true&troubleshoot255Enabled=true&sshTrou...

ssh.cloud.google.com/v2/ssh/projects/scala-3/zones/us-central1-a/instances/instance-for-mlib?authuser=0&hl=en_US&projectNumber=179637453175&useAdminProxy=true&troubleshoot4005Enabled=true&troubleshoot255Enabled=tru...

SSH-in-browser UPLOAD FILE DOWNLOAD FILE

```
+-------+-----+
|movieId|count|
+-------+-----+
|    356|  329|
|    318|  317|
|    296|  307|
|    593|  279|
|   2571|  278|
|    260|  251|
|    480|  238|
|    110|  237|
|    589|  224|
|    527|  220|
|   2959|  218|
|      1|  215|
|   1196|  211|
|   2858|  204|
|     50|  204|
|     47|  203|
|    780|  202|
|    150|  201|
|   1198|  200|
|   4993|  198|
+-------+-----+
only showing top 20 rows

22/11/18 22:59:58 INFO BlockManagerInfo: Removed broadcast_25_piece0 on instance-for-mlib.us-central1-a.c.scala-3.internal:46767 in memo
ry (size: 17.6 KiB, free: 434.3 MiB)
```

```
|    356|  329|
|    318|  317|
|    296|  307|
|    593|  279|
|   2571|  278|
|    260|  251|
|    480|  238|
|    110|  237|
|    589|  224|
|    527|  220|
|   2959|  218|
|      1|  215|
|   1196|  211|
|   2858|  204|
|     50|  204|
|     47|  203|
|    780|  202|
|    150|  201|
|   1198|  200|
|   4993|  198|
+-------+-----+
only showing top 20 rows

22/11/18 22:59:58 INFO BlockManagerInfo: Removed broadcast_25_piece0 on instance-for-mlib.us-central1-a.c.scala-3.internal:46767 in memo
ry (size: 17.6 KiB, free: 434.3 MiB)
22/11/18 23:00:28 INFO BlockManagerInfo: Removed broadcast_26_piece0 on instance-for-mlib.us-central1-a.c.scala-3.internal:46767 in memo
ry (size: 18.6 KiB, free: 434.4 MiB)
Confirm that a model called als was created
```

https://ssh.cloud.google.com/v2/ssh/projects/scala-3/zones/us-central1-a/instances/instance-for-mlib?authuser=0&hl=en_US&projectNumber=179637453175&useAdminProxy=true&troubleshoot4005Enabled=true&troubleshoot255Enabled=true&sshTrou...

ssh.cloud.google.com/v2/ssh/projects/scala-3/zones/us-central1-a/instances/instance-for-mlib?authuser=0&hl=en_US&projectNumber=179637453175&useAdminProxy=true&troubleshoot4005Enabled=true&troubleshoot255Enabled=tru...

SSH-in-browser UPLOAD FILE DOWNLOAD FILE

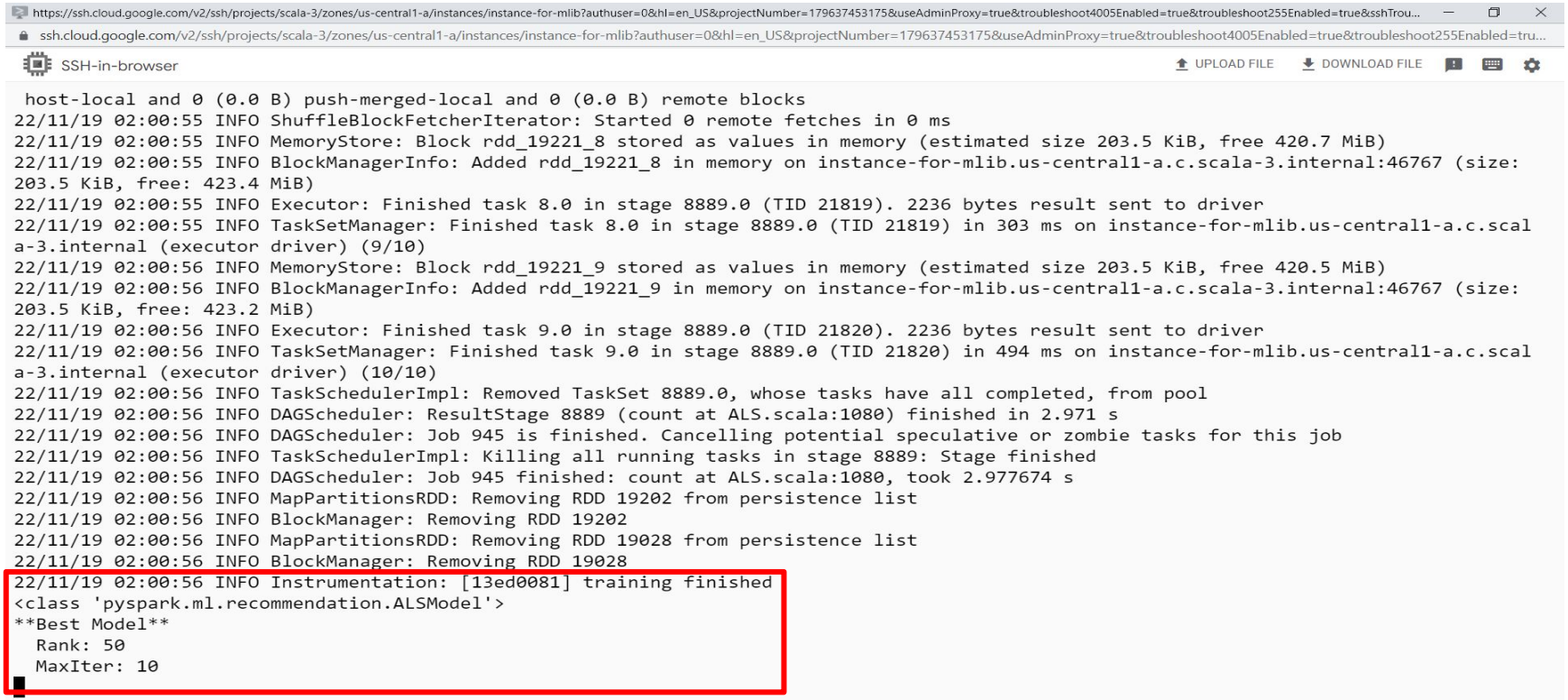
```
|    593|  279|
|   2571|  278|
|    260|  251|
|    480|  238|
|    110|  237|
|    589|  224|
|    527|  220|
|   2959|  218|
|      1|  215|
|   1196|  211|
|   2858|  204|
|     50|  204|
|     47|  203|
|    780|  202|
|    150|  201|
|   1198|  200|
|   4993|  198|
+-------+-----+
only showing top 20 rows

22/11/18 22:59:58 INFO BlockManagerInfo: Removed broadcast_25_piece0 on instance-for-mlib.us-central1-a.c.scala-3.internal:46767 in memo
ry (size: 17.6 KiB, free: 434.3 MiB)
22/11/18 23:00:28 INFO BlockManagerInfo: Removed broadcast_26_piece0 on instance-for-mlib.us-central1-a.c.scala-3.internal:46767 in memo
ry (size: 18.6 KiB, free: 434.4 MiB)
Confirm that a model called als was created
Num models to be tested:  16
CrossVidator
CrossValidator_259aeee816f1
```

