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# Airline Search Engine Project

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# AIRLINE SEARCH ENGINE PROJECT

By

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# ABSTRACT

The Airline Search Engine Project is a tool that helps anyone to find the facts/data related to Airlines/Airports. For this project, the raw data set is available in the .dat format. We are going to use this data, which can be downloaded from [1].

The tool may also do some first cleaning of the data if needed for forming dimensional data, the cleaning process such as data value unification, data type and size unification, deduplication, dropping columns, and correcting some known errors.

The data will be processed with the help of languages like Python and Spark. By storing the data, we can distribute storage systems such as Hadoop and Amazon S3. The Integrated Development Environment (IDE) used in this project would be editors such as Google Colab and PyCharm.

This tool can be run as a job in different clusters such as EMR (Elastic MapReduce), HDInsight, Cloudera, and Databricks. It can solve/derive data by analyzing terra bytes of raw data into useful information. We can create reports out of it, which Data Analysts, Data Scientists, and businesspeople can use.

# Table of Contents

## 1 Project Description

This tool is going to process various raw data sets which you can find in **Appendix A** and from this raw data we can derive some useful facts which you can find in **Appendix B**. The tool will process raw data and initially create various dimensional data models such as Airports, Airlines, Routes, Planes, and Countries tables. The schema of those tables can be found in **Appendix C**.

### 1.1 Appendix A:

The raw data sets are

1) Airport.dat – Which contains information related to Airports such as Airport id, Airport Name, etc.
2) Airlines.dat – Which contains information related to Airlines such as Airline id, Airline name, etc et al. [5].
3) Routes.dat – Which contains information related to routes such as Source Airport, Destination Airport.
4) Plane – Which contains information related to plane such as Plane name, etc.
5) Country – Which contains information related to Country name, iso_code et al. [5].

### 1.2 Appendix B:

a. Find list of Airports operating in the Country X.

b. Find the list of Airlines having X stops.

c. List of Airlines operating with code share.

d. Find the list of Active Airlines in the United States.

  i. Airline aggregation:

e. Which Country (or) Territory has the highest number of Airports.

f. The top K cities with most Incoming/Outgoing Airlines.

  i. Trip recommendation:

g. Define a trip as a sequence of connected routes. Find a trip that connects two cities X and Y (reachability).

h. Find a trip that connects X and Y with less than Z stops (constrained reachability).

i. Find all the cities reachable within d hops of a city (bounded reachability).

a. Fast Transitive closure/connected component implemented in parallel/distributed algorithms.

## *1.3 Appendix C:*

| **Table name** | **Airports** |
|---|---|
| airport_id | bigint |
| Name | string |
| city | string |
| country | String |
| iata | String |
| icao | String |
| latitude | Double |
| longitude | Double |
| altitude | Bigint |
| timezone | Double |
| dst | String |
| tz_database | String |
| type | String |
| source | String |

| **Table name** | **Airlines** |
|---|---|
| Airlineid | bigint |
| Name | string |
| Alias | String |
| Iata | String |
| Icao | String |
| Callsign | String |
| Country | String |
| active | String |

| **Table Name** | **Routes** |
|---|---|
| Airline | string |
| Airlineid | String |
| Source_airport | String |
| Source_airport_id | String |
| Destination_airport | string |
| Destination_airportid | string |
| Codeshare | string |
| Stops | Bigint |
| Equipment | string |

| **Table Name** | **Planes** |
|---|---|
| Name | String |
| Iata | String |
| Icao | string |

| **Table Name** | **Countries** |
|---|---|
| Name | String |
| Iso_code | String |
| Dafif_code | String |

## 2 *Architecture and flow of the Data Pipeline*

The given data set will be uploaded to either the Amazon S3 bucket et al. [4,6] or can be uploaded to Hadoop attributed filesystem. The uploaded data will be processed with the help of Apache Spark engine et al. [3]. The Apache Spark engine mostly will be cluster like Amazon Elastic Map Reduce (EMR) service or locally installed Spark. Once the data is processed, we can store the data again in another Amazon S3 bucket or it can be stored in the HDFS also. The output data can be viewed with the help of various tools such as Apache Superset, Tableau, Presto query engine, Amazon Athena et al. [6] or it can be created as another Hive table et al. [3].

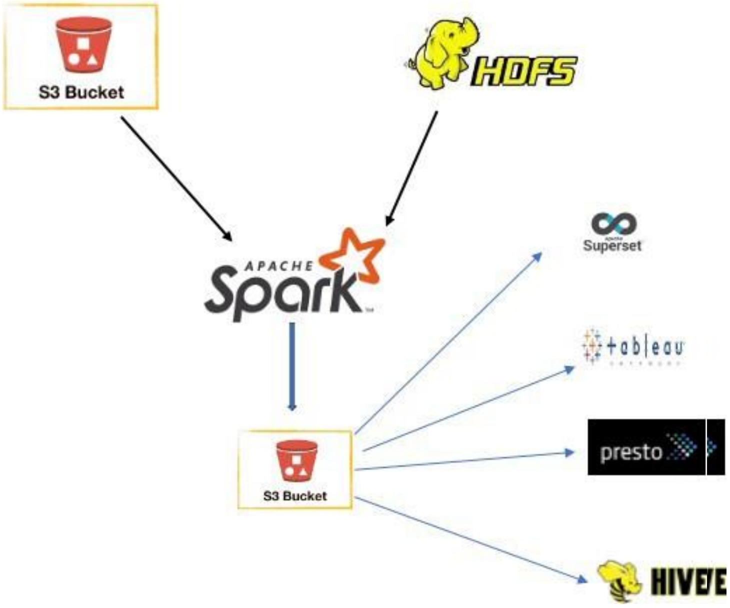


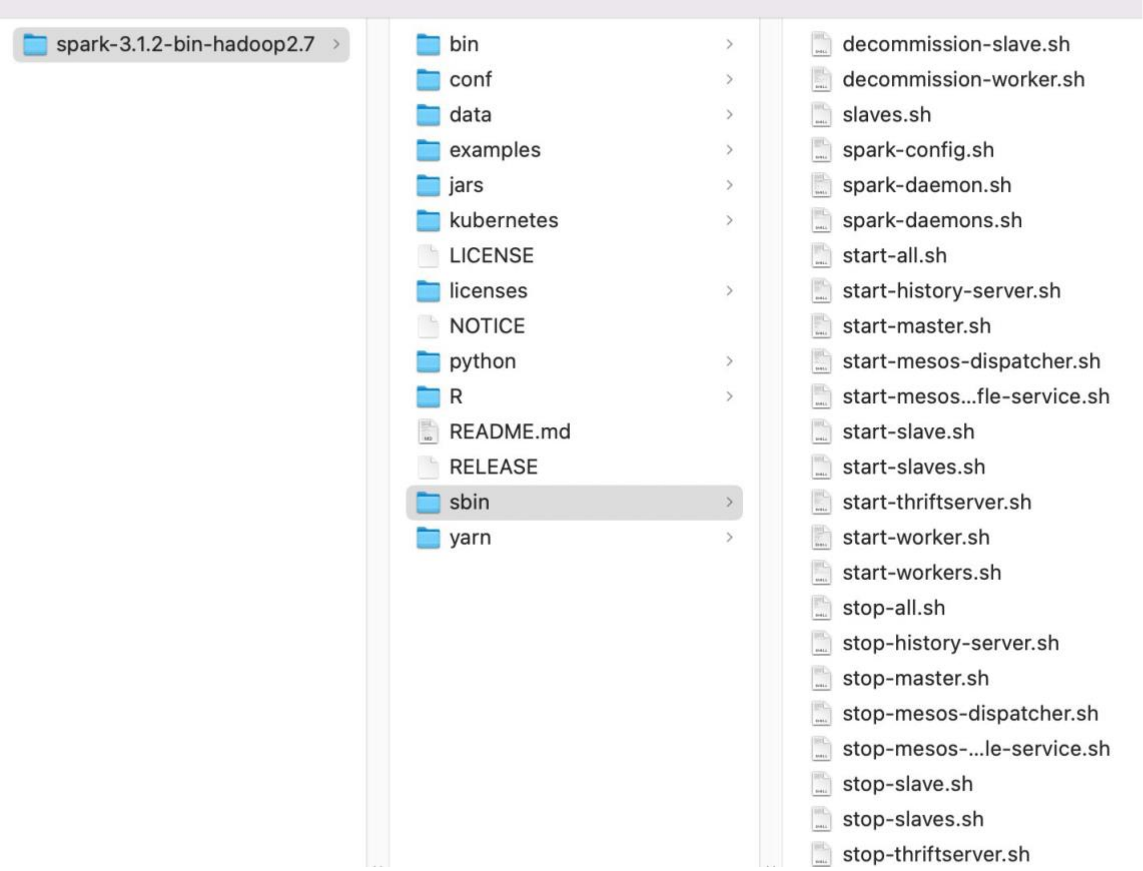
Figure 1: Architecture and flow of the Data Pipeline [2].

## 3 *Tools and Technologies*

Google Colab, Spark, Python, AWS, PyCharm, HDFS, AWS Resources such as S3 bucket, Identity Access Management (IAM), AWS Glue Data Catalog, AWS Glue Crawler, AWS Athena, SQL.

## *4 Project Structure*

The Airline Search Engine Project is developed with Integrated Development Environment ( IDE) such as PyCharm et al. [8] and by installing necessary language binaries like PySpark and Spark et al. [3,11].



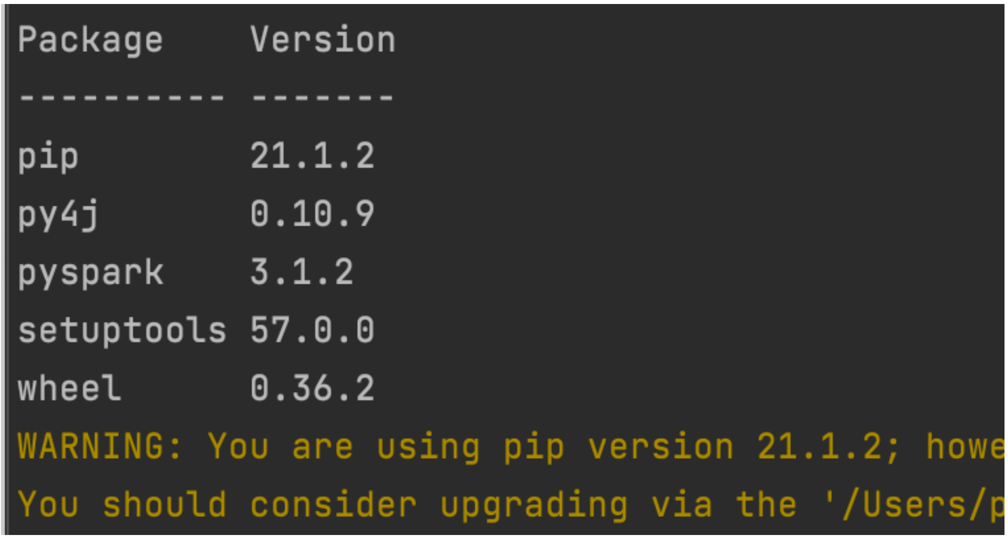
spark-3.1.2-bin-hadoop2.7

bin
conf
data
examples
jars
kubernetes
LICENSE
licenses
NOTICE
python
R
README.md
RELEASE
sbin
yarn

decommission-slave.sh
decommission-worker.sh
slaves.sh
spark-config.sh
spark-daemon.sh
spark-daemons.sh
start-all.sh
start-history-server.sh
start-master.sh
start-mesos-dispatcher.sh
start-mesos...fle-service.sh
start-slave.sh
start-slaves.sh
start-thriftserver.sh
start-worker.sh
start-workers.sh
stop-all.sh
stop-history-server.sh
stop-master.sh
stop-mesos-dispatcher.sh
stop-mesos-...le-service.sh
stop-slave.sh
stop-slaves.sh
stop-thriftserver.sh

Figure 2: PySpark version 3.1.2 and Spark version 3.1.2.

The pip list command shows the PySpark version used in this project. PySpark version 3.1.2 and Spark version 3.1.2.

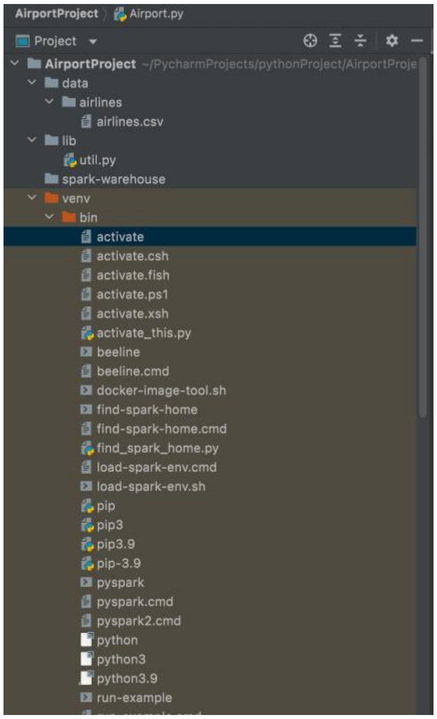


```
Package    Version
---------- -------
pip        21.1.2
py4j       0.10.9
pyspark    3.1.2
setuptools 57.0.0
wheel      0.36.2
WARNING: You are using pip version 21.1.2; howe
You should consider upgrading via the '/Users/p
```

Figure 3: pip list command showing PySpark Version.