Cross Validator

```
22/11/19 01:09:43 INFO Executor: Running task 3.0 in stage 6631.0 (TID 16221)
22/11/19 01:09:43 INFO BlockManager: Found block rdd_14292_3 locally
22/11/19 01:09:43 INFO BlockManager: Found block rdd_14291_3 locally
22/11/19 01:09:43 INFO ShuffleBlockFetcherIterator: Getting 10 (359.5 KiB) non-empty blocks including 10 (359.5 KiB) local and 0 (0.0 B)
 host-local and 0 (0.0 B) push-merged-local and 0 (0.0 B) remote blocks
22/11/19 01:09:43 INFO ShuffleBlockFetcherIterator: Started 0 remote fetches in 0 ms
22/11/19 01:09:46 INFO Executor: Finished task 2.0 in stage 6631.0 (TID 16220). 2694 bytes result sent to driver
22/11/19 01:09:46 INFO TaskSetManager: Starting task 4.0 in stage 6631.0 (TID 16222) (instance-for-mlib.us-central1-a.c.scala-3.internal
, executor driver, partition 4, PROCESS_LOCAL, 4550 bytes) taskResourceAssignments Map()
22/11/19 01:09:46 INFO TaskSetManager: Finished task 2.0 in stage 6631.0 (TID 16220) in 4271 ms on instance-for-mlib.us-central1-a.c.sca
la-3.internal (executor driver) (3/10)
22/11/19 01:09:46 INFO Executor: Running task 4.0 in stage 6631.0 (TID 16222)
22/11/19 01:09:46 INFO BlockManager: Found block rdd_14292_4 locally
22/11/19 01:09:46 INFO BlockManager: Found block rdd_14291_4 locally
22/11/19 01:09:46 INFO ShuffleBlockFetcherIterator: Getting 10 (349.7 KiB) non-empty blocks including 10 (349.7 KiB) local and 0 (0.0 B)
 host-local and 0 (0.0 B) push-merged-local and 0 (0.0 B) remote blocks
22/11/19 01:09:46 INFO ShuffleBlockFetcherIterator: Started 0 remote fetches in 0 ms
22/11/19 01:09:47 INFO Executor: Finished task 3.0 in stage 6631.0 (TID 16221). 2694 bytes result sent to driver
22/11/19 01:09:47 INFO TaskSetManager: Starting task 5.0 in stage 6631.0 (TID 16223) (instance-for-mlib.us-central1-a.c.scala-3.internal
, executor driver, partition 5, PROCESS_LOCAL, 4550 bytes) taskResourceAssignments Map()
22/11/19 01:09:47 INFO Executor: Running task 5.0 in stage 6631.0 (TID 16223)
22/11/19 01:09:47 INFO BlockManager: Found block rdd_14292_5 locally
22/11/19 01:09:47 INFO BlockManager: Found block rdd_14291_5 locally
22/11/19 01:09:47 INFO ShuffleBlockFetcherIterator: Getting 10 (352.5 KiB) non-empty blocks including 10 (352.5 KiB) local and 0 (0.0 B)
 host-local and 0 (0.0 B) push-merged-local and 0 (0.0 B) remote blocks
22/11/19 01:09:47 INFO ShuffleBlockFetcherIterator: Started 0 remote fetches in 0 ms
22/11/19 01:09:47 INFO TaskSetManager: Finished task 3.0 in stage 6631.0 (TID 16221) in 3839 ms on instance-for-mlib.us-central1-a.c.sca
la-3.internal (executor driver) (4/10)
```