## 5 *Project folder Hierarchy*

A separate project is created for this, and it includes a separate virtual environment to install the necessary project dependency modules like Pandas et al. [10], NumPy, etc. The folder structure includes a separate folder for data loading/reading and some util Spark code will be developed and developed folder like the util folder.

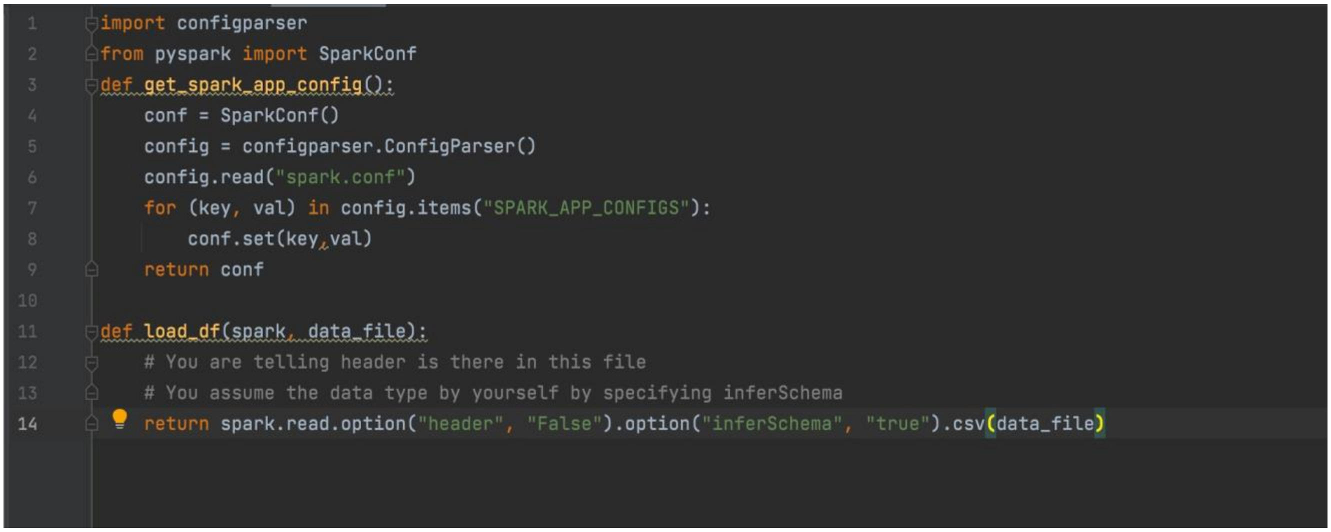


```
AirportProject ~/PycharmProjects/pythonProject/AirportProje
  data
    airlines
      airlines.csv
  lib
    util.py
  spark-warehouse
  venv
    bin
      activate
      activate.csh
      activate.fish
      activate.ps1
      activate.xsh
      activate_this.py
      beeline
      beeline.cmd
      docker-image-tool.sh
      find-spark-home
      find-spark-home.cmd
      find_spark_home.py
      load-spark-env.cmd
      load-spark-env.sh
      pip
      pip3
      pip3.9
      pip-3.9
      pyspark
      pyspark.cmd
      pyspark2.cmd
      python
      python3
      python3.9
      run-example
```

Figure 4: Project folder Hierarchy

## 6 *Utility Code*

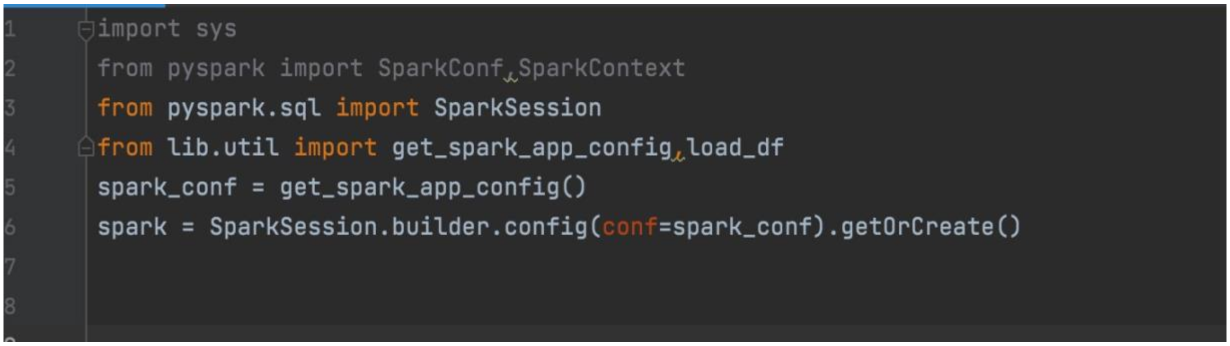
Utility code was developed to read the Spark session configuration and to set the Spark configuration at run time as well.  The load_df utility was developed to read the data. You can find the code in the belowscreenshot.



```
import configparser
from pyspark import SparkConf
def get_spark_app_config():
    conf = SparkConf()
    config = configparser.ConfigParser()
    config.read("spark.conf")
    for (key, val) in config.items("SPARK_APP_CONFIGS"):
        conf.set(key,val)
    return conf

def load_df(spark, data_file):
    # You are telling header is there in this file
    # You assume the data type by yourself by specifying inferSchema
    return spark.read.option("header", "False").option("inferSchema", "true").csv(data_file)
```

Figure 5 : Utility Code

## 7 *Code for creating the Spark session*

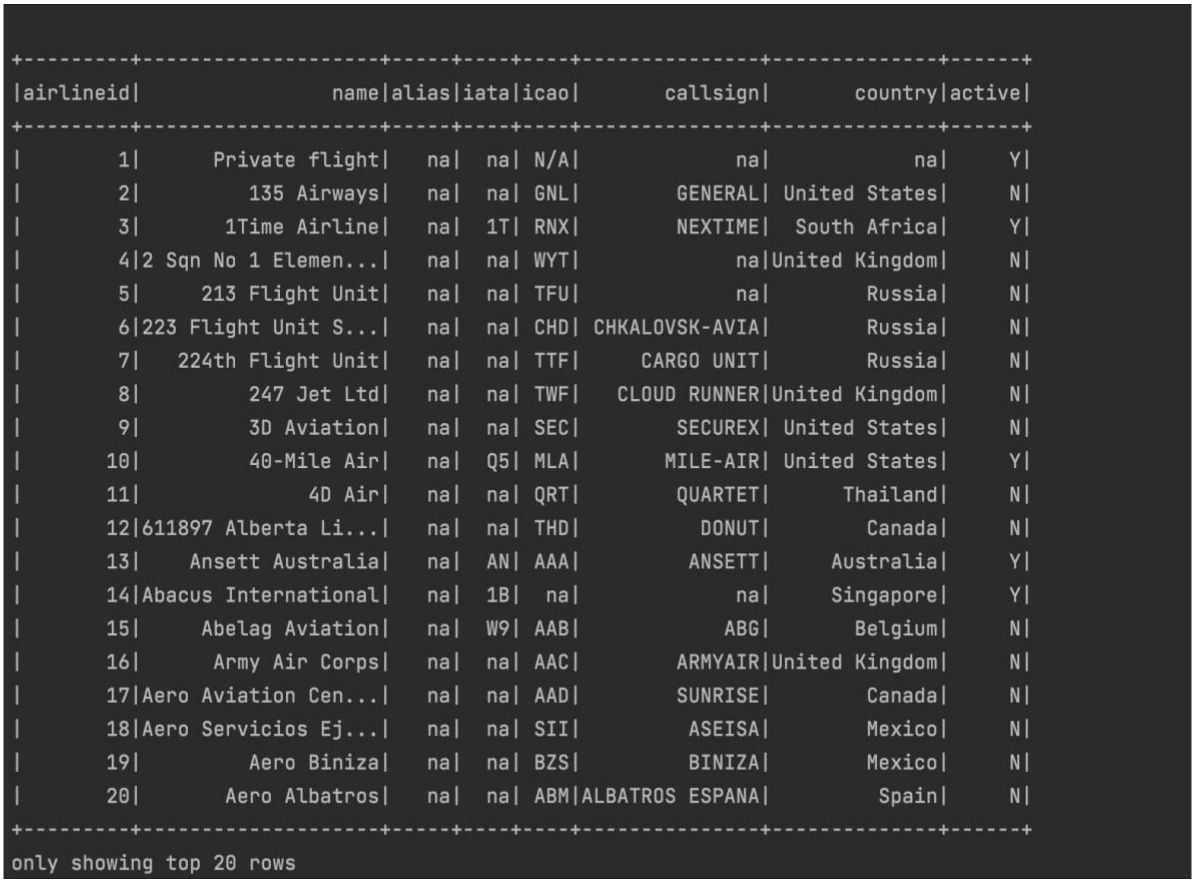


```
import sys
from pyspark import SparkConf,SparkContext
from pyspark.sql import SparkSession
from lib.util import get_spark_app_config,load_df
spark_conf = get_spark_app_config()
spark = SparkSession.builder.config(conf=spark_conf).getOrCreate()
```

Figure 6: Code for creating the Spark session

## 8 Transformation and Cleaning

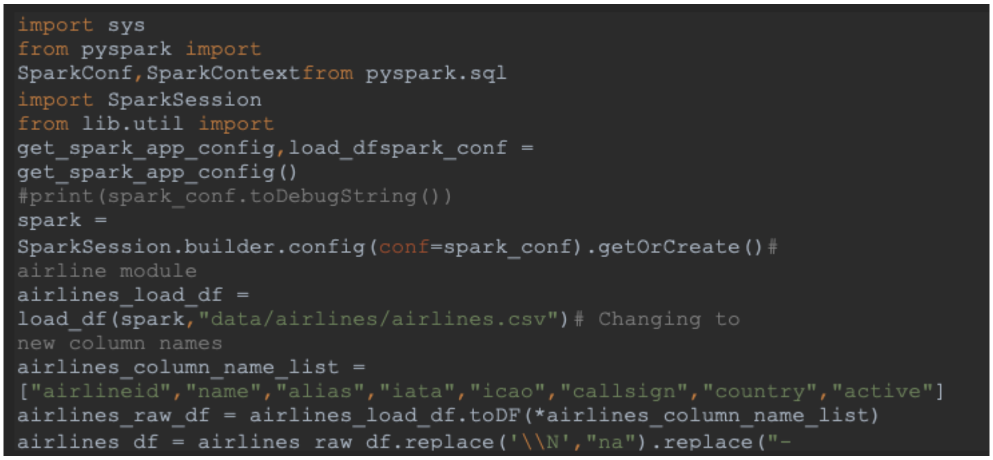
Doing some transformation and cleaning work like replace strings like “\N” and “- “with na and transformation by replacing all null values with strings like na. You can find the output in the screen below after this transformation and cleaning.



```
+---------+--------------------+-----+----+----+---------------+--------------+------+
|airlineid|                name|alias|iata|icao|       callsign|       country|active|
+---------+--------------------+-----+----+----+---------------+--------------+------+
|        1|      Private flight|   na|  na| N/A|             na|            na|     Y|
|        2|         135 Airways|   na|  na| GNL|        GENERAL| United States|     N|
|        3|       1Time Airline|   na|  1T| RNX|        NEXTIME|  South Africa|     Y|
|        4|2 Sqn No 1 Elemen...|   na|  na| WYT|             na|United Kingdom|     N|
|        5|     213 Flight Unit|   na|  na| TFU|             na|        Russia|     N|
|        6|223 Flight Unit S...|   na|  na| CHD| CHKALOVSK-AVIA|        Russia|     N|
|        7|   224th Flight Unit|   na|  na| TTF|     CARGO UNIT|        Russia|     N|
|        8|         247 Jet Ltd|   na|  na| TWF|   CLOUD RUNNER|United Kingdom|     N|
|        9|         3D Aviation|   na|  na| SEC|        SECUREX| United States|     N|
|       10|         40-Mile Air|   na|  Q5| MLA|       MILE-AIR| United States|     Y|
|       11|              4D Air|   na|  na| QRT|        QUARTET|      Thailand|     N|
|       12|611897 Alberta Li...|   na|  na| THD|          DONUT|        Canada|     N|
|       13|    Ansett Australia|   na|  AN| AAA|         ANSETT|     Australia|     Y|
|       14|Abacus International|   na|  1B|  na|             na|     Singapore|     Y|
|       15|     Abelag Aviation|   na|  W9| AAB|            ABG|       Belgium|     N|
|       16|      Army Air Corps|   na|  na| AAC|        ARMYAIR|United Kingdom|     N|
|       17|Aero Aviation Cen...|   na|  na| AAD|        SUNRISE|        Canada|     N|
|       18|Aero Servicios Ej...|   na|  na| SII|         ASEISA|        Mexico|     N|
|       19|         Aero Biniza|   na|  na| BZS|         BINIZA|        Mexico|     N|
|       20|       Aero Albatros|   na|  na| ABM|ALBATROS ESPANA|         Spain|     N|
+---------+--------------------+-----+----+----+---------------+--------------+------+
only showing top 20 rows
```