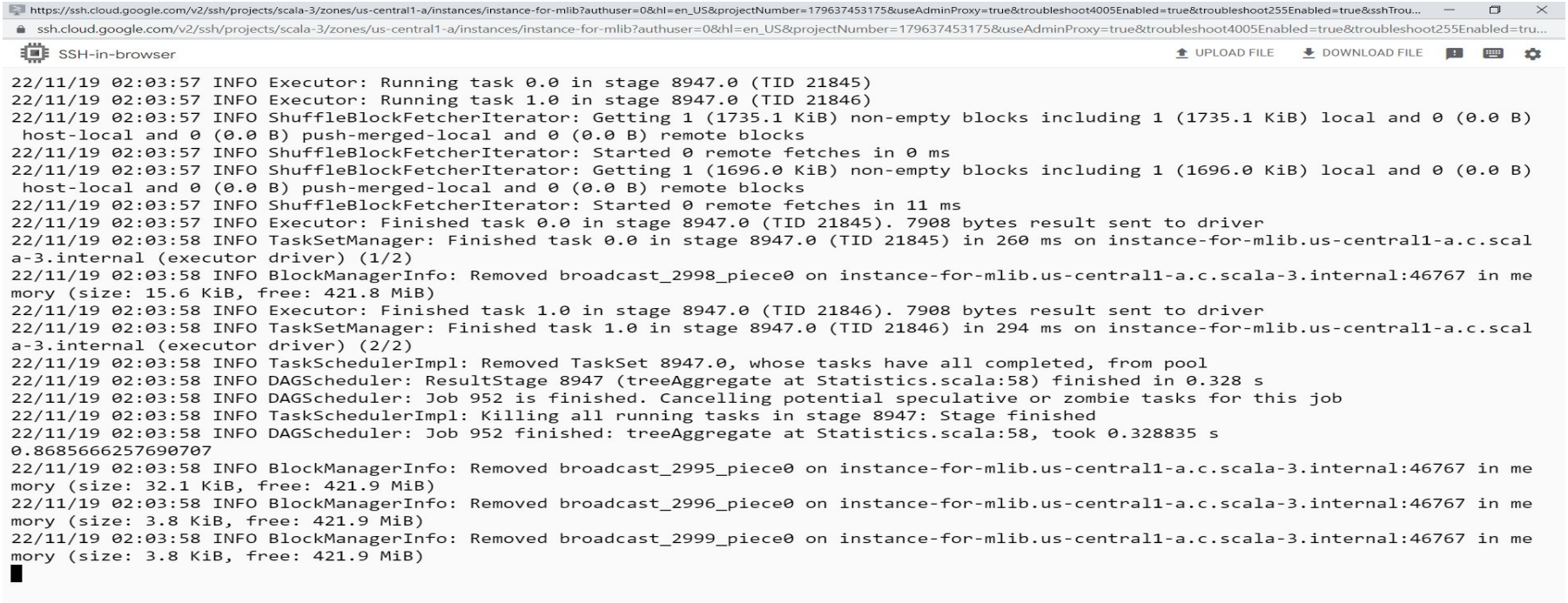
```
22/11/19 01:10:41 INFO Executor: Running task 3.0 in stage 6634.0 (TID 16251)
22/11/19 01:10:41 INFO BlockManager: Found block rdd_14287_3 locally
22/11/19 01:10:41 INFO BlockManager: Found block rdd_14286_3 locally
22/11/19 01:10:41 INFO ShuffleBlockFetcherIterator: Getting 10 (1289.4 KiB) non-empty blocks including 10 (1289.4 KiB) local and 0 (0.0
B) host-local and 0 (0.0 B) push-merged-local and 0 (0.0 B) remote blocks
22/11/19 01:10:41 INFO ShuffleBlockFetcherIterator: Started 0 remote fetches in 0 ms
22/11/19 01:10:45 INFO Executor: Finished task 2.0 in stage 6634.0 (TID 16250). 2694 bytes result sent to driver
22/11/19 01:10:45 INFO TaskSetManager: Starting task 4.0 in stage 6634.0 (TID 16252) (instance-for-mlib.us-central1-a.c.scala-3.internal
, executor driver, partition 4, PROCESS_LOCAL, 4550 bytes) taskResourceAssignments Map()
22/11/19 01:10:45 INFO TaskSetManager: Finished task 2.0 in stage 6634.0 (TID 16250) in 4039 ms on instance-for-mlib.us-central1-a.c.sca
la-3.internal (executor driver) (3/10)
22/11/19 01:10:45 INFO Executor: Running task 4.0 in stage 6634.0 (TID 16252)
22/11/19 01:10:45 INFO BlockManager: Found block rdd_14287_4 locally
22/11/19 01:10:45 INFO BlockManager: Found block rdd_14286_4 locally
22/11/19 01:10:45 INFO ShuffleBlockFetcherIterator: Getting 10 (2.1 MiB) non-empty blocks including 10 (2.1 MiB) local and 0 (0.0 B) hos
t-local and 0 (0.0 B) push-merged-local and 0 (0.0 B) remote blocks
22/11/19 01:10:45 INFO ShuffleBlockFetcherIterator: Started 0 remote fetches in 0 ms
22/11/19 01:10:46 INFO Executor: Finished task 3.0 in stage 6634.0 (TID 16251). 2694 bytes result sent to driver
22/11/19 01:10:46 INFO TaskSetManager: Starting task 5.0 in stage 6634.0 (TID 16253) (instance-for-mlib.us-central1-a.c.scala-3.internal
, executor driver, partition 5, PROCESS_LOCAL, 4550 bytes) taskResourceAssignments Map()
22/11/19 01:10:46 INFO TaskSetManager: Finished task 3.0 in stage 6634.0 (TID 16251) in 4695 ms on instance-for-mlib.us-central1-a.c.sca
la-3.internal (executor driver) (4/10)
22/11/19 01:10:46 INFO Executor: Running task 5.0 in stage 6634.0 (TID 16253)
22/11/19 01:10:46 INFO BlockManager: Found block rdd_14287_5 locally
22/11/19 01:10:46 INFO BlockManager: Found block rdd_14286_5 locally
22/11/19 01:10:46 INFO ShuffleBlockFetcherIterator: Getting 10 (1379.8 KiB) non-empty blocks including 10 (1379.8 KiB) local and 0 (0.0
B) host-local and 0 (0.0 B) push-merged-local and 0 (0.0 B) remote blocks
22/11/19 01:10:46 INFO ShuffleBlockFetcherIterator: Started 0 remote fetches in 0 ms
```

Best Model , Rank, MaxIter, RegParam

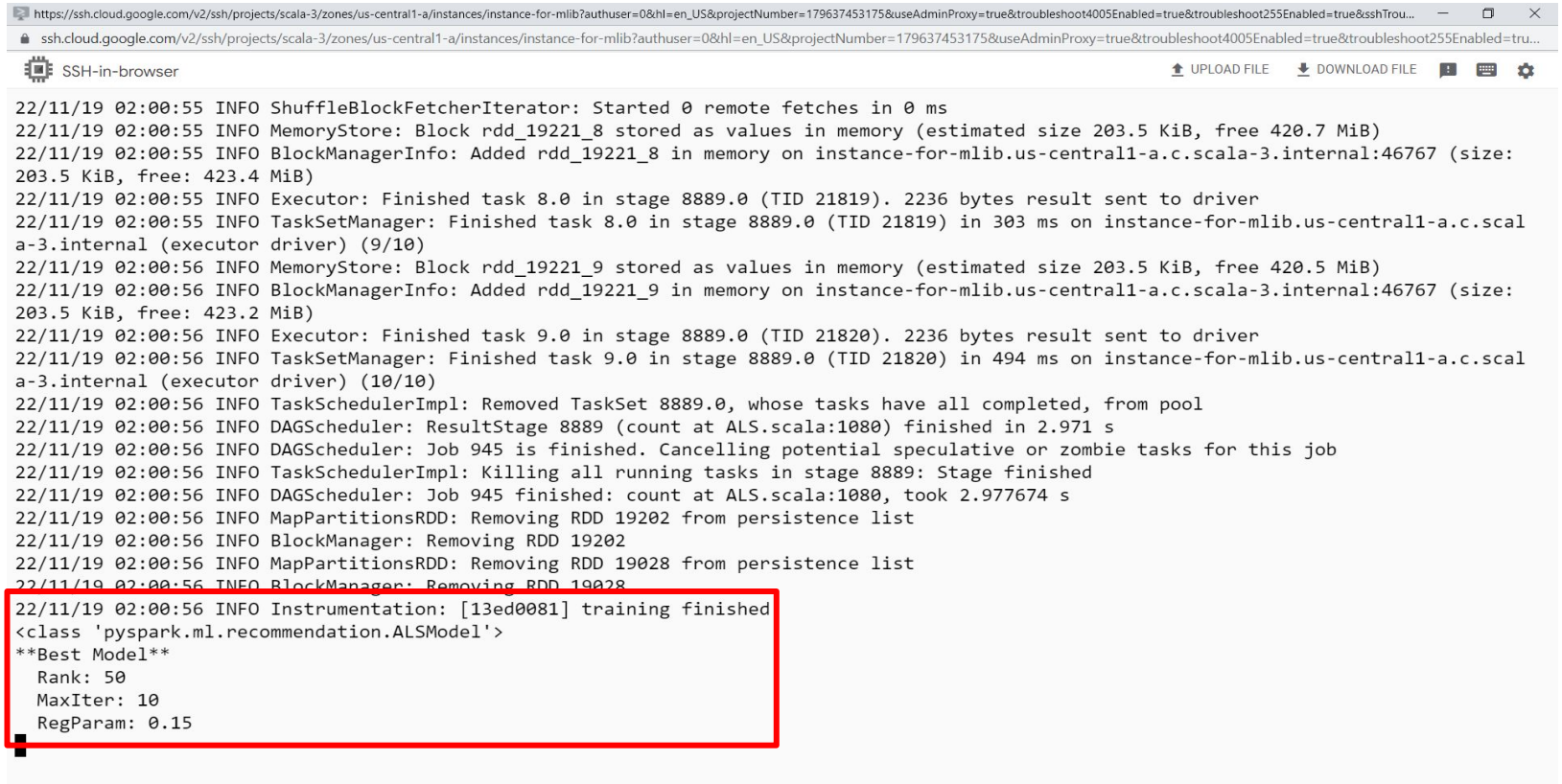