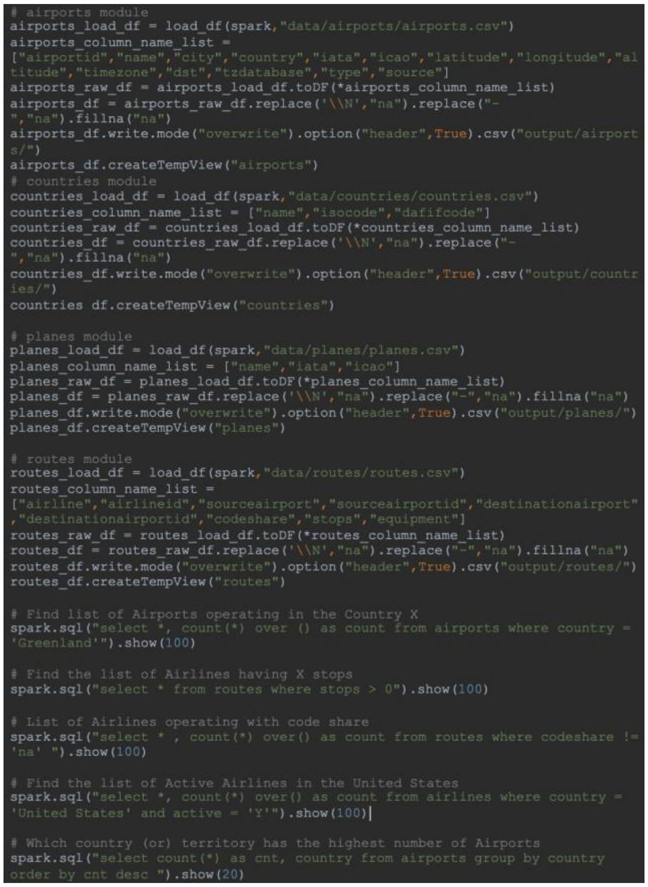
Figure 7: Transformation and Cleaning

## 9 Complete Project Code:



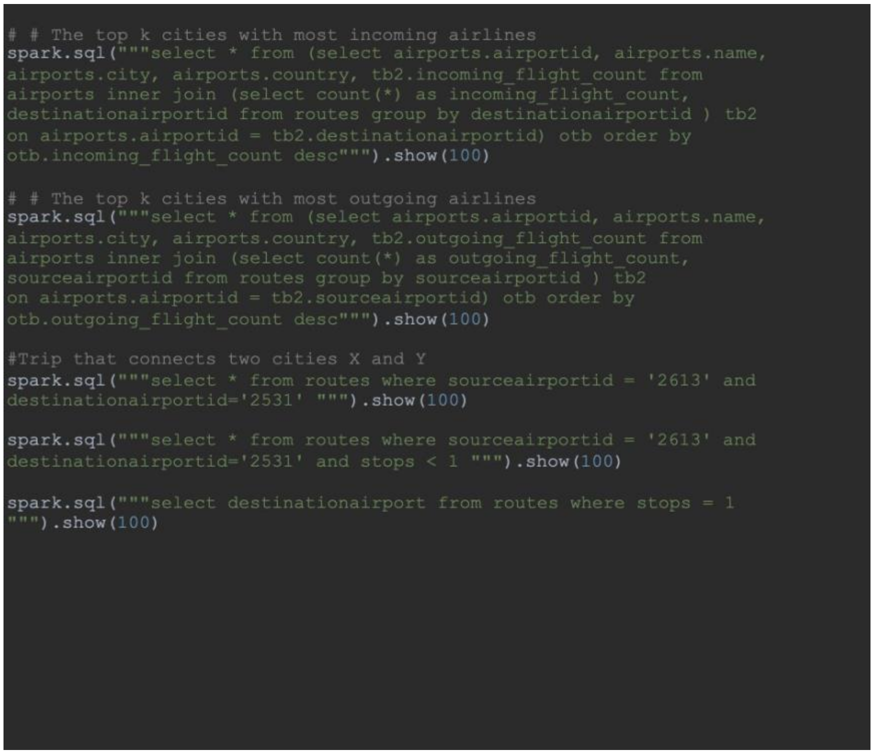
```
import sys
from pyspark import
SparkConf,SparkContextfrom pyspark.sql
import SparkSession
from lib.util import
get_spark_app_config,load_dfspark_conf =
get_spark_app_config()
#print(spark_conf.toDebugString())
spark =
SparkSession.builder.config(conf=spark_conf).getOrCreate()#
airline module
airlines_load_df =
load_df(spark,"data/airlines/airlines.csv")# Changing to
new column names
airlines_column_name_list =
["airlineid","name","alias","iata","icao","callsign","country","active"]
airlines_raw_df = airlines_load_df.toDF(*airlines_column_name_list)
airlines df = airlines raw df.replace('\\N',"na").replace("-
```

Figure 8: Project Code



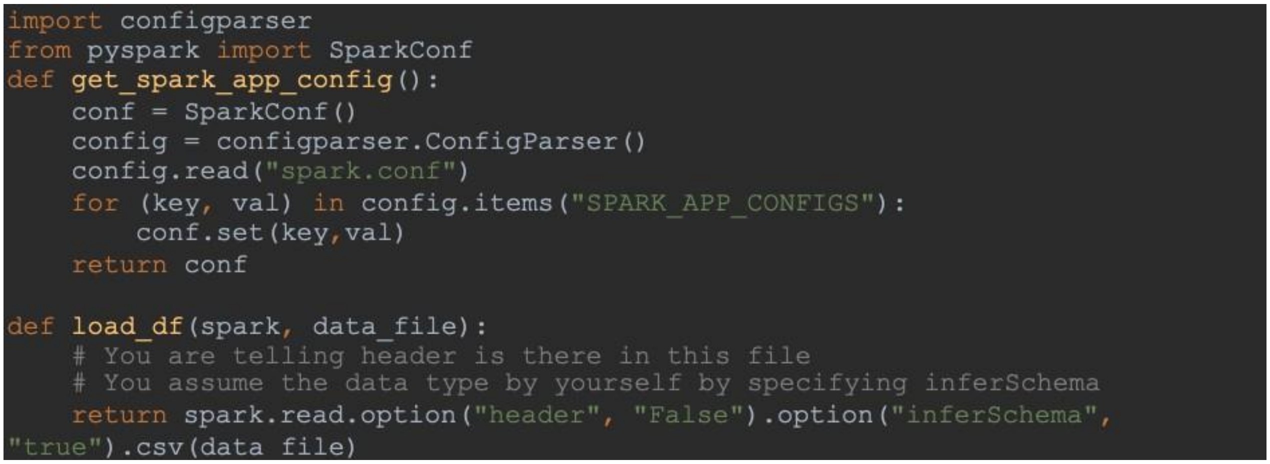
```
# airports module
airports_load_df = load_df(spark,"data/airports/airports.csv")
airports_column_name_list =
["airportid","name","city","country","iata","icao","latitude","longitude","al
titude","timezone","dst","tzdatabase","type","source"]
airports_raw_df = airports_load_df.toDF(*airports_column_name_list)
airports_df = airports_raw_df.replace('\\N',"na").replace("-
","na").fillna("na")
airports_df.write.mode("overwrite").option("header",True).csv("output/airport
s/")
airports_df.createTempView("airports")
# countries module
countries_load_df = load_df(spark,"data/countries/countries.csv")
countries_column_name_list = ["name","isocode","dafifcode"]
countries_raw_df = countries_load_df.toDF(*countries_column_name_list)
countries_df = countries_raw_df.replace('\\N',"na").replace("-
","na").fillna("na")
countries_df.write.mode("overwrite").option("header",True).csv("output/countr
ies/")
countries df.createTempView("countries")

# planes module
planes_load_df = load_df(spark,"data/planes/planes.csv")
planes_column_name_list = ["name","iata","icao"]
planes_raw_df = planes_load_df.toDF(*planes_column_name_list)
planes_df = planes_raw_df.replace('\\N',"na").replace("-","na").fillna("na")
planes_df.write.mode("overwrite").option("header",True).csv("output/planes/")
planes_df.createTempView("planes")

# routes module
routes_load_df = load_df(spark,"data/routes/routes.csv")
routes_column_name_list =
["airline","airlineid","sourceairport","sourceairportid","destinationairport"
,"destinationairportid","codeshare","stops","equipment"]
routes_raw_df = routes_load_df.toDF(*routes_column_name_list)
routes_df = routes_raw_df.replace('\\N',"na").replace("-","na").fillna("na")
routes_df.write.mode("overwrite").option("header",True).csv("output/routes/")
routes_df.createTempView("routes")

# Find list of Airports operating in the Country X
spark.sql("select *, count(*) over () as count from airports where country =
'Greenland'").show(100)

# Find the list of Airlines having X stops
spark.sql("select * from routes where stops > 0").show(100)

# List of Airlines operating with code share
spark.sql("select * , count(*) over() as count from routes where codeshare !=
'na' ").show(100)

# Find the list of Active Airlines in the United States
spark.sql("select *, count(*) over() as count from airlines where country =
'United States' and active = 'Y'").show(100)

# Which country (or) territory has the highest number of Airports
spark.sql("select count(*) as cnt, country from airports group by country
order by cnt desc ").show(20)
```

Figure 9: Complete Project Code



```
# # The top k cities with most incoming airlines
spark.sql("""select * from (select airports.airportid, airports.name,
airports.city, airports.country, tb2.incoming_flight_count from
airports inner join (select count(*) as incoming_flight_count,
destinationairportid from routes group by destinationairportid ) tb2
on airports.airportid = tb2.destinationairportid) otb order by
otb.incoming_flight_count desc""").show(100)

# # The top k cities with most outgoing airlines
spark.sql("""select * from (select airports.airportid, airports.name,
airports.city, airports.country, tb2.outgoing_flight_count from
airports inner join (select count(*) as outgoing_flight_count,
sourceairportid from routes group by sourceairportid ) tb2
on airports.airportid = tb2.sourceairportid) otb order by
otb.outgoing_flight_count desc""").show(100)

#Trip that connects two cities X and Y
spark.sql("""select * from routes where sourceairportid = '2613' and
destinationairportid='2531' """).show(100)

spark.sql("""select * from routes where sourceairportid = '2613' and
destinationairportid='2531' and stops < 1 """).show(100)

spark.sql("""select destinationairport from routes where stops = 1
""").show(100)
```

Figure 10: Complete Project Code



```
import configparser
from pyspark import SparkConf
def get_spark_app_config():
    conf = SparkConf()
    config = configparser.ConfigParser()
    config.read("spark.conf")
    for (key, val) in config.items("SPARK_APP_CONFIGS"):
        conf.set(key,val)
    return conf

def load_df(spark, data_file):
    # You are telling header is there in this file
    # You assume the data type by yourself by specifying inferSchema
    return spark.read.option("header", "False").option("inferSchema",
"true").csv(data_file)
```

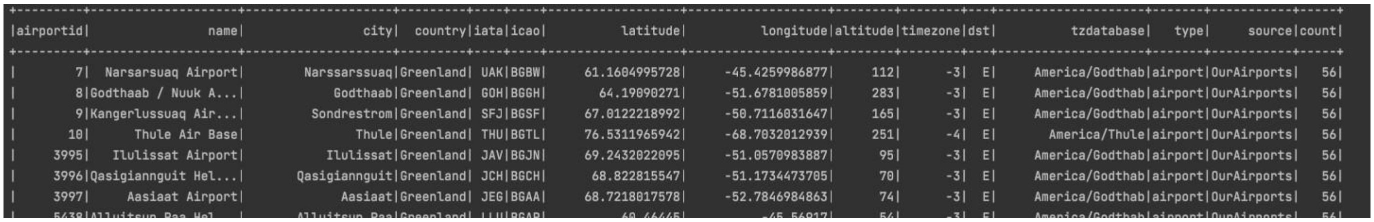
Figure 11: Spark Session Configuration Code

## 10 Project Output Screenshots

### 10.1 Find a list of Airports operating in the Country X

spark.sql("select *, count(*) over () as count from airports where country = 'Greenland'").show(100)