View the Predictions

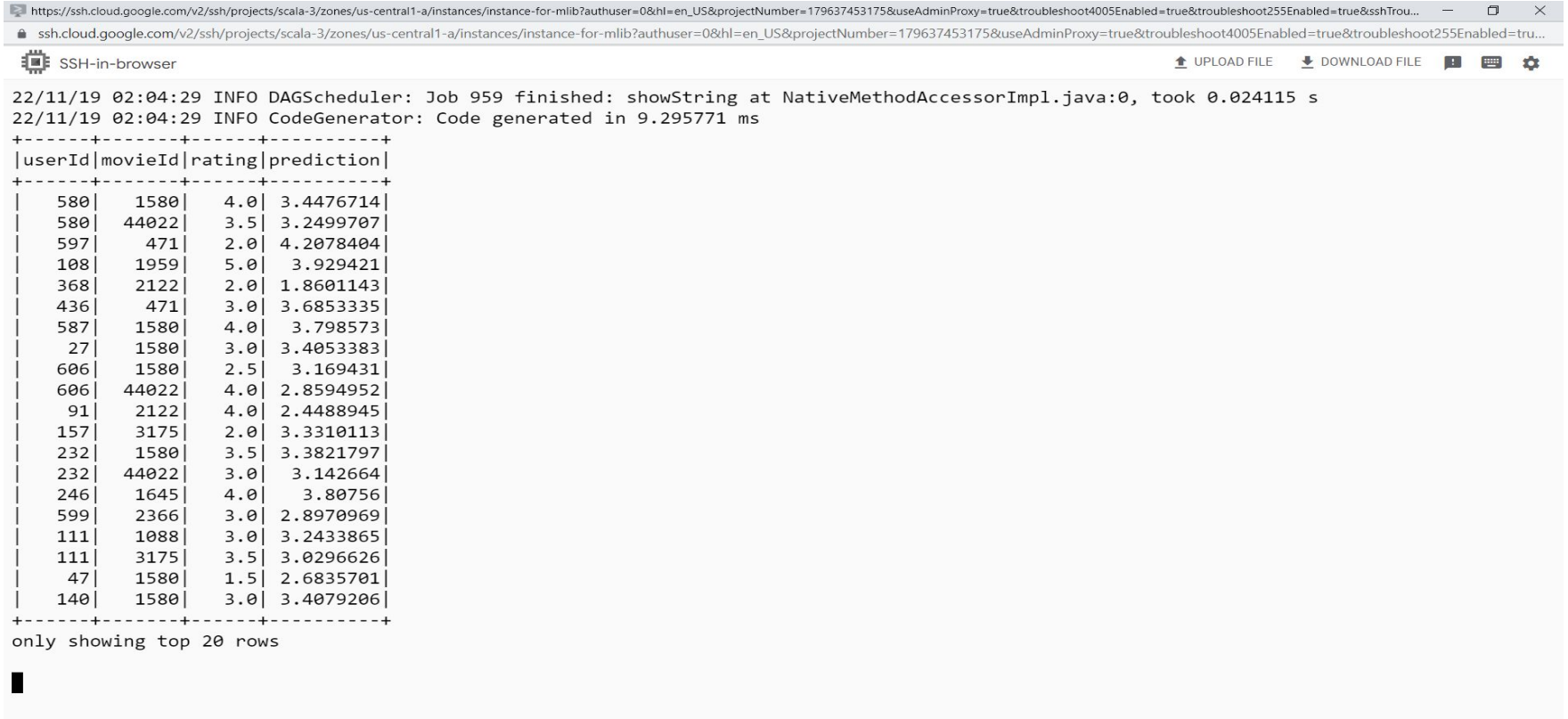
Print(RMSE)