**Output:**



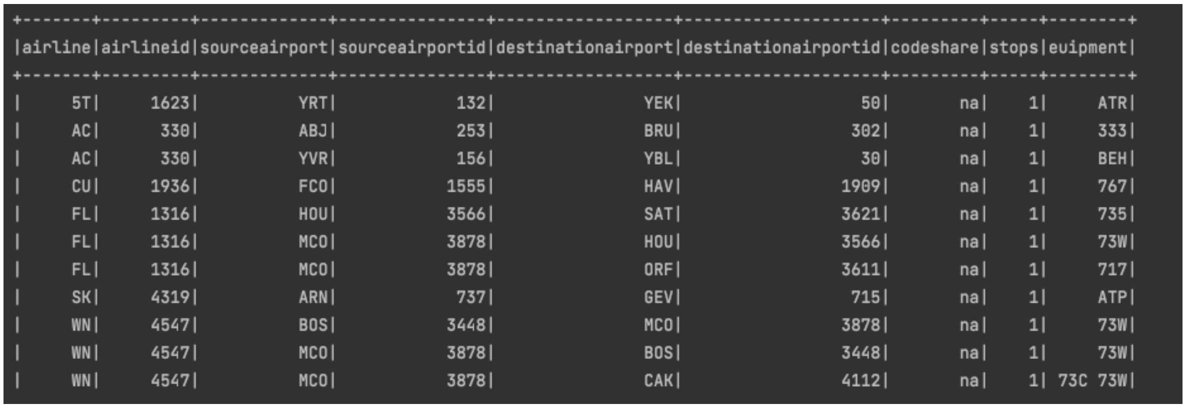
```
+---------+--------------------+--------------------+---------+----+----+------------------+------------------+--------+--------+---+--------------------+-------+-----------+-----+
|airportid|                name|                city|  country|iata|icao|          latitude|         longitude|altitude|timezone|dst|          tzdatabase|   type|     source|count|
+---------+--------------------+--------------------+---------+----+----+------------------+------------------+--------+--------+---+--------------------+-------+-----------+-----+
|        7|  Narsarsuaq Airport|         Narssarssuaq|Greenland| UAK|BGBW|     61.1604995728|    -45.4259986877|     112|      -3|  E|     America/Godthab|airport|OurAirports|   56|
|        8|Godthaab / Nuuk A...|             Godthaab|Greenland| GOH|BGGH|       64.19090271|    -51.6781005859|     283|      -3|  E|     America/Godthab|airport|OurAirports|   56|
|        9|Kangerlussuaq Air...|           Sondrestrom|Greenland| SFJ|BGSF|     67.0122218992|    -50.7116031647|     165|      -3|  E|     America/Godthab|airport|OurAirports|   56|
|       10|      Thule Air Base|                Thule|Greenland| THU|BGTL|     76.5311965942|    -68.7032012939|     251|      -4|  E|       America/Thule|airport|OurAirports|   56|
|     3995|   Ilulissat Airport|            Ilulissat|Greenland| JAV|BGJN|     69.2432022095|    -51.0570983887|      95|      -3|  E|     America/Godthab|airport|OurAirports|   56|
|     3996|Qasigiannguit Hel...|        Qasigiannguit|Greenland| JCH|BGCH|      68.822815547|    -51.1734473705|      70|      -3|  E|     America/Godthab|airport|OurAirports|   56|
|     3997|      Aasiaat Airport|              Aasiaat|Greenland| JEG|BGAA|     68.7218017578|    -52.7846984863|      74|      -3|  E|     America/Godthab|airport|OurAirports|   56|
|     5438|Alluitsup Paa Hel...|        Alluitsup Paa|Greenland| LLU|BGAP|          60.46445|         -45.56917|      54|      -3|  E|     America/Godthab|airport|OurAirports|   56|
```

Figure 10.1: Output for list of Airports operating in the Country X (‘GREENLAND’)

### 10.2 Find the list of Airlines having X stops

spark.sql("select * from routes where stops > 0").show(100)

**Output:**



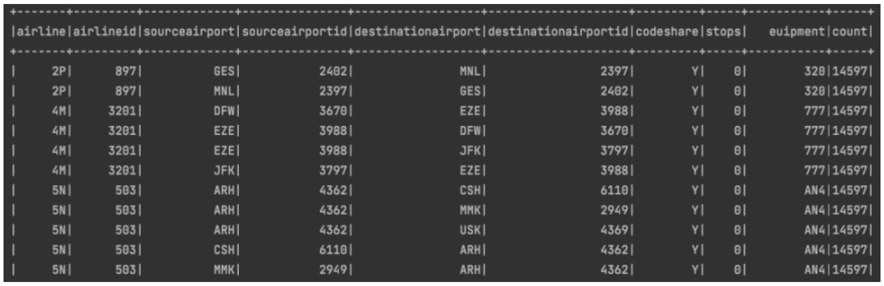
```
+-------+---------+-------------+---------------+------------------+--------------------+---------+-----+--------+
|airline|airlineid|sourceairport|sourceairportid|destinationairport|destinationairportid|codeshare|stops|euipment|
+-------+---------+-------------+---------------+------------------+--------------------+---------+-----+--------+
|     5T|     1623|          YRT|            132|               YEK|                  50|       na|    1|     ATR|
|     AC|      330|          ABJ|            253|               BRU|                 302|       na|    1|     333|
|     AC|      330|          YVR|            156|               YBL|                  30|       na|    1|     BEH|
|     CU|     1936|          FCO|           1555|               HAV|                1909|       na|    1|     767|
|     FL|     1316|          HOU|           3566|               SAT|                3621|       na|    1|     735|
|     FL|     1316|          MCO|           3878|               HOU|                3566|       na|    1|     73W|
|     FL|     1316|          MCO|           3878|               ORF|                3611|       na|    1|     717|
|     SK|     4319|          ARN|            737|               GEV|                 715|       na|    1|     ATP|
|     WN|     4547|          BOS|           3448|               MCO|                3878|       na|    1|     73W|
|     WN|     4547|          MCO|           3878|               BOS|                3448|       na|    1|     73W|
|     WN|     4547|          MCO|           3878|               CAK|                4112|       na|    1| 73C 73W|
```

Figure 10.2: Output for list of Airlines having X stops

### *10.3 List of Airlines operating with codeshare*

spark.sql("select * , count(*) over() as count from routes where codeshare != 'na' ").show(100)

**Output:**



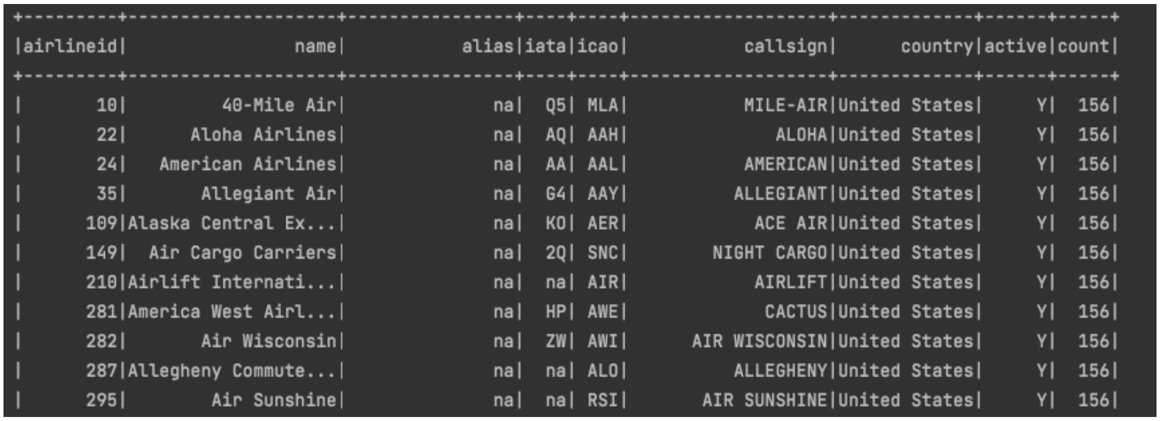
```
+-------+---------+-------------+---------------+------------------+--------------------+---------+-----+-----------+-----+
|airline|airlineid|sourceairport|sourceairportid|destinationairport|destinationairportid|codeshare|stops|   euipment|count|
+-------+---------+-------------+---------------+------------------+--------------------+---------+-----+-----------+-----+
|     2P|      897|          GES|           2402|               MNL|                2397|        Y|    0|        320|14597|
|     2P|      897|          MNL|           2397|               GES|                2402|        Y|    0|        320|14597|
|     4M|     3201|          DFW|           3670|               EZE|                3988|        Y|    0|        777|14597|
|     4M|     3201|          EZE|           3988|               DFW|                3670|        Y|    0|        777|14597|
|     4M|     3201|          EZE|           3988|               JFK|                3797|        Y|    0|        777|14597|
|     4M|     3201|          JFK|           3797|               EZE|                3988|        Y|    0|        777|14597|
|     5N|      503|          ARH|           4362|               CSH|                6110|        Y|    0|        AN4|14597|
|     5N|      503|          ARH|           4362|               MMK|                2949|        Y|    0|        AN4|14597|
|     5N|      503|          ARH|           4362|               USK|                4369|        Y|    0|        AN4|14597|
|     5N|      503|          CSH|           6110|               ARH|                4362|        Y|    0|        AN4|14597|
|     5N|      503|          MMK|           2949|               ARH|                4362|        Y|    0|        AN4|14597|
```

Figure 10.3: Output for list of Airlines operating with codeshare

### *10.4 Find the list of Active Airlines in the United States*

spark.sql("select *, count(*) over() as count from airlines where country = 'United States' andactive = 'Y'").show(100)

**Output:**



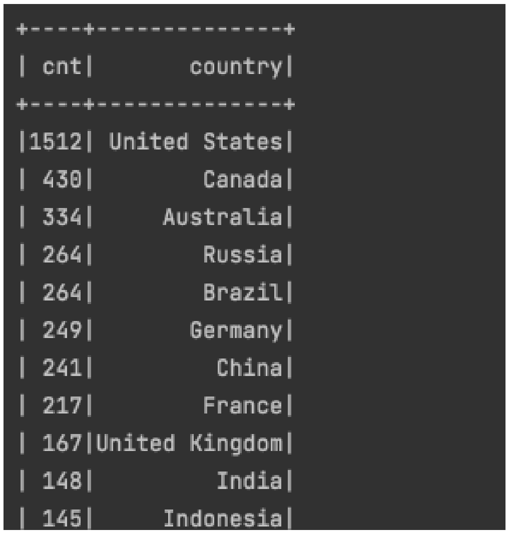
```
+---------+--------------------+---------------+----+----+-------------------+-------------+------+-----+
|airlineid|                name|          alias|iata|icao|           callsign|      country|active|count|
+---------+--------------------+---------------+----+----+-------------------+-------------+------+-----+
|       10|         40-Mile Air|             na|  Q5| MLA|           MILE-AIR|United States|     Y|  156|
|       22|     Aloha Airlines|             na|  AQ| AAH|              ALOHA|United States|     Y|  156|
|       24|   American Airlines|             na|  AA| AAL|           AMERICAN|United States|     Y|  156|
|       35|       Allegiant Air|             na|  G4| AAY|          ALLEGIANT|United States|     Y|  156|
|      109|Alaska Central Ex...|             na|  KO| AER|            ACE AIR|United States|     Y|  156|
|      149|  Air Cargo Carriers|             na|  2Q| SNC|        NIGHT CARGO|United States|     Y|  156|
|      210|Airlift Internati...|             na|  na| AIR|            AIRLIFT|United States|     Y|  156|
|      281|America West Airl...|             na|  HP| AWE|             CACTUS|United States|     Y|  156|
|      282|       Air Wisconsin|             na|  ZW| AWI|      AIR WISCONSIN|United States|     Y|  156|
|      287|Allegheny Commute...|             na|  na| ALO|          ALLEGHENY|United States|     Y|  156|
|      295|        Air Sunshine|             na|  na| RSI|       AIR SUNSHINE|United States|     Y|  156|
```

Figure 10.4: Output for list of active Airlines in the United States

### *10.5 Which country (or) territory has the highest number of Airports*

spark.sql("select count(*) as cnt, country from airports group by country order by cnt desc").show(20)

**Output:**



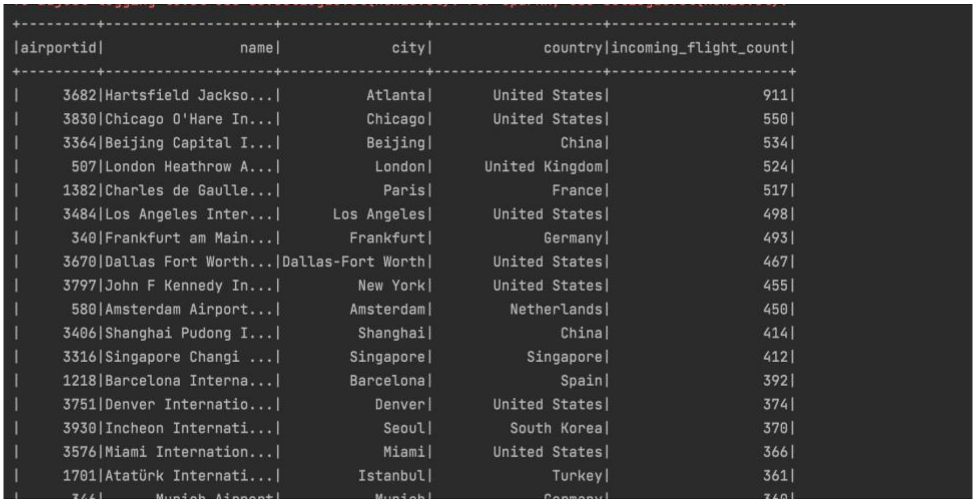
```
+----+--------------+
| cnt|       country|
+----+--------------+
|1512| United States|
| 430|        Canada|
| 334|     Australia|
| 264|        Russia|
| 264|        Brazil|
| 249|       Germany|
| 241|         China|
| 217|        France|
| 167|United Kingdom|
| 148|         India|
| 145|     Indonesia|
```

Figure 10.5: Output for the countries with highest number of Airports

### *10.6 The top K cities with most Incoming Airlines*

spark.sql("""select * from (select airports.airportid, airports.name, airports.city,airports.country, tb2.incoming_flight_count from airports inner join (select count (*) as incoming_flight_count, destinationairportid from routesgroup by destinationairportid ) tb2 on airports.airportid = tb2.destinationairportid) otb order by otb.incoming_flight_countdesc""").show(100)

**Output:**



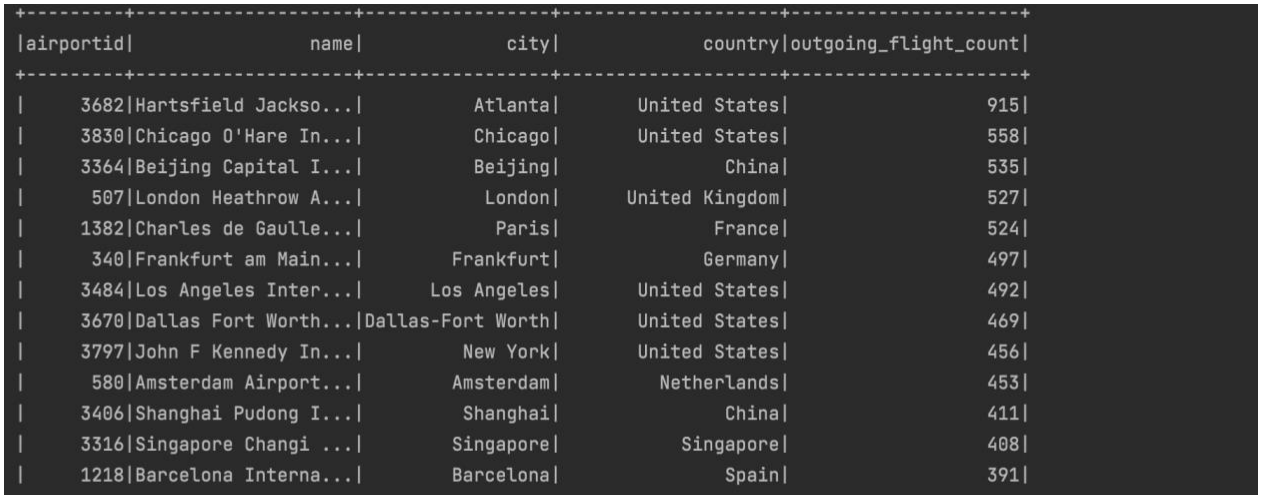
```
+---------+--------------------+-----------------+------------------+---------------------+
|airportid|                name|             city|           country|incoming_flight_count|
+---------+--------------------+-----------------+------------------+---------------------+
|     3682|Hartsfield Jackso...|          Atlanta|     United States|                  911|
|     3830|Chicago O'Hare In...|          Chicago|     United States|                  550|
|     3364|Beijing Capital I...|          Beijing|             China|                  534|
|      507|London Heathrow A...|           London|    United Kingdom|                  524|
|     1382|Charles de Gaulle...|            Paris|            France|                  517|
|     3484|Los Angeles Inter...|      Los Angeles|     United States|                  498|
|      340|Frankfurt am Main...|        Frankfurt|           Germany|                  493|
|     3670|Dallas Fort Worth...|Dallas-Fort Worth|     United States|                  467|
|     3797|John F Kennedy In...|         New York|     United States|                  455|
|      580|Amsterdam Airport...|        Amsterdam|       Netherlands|                  450|
|     3406|Shanghai Pudong I...|         Shanghai|             China|                  414|
|     3316|Singapore Changi ...|        Singapore|         Singapore|                  412|
|     1218|Barcelona Interna...|        Barcelona|             Spain|                  392|
|     3751|Denver Internatio...|           Denver|     United States|                  374|
|     3930|Incheon Internati...|            Seoul|       South Korea|                  370|
|     3576|Miami Internation...|            Miami|     United States|                  366|
|     1701|Atatürk Internati...|         Istanbul|            Turkey|                  361|
|      346|      Munich Airport|           Munich|           Germany|                  360|
```

Figure 10.6: Output for the top cities with most incoming Airlines

## 10.7 *The top K cities with most Outgoing Airlines*

spark.sql("""select * from (select airports.airportid, airports.name, airports.city,airports.country, tb2.outgoing_flight_count from airports inner join (select count (*) as outgoing_flight_count, sourceairportid from routes groupby sourceairportid ) tb2 on airports.airportid = tb2.sourceairportid) otb order by otb.outgoing_flight_count desc""").show(100)

**Output:**



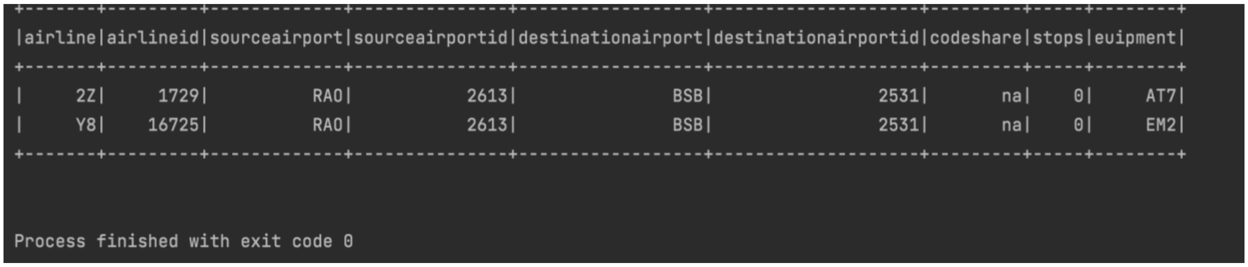
```
+---------+--------------------+-----------------+--------------------+---------------------+
|airportid|                name|             city|             country|outgoing_flight_count|
+---------+--------------------+-----------------+--------------------+---------------------+
|     3682|Hartsfield Jackso...|          Atlanta|       United States|                  915|
|     3830|Chicago O'Hare In...|          Chicago|       United States|                  558|
|     3364|Beijing Capital I...|          Beijing|               China|                  535|
|      507|London Heathrow A...|           London|      United Kingdom|                  527|
|     1382|Charles de Gaulle...|            Paris|              France|                  524|
|      340|Frankfurt am Main...|        Frankfurt|             Germany|                  497|
|     3484|Los Angeles Inter...|      Los Angeles|       United States|                  492|
|     3670|Dallas Fort Worth...|Dallas-Fort Worth|       United States|                  469|
|     3797|John F Kennedy In...|         New York|       United States|                  456|
|      580|Amsterdam Airport...|        Amsterdam|         Netherlands|                  453|
|     3406|Shanghai Pudong I...|         Shanghai|               China|                  411|
|     3316|Singapore Changi ...|        Singapore|           Singapore|                  408|
|     1218|Barcelona Interna...|        Barcelona|               Spain|                  391|
```

Figure 10.7: Output for top cities with most outgoing Airlines

## 10.8 Trip that connects two cities X and Y

spark.sql("""select * from routes where sourceairportid = '2613' and destinationairportid='2531' """).show(100)

**Output:**



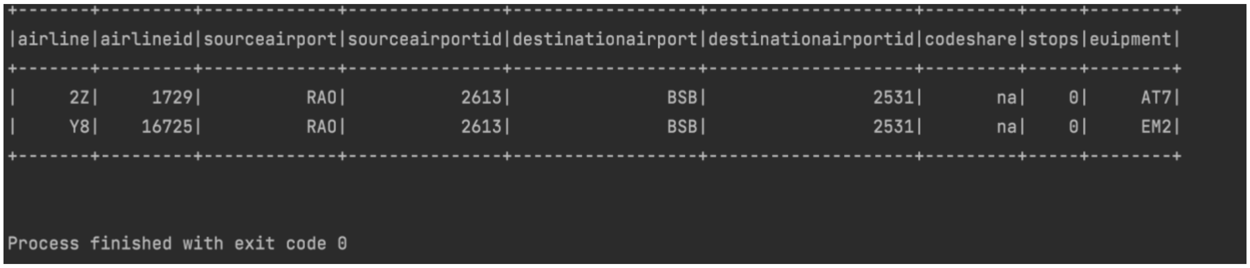
```
+-------+---------+-------------+---------------+------------------+--------------------+---------+-----+--------+
|airline|airlineid|sourceairport|sourceairportid|destinationairport|destinationairportid|codeshare|stops|euipment|
+-------+---------+-------------+---------------+------------------+--------------------+---------+-----+--------+
|     2Z|     1729|          RAO|           2613|               BSB|                2531|       na|    0|     AT7|
|     Y8|    16725|          RAO|           2613|               BSB|                2531|       na|    0|     EM2|
+-------+---------+-------------+---------------+------------------+--------------------+---------+-----+--------+


Process finished with exit code 0
```

Figure 10.8: Output for trip that connects two cities X and Y

## *10.9 Trip that connects X and Y with less than Z stops*

spark.sql("""select * from routes where sourceairportid = '2613' and destinationairportid='2531' and stops < 1 """).show(100)

**Output:**



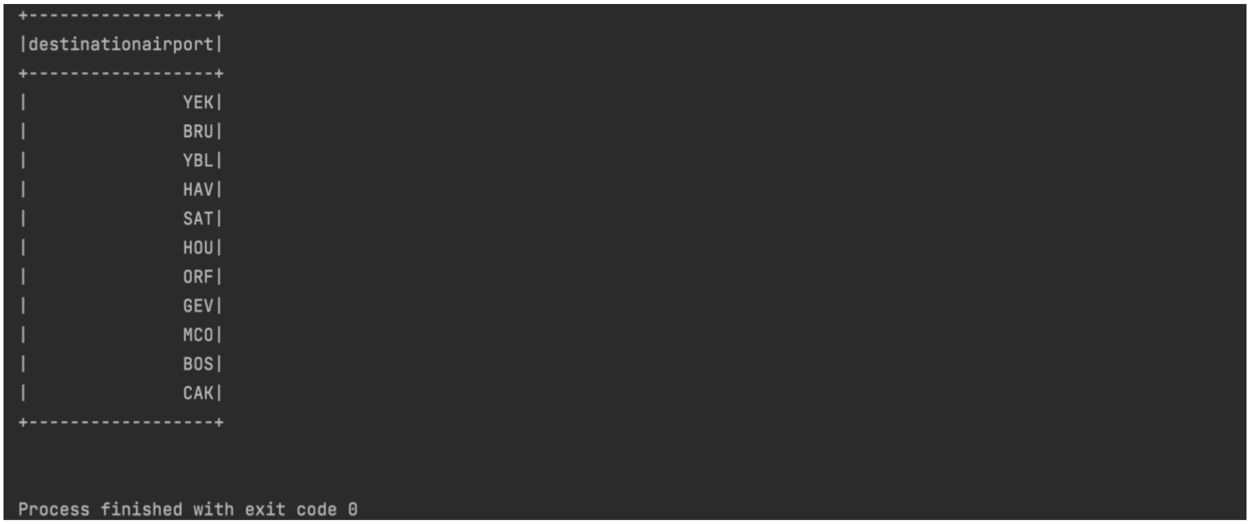
```
+-------+---------+-------------+---------------+------------------+--------------------+---------+-----+--------+
|airline|airlineid|sourceairport|sourceairportid|destinationairport|destinationairportid|codeshare|stops|euipment|
+-------+---------+-------------+---------------+------------------+--------------------+---------+-----+--------+
|     2Z|     1729|          RAO|           2613|               BSB|                2531|       na|    0|     AT7|
|     Y8|    16725|          RAO|           2613|               BSB|                2531|       na|    0|     EM2|
+-------+---------+-------------+---------------+------------------+--------------------+---------+-----+--------+


Process finished with exit code 0
```

Figure 10.9: Output for trip that connects X and Y with less than Z stops

## *10.10 All the cities reachable within d hops of a city*

spark.sql("""select destinationairport from routes where stops = 1 """).show(100)

**Output:**



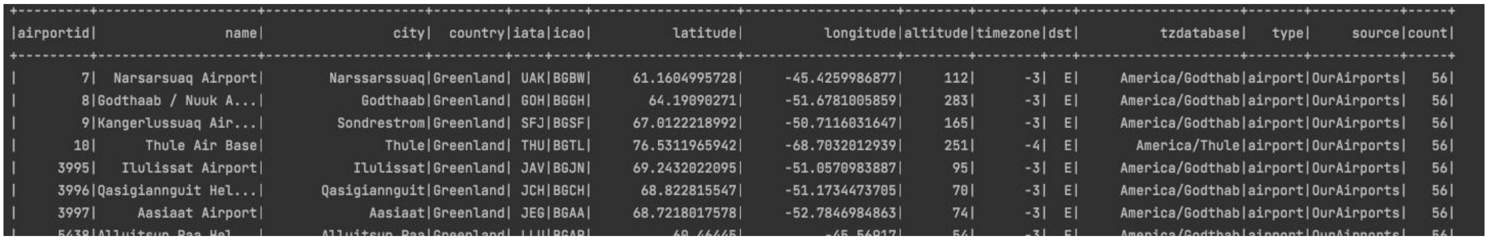
```
+------------------+
|destinationairport|
+------------------+
|               YEK|
|               BRU|
|               YBL|
|               HAV|
|               SAT|
|               HOU|
|               ORF|
|               GEV|
|               MCO|
|               BOS|
|               CAK|
+------------------+


Process finished with exit code 0
```