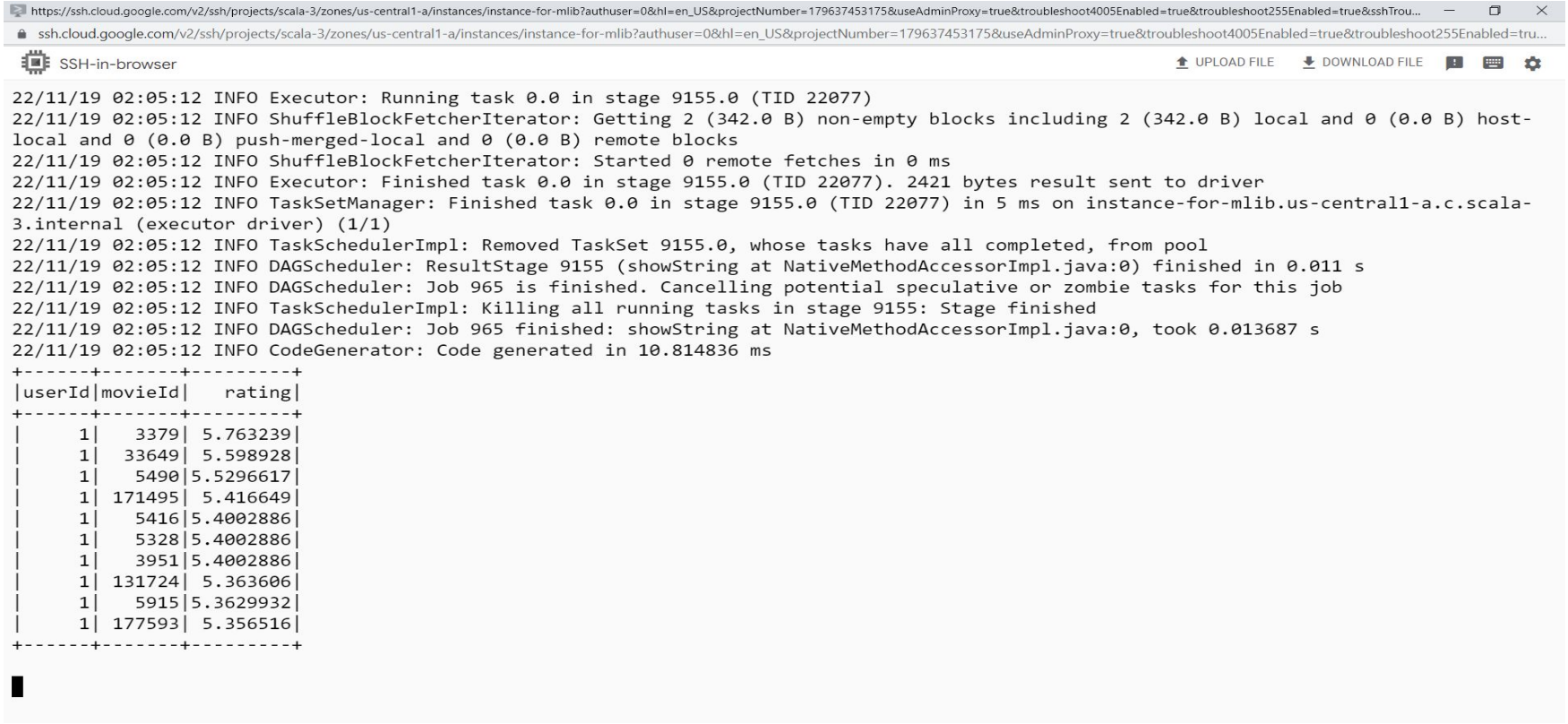
Best Model , Rank, MaxIter, RegParam



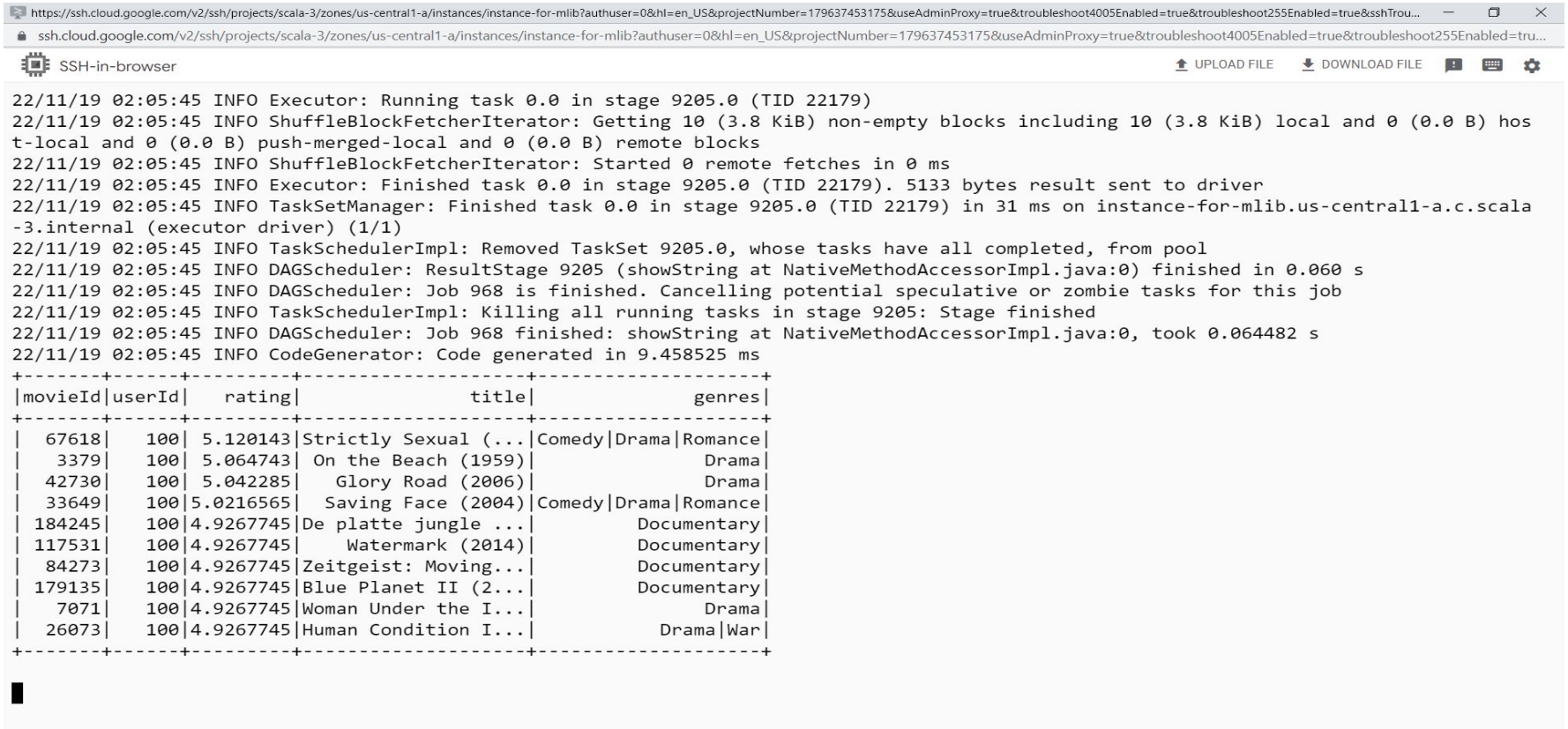
Test_predictions.show()