Figure 10.10: Output for all the cities reachable within d hops of a city

## 10.11 *Find list of Airports operating in the Country X*

spark.sql("select *, count(*) over () as count from airports where country = 'Greenland'").show(100)

**Output**:



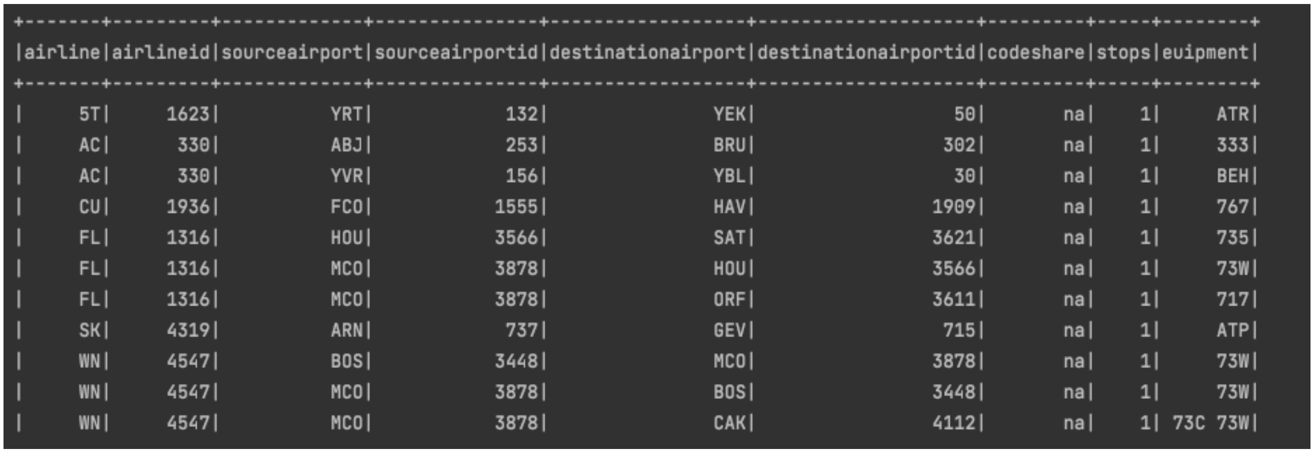
```
+---------+--------------------+------------------+---------+----+----+-----------------+-----------------+--------+--------+---+-------------------+-------+-----------+-----+
|airportid|                name|              city|  country|iata|icao|         latitude|        longitude|altitude|timezone|dst|         tzdatabase|   type|     source|count|
+---------+--------------------+------------------+---------+----+----+-----------------+-----------------+--------+--------+---+-------------------+-------+-----------+-----+
|        7|  Narsarsuaq Airport|       Narssarssuaq|Greenland| UAK|BGBW|    61.1604995728|   -45.4259986877|     112|      -3|  E|    America/Godthab|airport|OurAirports|   56|
|        8|Godthaab / Nuuk A...|           Godthaab|Greenland| GOH|BGGH|      64.19090271|   -51.6781005859|     283|      -3|  E|    America/Godthab|airport|OurAirports|   56|
|        9|Kangerlussuaq Air...|         Sondrestrom|Greenland| SFJ|BGSF|    67.0122218992|   -50.7116031647|     165|      -3|  E|    America/Godthab|airport|OurAirports|   56|
|       10|     Thule Air Base|              Thule|Greenland| THU|BGTL|    76.5311965942|   -68.7032012939|     251|      -4|  E|      America/Thule|airport|OurAirports|   56|
|     3995|   Ilulissat Airport|          Ilulissat|Greenland| JAV|BGJN|    69.2432022095|   -51.0570983887|      95|      -3|  E|    America/Godthab|airport|OurAirports|   56|
|     3996|Qasigiannguit Hel...|      Qasigiannguit|Greenland| JCH|BGCH|     68.822815547|   -51.1734473705|      70|      -3|  E|    America/Godthab|airport|OurAirports|   56|
|     3997|     Aasiaat Airport|            Aasiaat|Greenland| JEG|BGAA|    68.7218017578|   -52.7846984863|      74|      -3|  E|    America/Godthab|airport|OurAirports|   56|
|     5438|Alluitsup Paa Hel...|      Alluitsup Paa|Greenland| LLU|BGAP|         60.46445|        -45.56917|      54|      -3|  E|    America/Godthab|airport|OurAirports|   56|
```

Figure 10.11: Output for list of Airports operating in the country X

## 10.12 *Find the list of Airlines having X stops*

spark.sql("select * from routes where stops > 0").show(100)

**Output:**



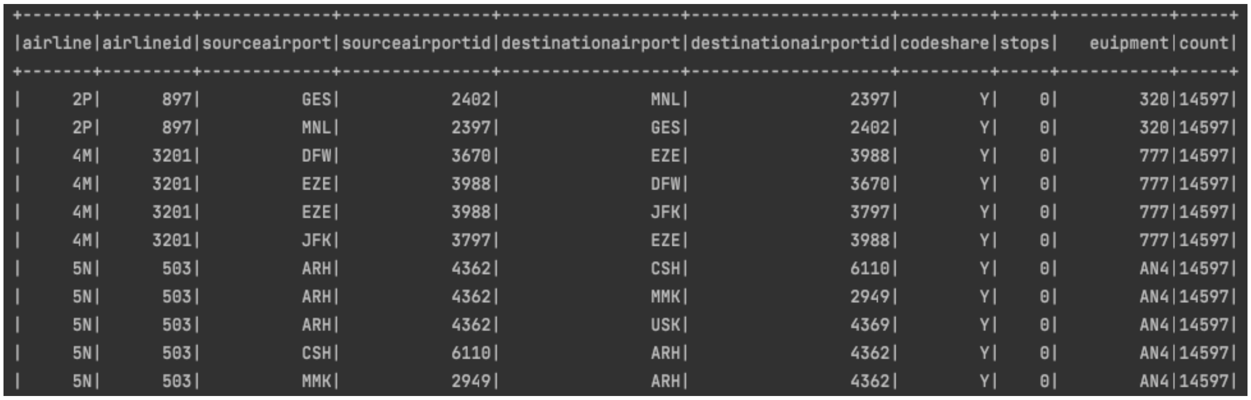
```
+-------+---------+-------------+---------------+------------------+--------------------+---------+-----+--------+
|airline|airlineid|sourceairport|sourceairportid|destinationairport|destinationairportid|codeshare|stops|euipment|
+-------+---------+-------------+---------------+------------------+--------------------+---------+-----+--------+
|     5T|     1623|          YRT|            132|               YEK|                  50|       na|    1|     ATR|
|     AC|      330|          ABJ|            253|               BRU|                 302|       na|    1|     333|
|     AC|      330|          YVR|            156|               YBL|                  30|       na|    1|     BEH|
|     CU|     1936|          FCO|           1555|               HAV|                1909|       na|    1|     767|
|     FL|     1316|          HOU|           3566|               SAT|                3621|       na|    1|     735|
|     FL|     1316|          MCO|           3878|               HOU|                3566|       na|    1|     73W|
|     FL|     1316|          MCO|           3878|               ORF|                3611|       na|    1|     717|
|     SK|     4319|          ARN|            737|               GEV|                 715|       na|    1|     ATP|
|     WN|     4547|          BOS|           3448|               MCO|                3878|       na|    1|     73W|
|     WN|     4547|          MCO|           3878|               BOS|                3448|       na|    1|     73W|
|     WN|     4547|          MCO|           3878|               CAK|                4112|       na|    1| 73C 73W|
```

Figure 10.12: Output for the list of Airlines having X stops

## 10.13  List of Airlines operating with code share

spark.sql("select * , count(*) over() as count from routes where codeshare != 'na' ").show(100)

**Output:**



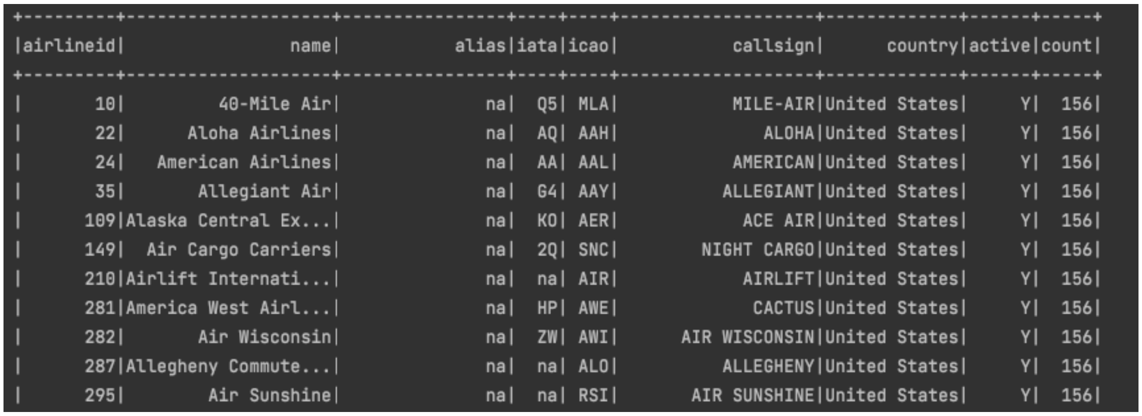
```
+-------+---------+-------------+---------------+------------------+--------------------+---------+-----+-----------+-----+
|airline|airlineid|sourceairport|sourceairportid|destinationairport|destinationairportid|codeshare|stops|   euipment|count|
+-------+---------+-------------+---------------+------------------+--------------------+---------+-----+-----------+-----+
|     2P|      897|          GES|           2402|               MNL|                2397|        Y|    0|        320|14597|
|     2P|      897|          MNL|           2397|               GES|                2402|        Y|    0|        320|14597|
|     4M|     3201|          DFW|           3670|               EZE|                3988|        Y|    0|        777|14597|
|     4M|     3201|          EZE|           3988|               DFW|                3670|        Y|    0|        777|14597|
|     4M|     3201|          EZE|           3988|               JFK|                3797|        Y|    0|        777|14597|
|     4M|     3201|          JFK|           3797|               EZE|                3988|        Y|    0|        777|14597|
|     5N|      503|          ARH|           4362|               CSH|                6110|        Y|    0|        AN4|14597|
|     5N|      503|          ARH|           4362|               MMK|                2949|        Y|    0|        AN4|14597|
|     5N|      503|          ARH|           4362|               USK|                4369|        Y|    0|        AN4|14597|
|     5N|      503|          CSH|           6110|               ARH|                4362|        Y|    0|        AN4|14597|
|     5N|      503|          MMK|           2949|               ARH|                4362|        Y|    0|        AN4|14597|
```

Figure 10.13: Output for Airlines operating with code share

## 10.14  Find the list of Active Airlines in the United States

spark.sql("select *, count(*) over() as count from airlines where country = 'United States' andactive = 'Y'").show(100)

**Output:**



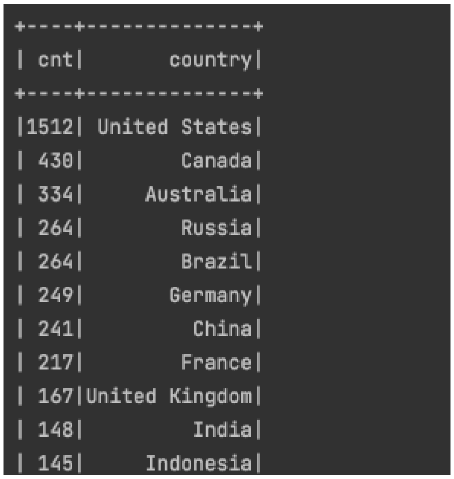
```
+---------+--------------------+---------------+----+----+------------------+-------------+------+-----+
|airlineid|                name|          alias|iata|icao|          callsign|      country|active|count|
+---------+--------------------+---------------+----+----+------------------+-------------+------+-----+
|       10|         40-Mile Air|             na|  Q5| MLA|          MILE-AIR|United States|     Y|  156|
|       22|      Aloha Airlines|             na|  AQ| AAH|             ALOHA|United States|     Y|  156|
|       24|   American Airlines|             na|  AA| AAL|          AMERICAN|United States|     Y|  156|
|       35|       Allegiant Air|             na|  G4| AAY|         ALLEGIANT|United States|     Y|  156|
|      109|Alaska Central Ex...|             na|  KO| AER|           ACE AIR|United States|     Y|  156|
|      149|  Air Cargo Carriers|             na|  2Q| SNC|       NIGHT CARGO|United States|     Y|  156|
|      210|Airlift Internati...|             na|  na| AIR|           AIRLIFT|United States|     Y|  156|
|      281|America West Airl...|             na|  HP| AWE|            CACTUS|United States|     Y|  156|
|      282|       Air Wisconsin|             na|  ZW| AWI|      AIR WISCONSIN|United States|     Y|  156|
|      287|Allegheny Commute...|             na|  na| ALO|         ALLEGHENY|United States|     Y|  156|
|      295|        Air Sunshine|             na|  na| RSI|      AIR SUNSHINE|United States|     Y|  156|
```

Figure 10.14: Output for list of active airlines in the United States

### *10.15 Which country (or) territory has the highest number of Airports*

spark.sql("select count(*) as cnt, country from airports group by country order by cnt desc").show(20)

**Output:**



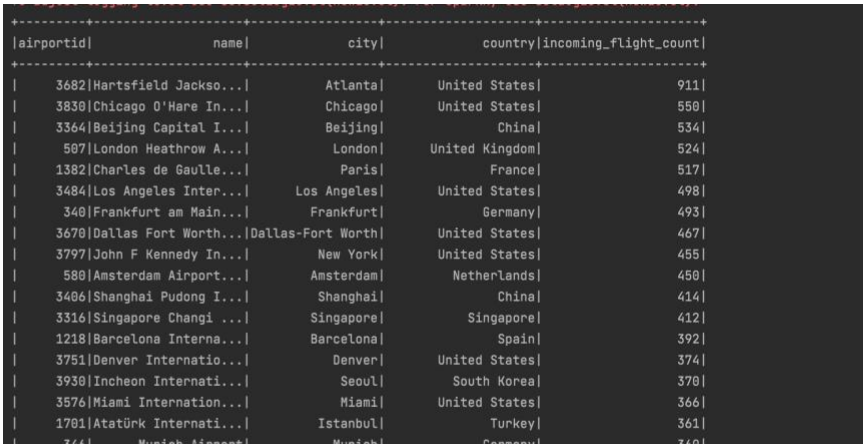
```
+----+--------------+
| cnt|       country|
+----+--------------+
|1512| United States|
| 430|        Canada|
| 334|     Australia|
| 264|        Russia|
| 264|        Brazil|
| 249|       Germany|
| 241|         China|
| 217|        France|
| 167|United Kingdom|
| 148|         India|
| 145|     Indonesia|
```

Figure 10.15: Output for multiple countries having highest number of Airports

## 10.16 The top K cities with most incoming Airlines

spark.sql("""select * from (select airports.airportid, airports.name, airports.city,airports.country, tb2.incoming_flight_count from airports inner join (select count (*) as incoming_flight_count, destinationairportid from routesgroup by destinationairportid ) tb2 on airports.airportid = tb2.destinationairportid) otb order by otb.incoming_flight_count desc""").show(100)

**Output:**



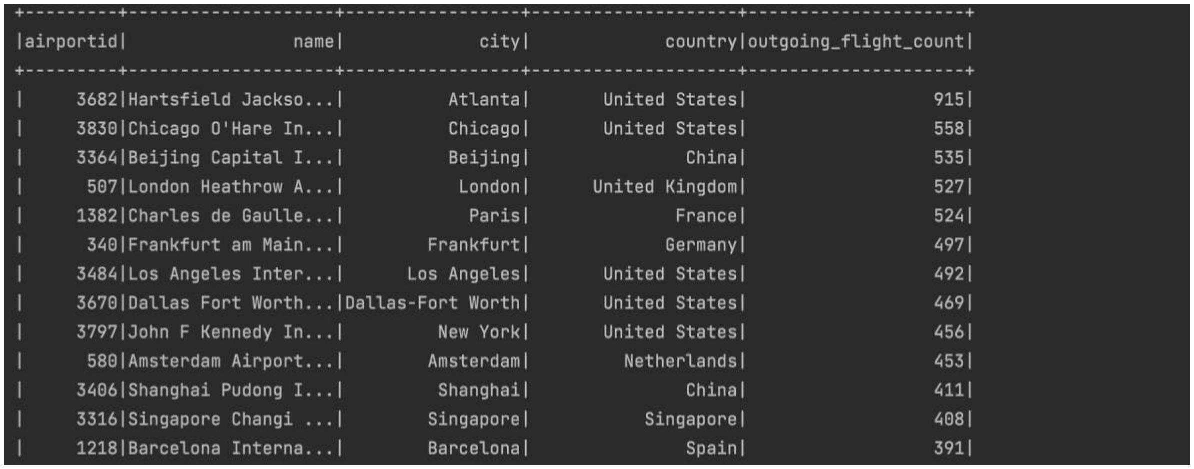
```
+---------+--------------------+----------------+--------------------+---------------------+
|airportid|                name|            city|             country|incoming_flight_count|
+---------+--------------------+----------------+--------------------+---------------------+
|     3682|Hartsfield Jackso...|         Atlanta|       United States|                  911|
|     3830|Chicago O'Hare In...|         Chicago|       United States|                  550|
|     3364|Beijing Capital I...|         Beijing|               China|                  534|
|      507|London Heathrow A...|          London|      United Kingdom|                  524|
|     1382|Charles de Gaulle...|           Paris|              France|                  517|
|     3484|Los Angeles Inter...|     Los Angeles|       United States|                  498|
|      340|Frankfurt am Main...|       Frankfurt|             Germany|                  493|
|     3670|Dallas Fort Worth...|Dallas-Fort Worth|       United States|                  467|
|     3797|John F Kennedy In...|        New York|       United States|                  455|
|      580|Amsterdam Airport...|       Amsterdam|         Netherlands|                  450|
|     3406|Shanghai Pudong I...|        Shanghai|               China|                  414|
|     3316|Singapore Changi ...|       Singapore|           Singapore|                  412|
|     1218|Barcelona Interna...|       Barcelona|               Spain|                  392|
|     3751|Denver Internatio...|          Denver|       United States|                  374|
|     3930|Incheon Internati...|           Seoul|         South Korea|                  370|
|     3576|Miami Internation...|           Miami|       United States|                  366|
|     1701|Atatürk Internati...|        Istanbul|              Turkey|                  361|
```

Figure 10.16: Output for top K cities with most incoming Airlines

## 10.17 The top K cities with most outgoing Airlines

spark.sql("""select * from (select airports.airportid, airports.name, airports.city,airports.country, tb2.outgoing_flight_count from airports inner join (select count (*) as outgoing_flight_count, sourceairportid from routes groupby sourceairportid ) tb2 on airports.airportid = tb2.sourceairportid) otb order by otb.outgoing_flight_count desc""").show(100)

**Output:**



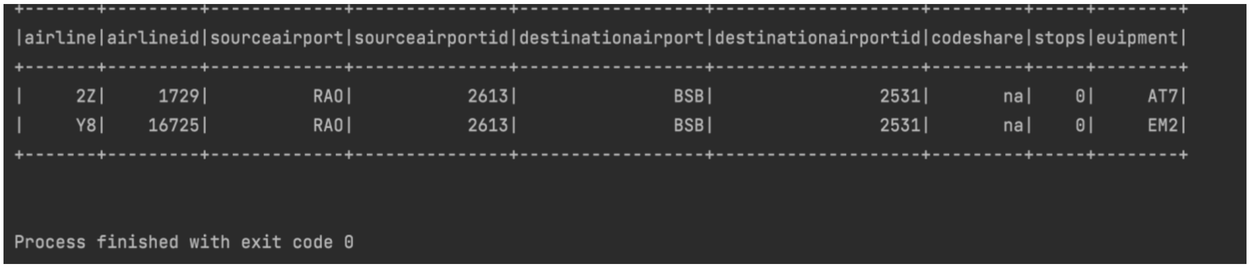
```
+---------+--------------------+-----------------+--------------------+---------------------+
|airportid|                name|             city|             country|outgoing_flight_count|
+---------+--------------------+-----------------+--------------------+---------------------+
|     3682|Hartsfield Jackso...|          Atlanta|       United States|                  915|
|     3830|Chicago O'Hare In...|          Chicago|       United States|                  558|
|     3364|Beijing Capital I...|          Beijing|               China|                  535|
|      507|London Heathrow A...|           London|      United Kingdom|                  527|
|     1382|Charles de Gaulle...|            Paris|              France|                  524|
|      340|Frankfurt am Main...|        Frankfurt|             Germany|                  497|
|     3484|Los Angeles Inter...|      Los Angeles|       United States|                  492|
|     3670|Dallas Fort Worth...|Dallas-Fort Worth|       United States|                  469|
|     3797|John F Kennedy In...|         New York|       United States|                  456|
|      580|Amsterdam Airport...|        Amsterdam|         Netherlands|                  453|
|     3406|Shanghai Pudong I...|         Shanghai|               China|                  411|
|     3316|Singapore Changi ...|        Singapore|           Singapore|                  408|
|     1218|Barcelona Interna...|        Barcelona|               Spain|                  391|
```

Figure 10.17: Output for top K cities with most outgoing Airlines

## 10.18 Trip that connects two cities X and Y

spark.sql("""select * from routes where sourceairportid = '2613' and destinationairportid='2531' """).show(100)

**Output:**



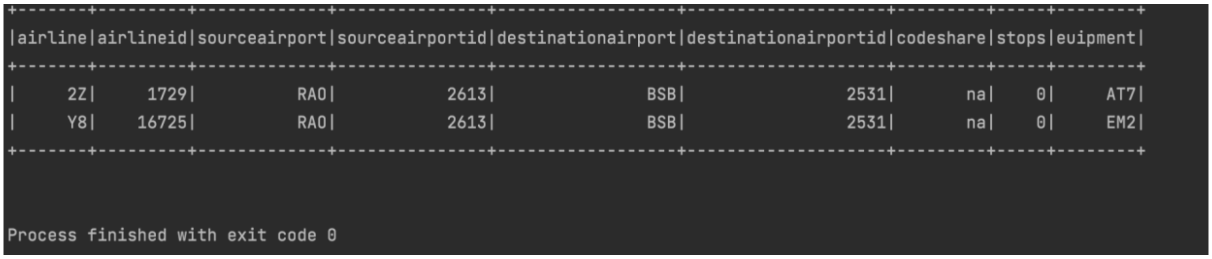
```
+-------+---------+-------------+---------------+------------------+--------------------+---------+-----+--------+
|airline|airlineid|sourceairport|sourceairportid|destinationairport|destinationairportid|codeshare|stops|euipment|
+-------+---------+-------------+---------------+------------------+--------------------+---------+-----+--------+
|     2Z|     1729|          RAO|           2613|               BSB|                2531|       na|    0|     AT7|
|     Y8|    16725|          RAO|           2613|               BSB|                2531|       na|    0|     EM2|
+-------+---------+-------------+---------------+------------------+--------------------+---------+-----+--------+



Process finished with exit code 0
```

Figure 10.18: Output for trip that connects two cities X and Y

## 10.19 Trip that connects X and Y with less than Z stops

spark.sql("""select * from routes where sourceairportid = '2613' and destinationairportid='2531' and stops < 1 """).show(100)

**Output**:



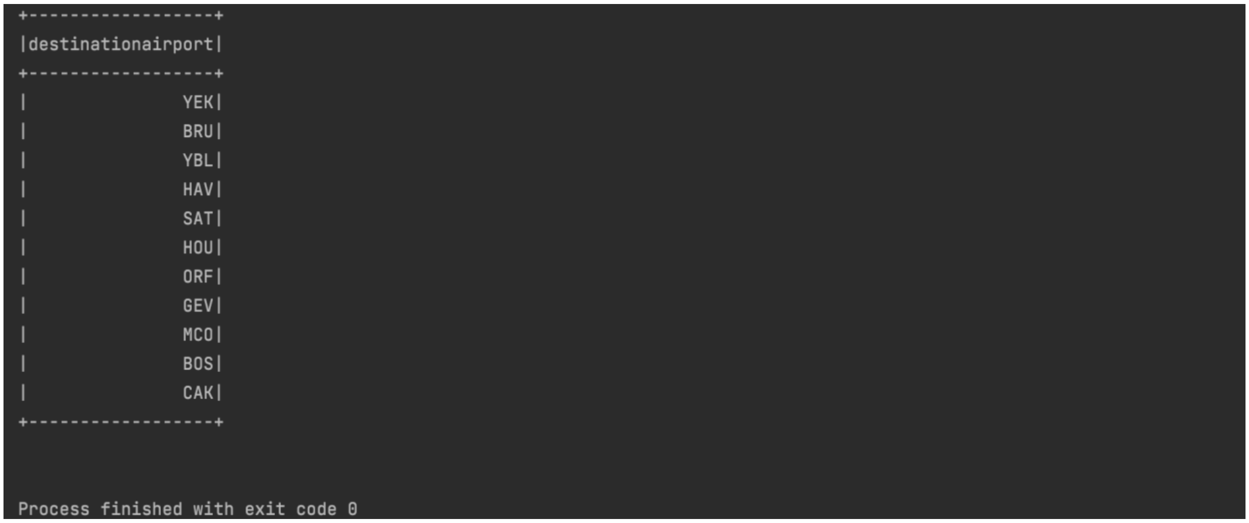
```
+-------+---------+-------------+---------------+------------------+--------------------+---------+-----+--------+
|airline|airlineid|sourceairport|sourceairportid|destinationairport|destinationairportid|codeshare|stops|euipment|
+-------+---------+-------------+---------------+------------------+--------------------+---------+-----+--------+
|     2Z|     1729|          RAO|           2613|               BSB|                2531|       na|    0|     AT7|
|     Y8|    16725|          RAO|           2613|               BSB|                2531|       na|    0|     EM2|
+-------+---------+-------------+---------------+------------------+--------------------+---------+-----+--------+


Process finished with exit code 0
```

Figure 10.19: Output for trip that connects X and Y with less than Z stops

## 10.20 *All the cities reachable within d hops of a city*

spark.sql("""select destinationairport from routes where stops = 1 """).show(100)