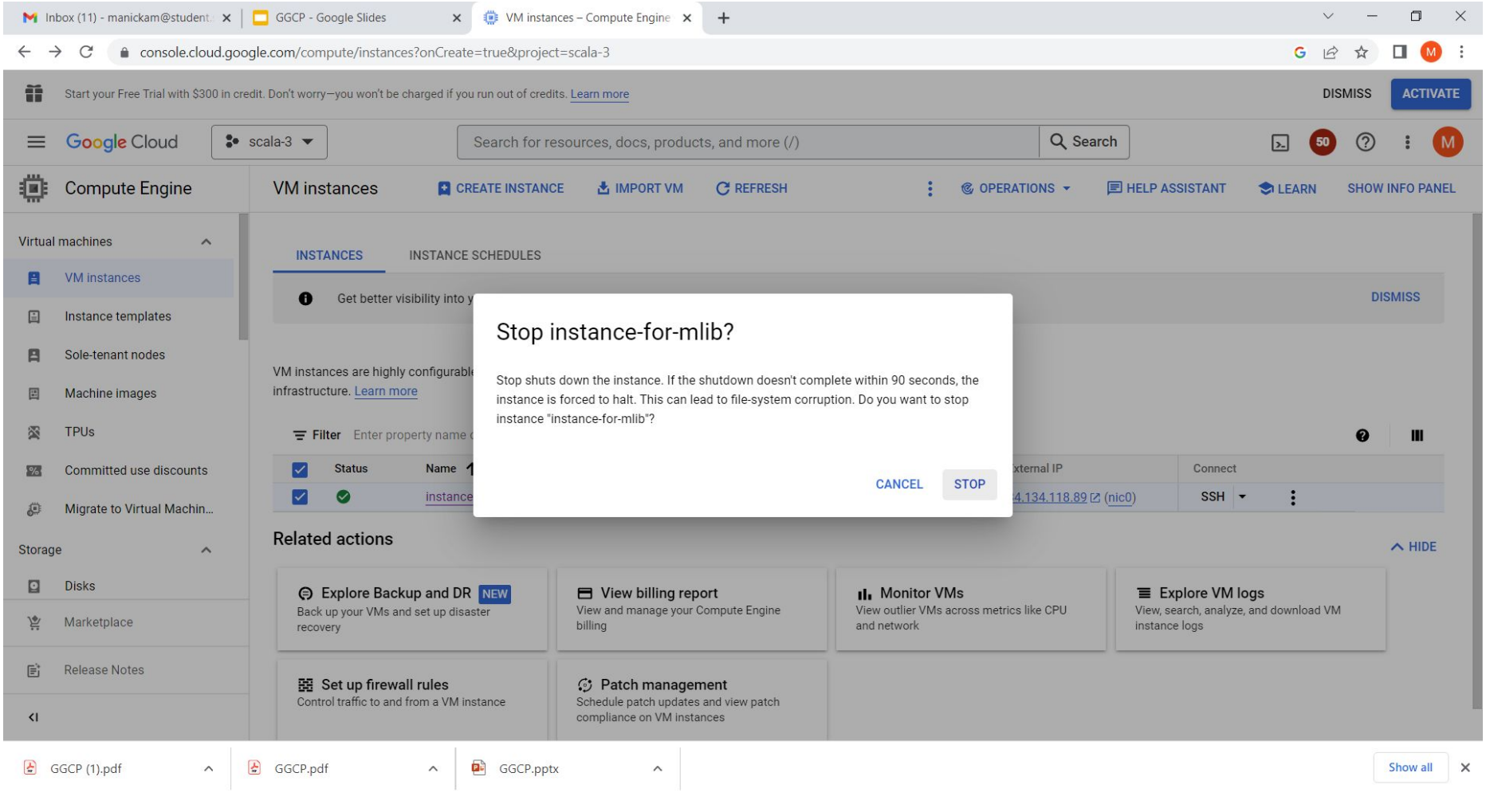
‘nrecommendations.limit(10).show()



nrecommendations.join(movies, on='movieId').filter('userId = 100').show()



```
ratings.join(movis, on='movId').filter('userId=100').sort('rating',
ascending=False.limit(10).show()
```


Inbox (11) - manickam@student
GGCP - Google Slides
VM instances – Compute Engine
console.cloud.google.com/compute/instances?onCreate=true&project=scala-3
Start your Free Trial with $300 in credit. Don't worry—you won't be charged if you run out of credits. Learn more
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IMPORT VM
REFRESH
OPERATIONS
HELP ASSISTANT
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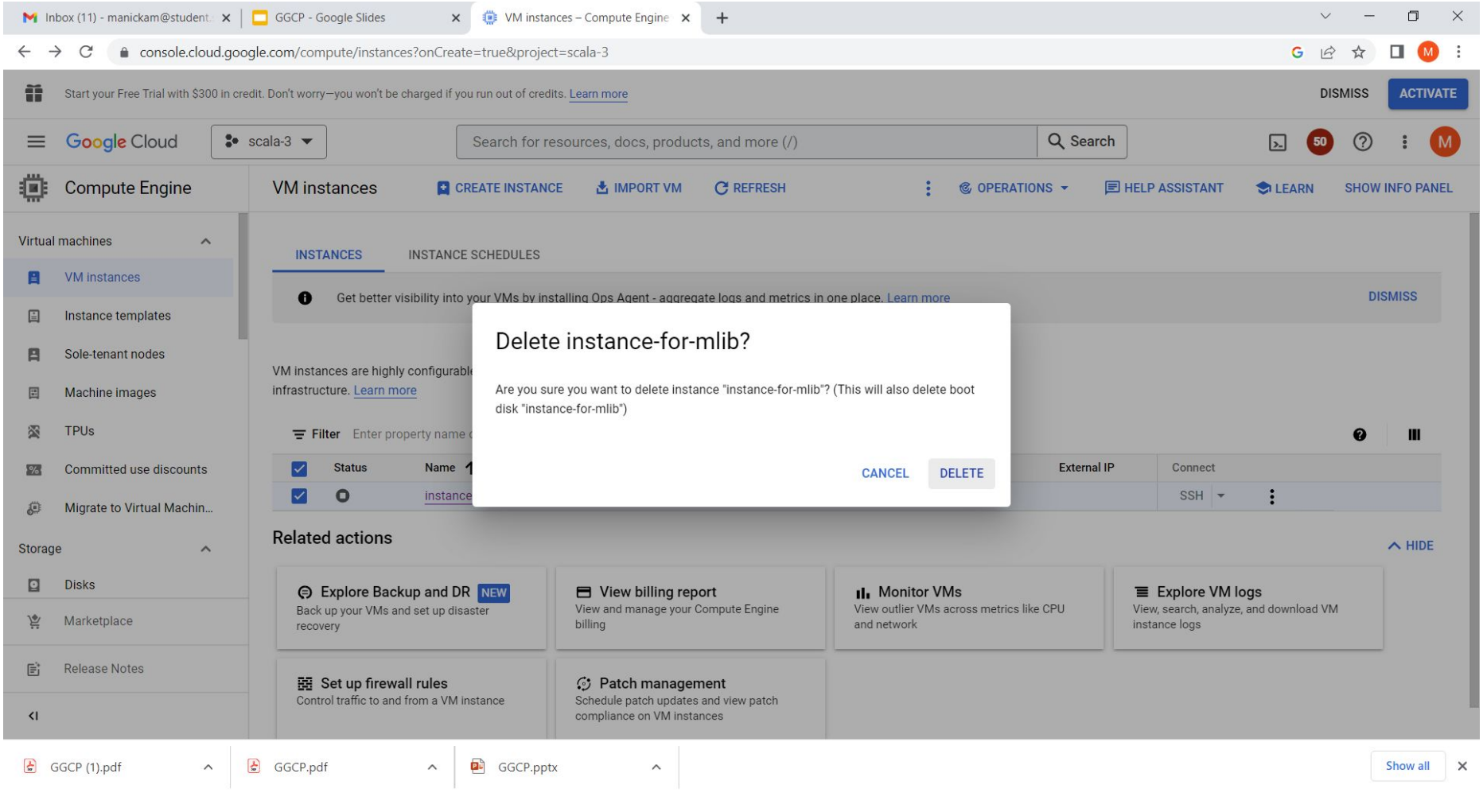
Virtual machines
VM instances
Instance templates
Sole-tenant nodes
Machine images
TPUs
Committed use discounts
Migrate to Virtual Machin...
Storage
Disks
Marketplace
Release Notes
INSTANCES
INSTANCE SCHEDULES
Get better visibility into y
DISMISS
VM instances are highly configurable
infrastructure. Learn more
Filter
Enter property name
Status
Name
External IP
Connect
instance
4.134.118.89 (nic0)
SSH
Stop instance-for-mlib?
Stop shuts down the instance. If the shutdown doesn't complete within 90 seconds, the instance is forced to halt. This can lead to file-system corruption. Do you want to stop instance "instance-for-mlib"?
CANCEL
STOP
Related actions
HIDE
Explore Backup and DR NEW
Back up your VMs and set up disaster recovery
View billing report
View and manage your Compute Engine billing
Monitor VMs
View outlier VMs across metrics like CPU and network
Explore VM logs
View, search, analyze, and download VM instance logs
Set up firewall rules
Control traffic to and from a VM instance
Patch management
Schedule patch updates and view patch compliance on VM instances
GGCP (1).pdf
GGCP.pdf
GGCP.pptx
Show all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Compute Engine
VM instances
CREATE INSTANCE
IMPORT VM
REFRESH
OPERATIONS
HELP ASSISTANT
LEARN
SHOW INFO PANEL
Virtual machines
VM instances
Instance templates
Sole-tenant nodes
Machine images
TPUs
Committed use discounts
Migrate to Virtual Machin...
Storage
Disks
Marketplace
Release Notes
INSTANCES
INSTANCE SCHEDULES
Get better visibility into your VMs by installing Ops Agent - aggregate logs and metrics in one place. Learn more
DISMISS
VM instances are highly configurable
infrastructure. Learn more
Filter
Enter property name
Status
Name
External IP
Connect
instance
SSH
Delete instance-for-mlib?
Are you sure you want to delete instance "instance-for-mlib"? (This will also delete boot disk "instance-for-mlib")
CANCEL
DELETE
Related actions
HIDE
Explore Backup and DR NEW
Back up your VMs and set up disaster recovery
View billing report
View and manage your Compute Engine billing
Monitor VMs
View outlier VMs across metrics like CPU and network
Explore VM logs
View, search, analyze, and download VM instance logs
Set up firewall rules
Control traffic to and from a VM instance
Patch management
Schedule patch updates and view patch compliance on VM instances
GGCP (1).pdf
GGCP.pdf
GGCP.pptx
Show all

Conclusion

Many recommendation systems suggest items to users by utilizing the techniques of collaborative filtering (CF) based on historical records of items that the users have viewed, purchased, or rated. Two major problems that most CF approaches must contend with are scalability and sparseness of the user profiles. To tackle these issues, in this program, we followed a CF algorithm Alternating-least-squares,

Similar logic is followed by amazon, Netflix, google.

References: SFBU exercises materials