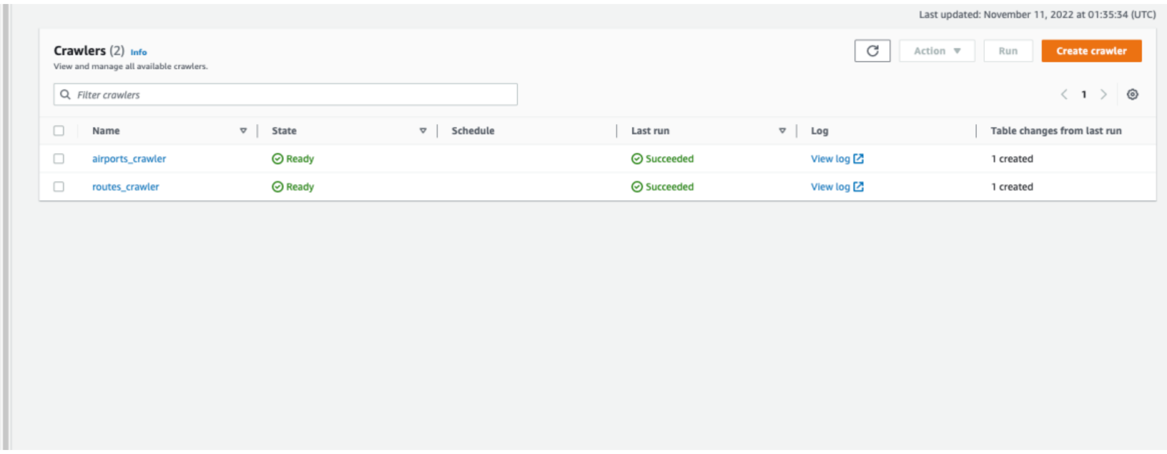
**Output:**



```
+------------------+
|destinationairport|
+------------------+
|               YEK|
|               BRU|
|               YBL|
|               HAV|
|               SAT|
|               HOU|
|               ORF|
|               GEV|
|               MCO|
|               BOS|
|               CAK|
+------------------+


Process finished with exit code 0
```

Figure 10.20: Output for all the cities reachable within d hops of a city

# 11 AWS Output Screenshot



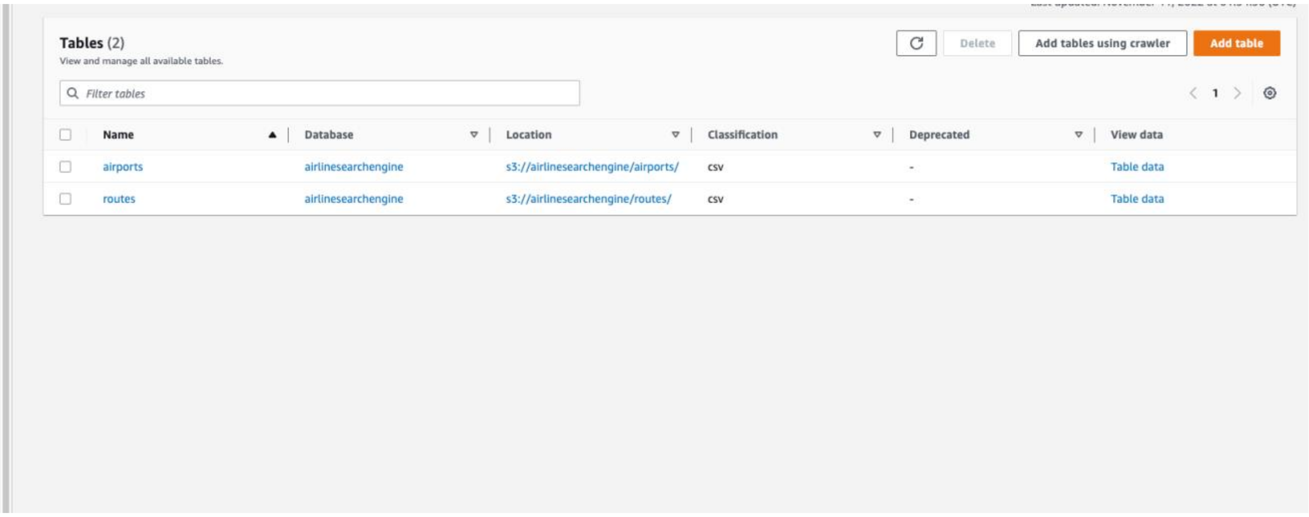
Last updated: November 11, 2022 at 01:35:34 (UTC)

Crawlers (2) Info

View and manage all available crawlers.

| □ | Name | State | Schedule | Last run | Log | Table changes from last run |
|---|---|---|---|---|---|---|
| □ | airports_crawler | Ready | | Succeeded | View log | 1 created |
| □ | routes_crawler | Ready | | Succeeded | View log | 1 created |

Figure 30: AWS Crawlers page

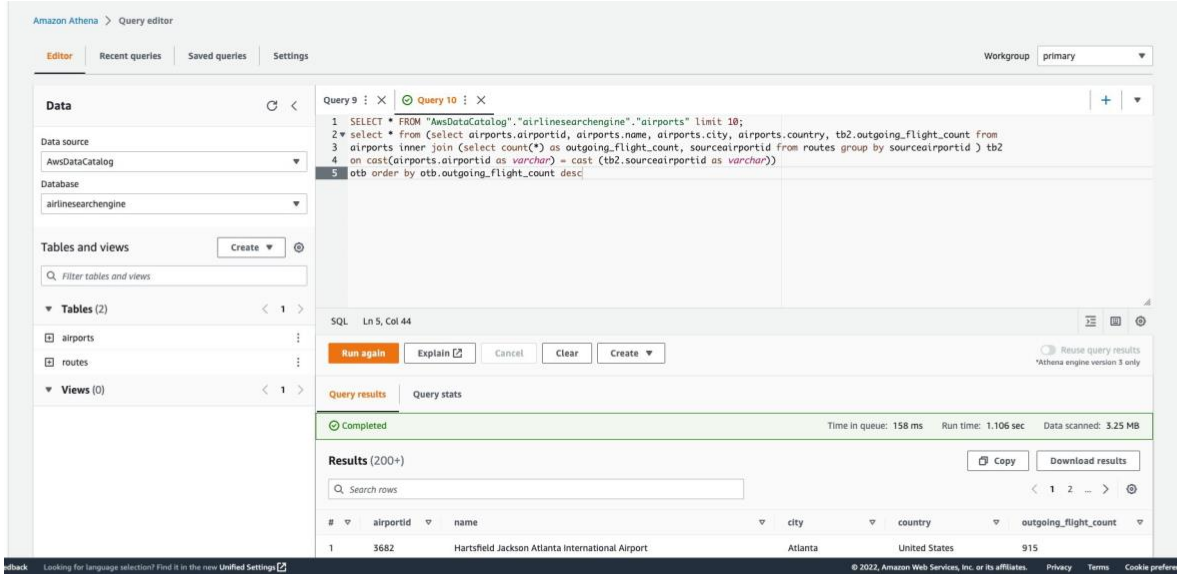


Tables (2)

View and manage all available tables.

| □ | Name | Database | Location | Classification | Deprecated | View data |
|---|---|---|---|---|---|---|
| □ | airports | airlinesearchengine | s3://airlinesearchengine/airports/ | csv | - | Table data |
| □ | routes | airlinesearchengine | s3://airlinesearchengine/routes/ | csv | - | Table data |

Figure 31: AWS Tables



Data source: AwsDataCatalog

Database: airlinesearchengine

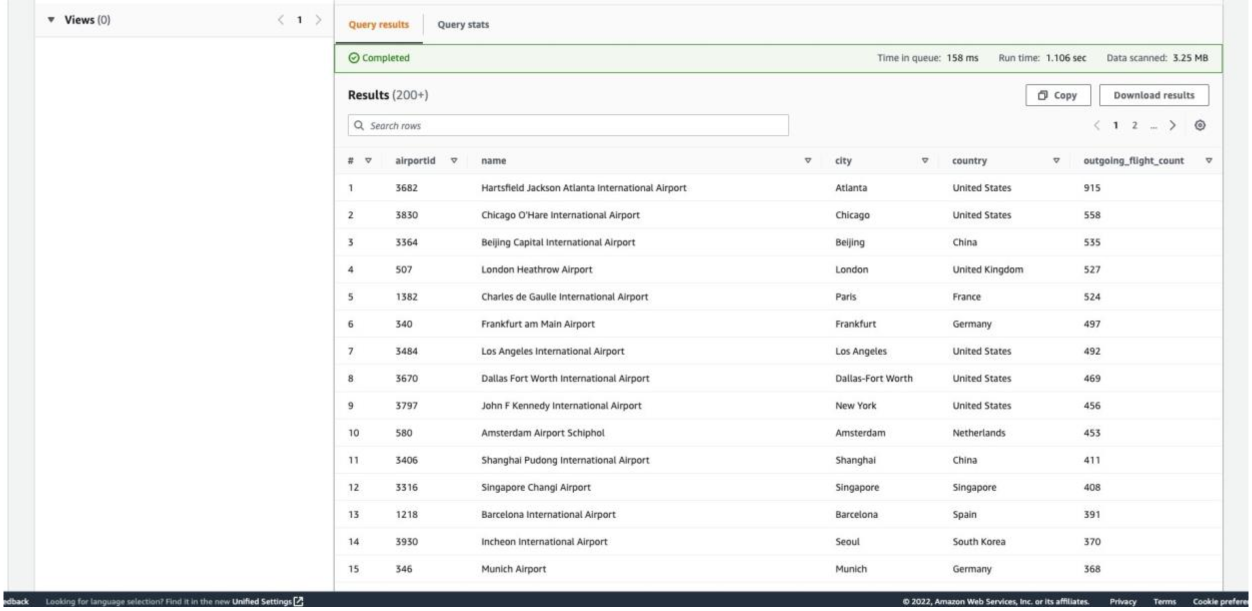
```sql
SELECT * FROM "AwsDataCatalog"."airlinesearchengine"."airports" limit 10;
select * from (select airports.airportid, airports.name, airports.city, airports.country, tb2.outgoing_flight_count from
airports inner join (select count(*) as outgoing_flight_count, sourceairportid from routes group by sourceairportid ) tb2
on cast(airports.airportid as varchar) = cast (tb2.sourceairportid as varchar))
otb order by otb.outgoing_flight_count desc
```

Completed    Time in queue: 158 ms    Run time: 1.106 sec    Data scanned: 3.25 MB

Results (200+)

| # | airportid | name | city | country | outgoing_flight_count |
|---|---|---|---|---|---|
| 1 | 3682 | Hartsfield Jackson Atlanta International Airport | Atlanta | United States | 915 |

Figure 32: AWS Athena Query


Views (0)
Query results
Query stats
Copy
Download results
Search rows
Looking for language selection? Find it in the new Unified Settings
© 2022, Amazon Web Services, Inc. or its affiliates.
Privacy
Terms
Cookie prefere

Completed    Time in queue: 158 ms    Run time: 1.106 sec    Data scanned: 3.25 MB

Results (200+)

| # | airportid | name | city | country | outgoing_flight_count |
|---|---|---|---|---|---|
| 1 | 3682 | Hartsfield Jackson Atlanta International Airport | Atlanta | United States | 915 |
| 2 | 3830 | Chicago O'Hare International Airport | Chicago | United States | 558 |
| 3 | 3364 | Beijing Capital International Airport | Beijing | China | 535 |
| 4 | 507 | London Heathrow Airport | London | United Kingdom | 527 |
| 5 | 1382 | Charles de Gaulle International Airport | Paris | France | 524 |
| 6 | 340 | Frankfurt am Main Airport | Frankfurt | Germany | 497 |
| 7 | 3484 | Los Angeles International Airport | Los Angeles | United States | 492 |
| 8 | 3670 | Dallas Fort Worth International Airport | Dallas-Fort Worth | United States | 469 |
| 9 | 3797 | John F Kennedy International Airport | New York | United States | 456 |
| 10 | 580 | Amsterdam Airport Schiphol | Amsterdam | Netherlands | 453 |
| 11 | 3406 | Shanghai Pudong International Airport | Shanghai | China | 411 |
| 12 | 3316 | Singapore Changi Airport | Singapore | Singapore | 408 |
| 13 | 1218 | Barcelona International Airport | Barcelona | Spain | 391 |
| 14 | 3930 | Incheon International Airport | Seoul | South Korea | 370 |
| 15 | 346 | Munich Airport | Munich | Germany | 368 |

Figure 33: AWS Athena Output

## 12 Acknowledgement

I would like to thank my major professor, Liu Yunchuan, for having faith in me and my talents and for continuing to believe that I would be able to complete the project on schedule. This Project was completed successfully thanks to the support, ongoing direction, and insightful feedback. I also want to express my sincere gratitude to my mentor for being on my panel, working as my academic advisor, helping me make all the important choices, and having faith in me.

## 13 References:

[1] http://openflights.org/data.html.
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[3] https://spoddutur.github.io/spark-notes/spark-as-cloud-based-sql-engine-via-thrift-server.html
[4] https://docs.aws.amazon.com/s3/index.html
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[6] https://www.youtube.com/watch?v=8VOf1PUFE0I
[7] https://docs.aws.amazon.com/iam/index.html
[8] https://www.jetbrains.com/pycharm/learn/
[9] https://docs.python.org/3/library/index.html
[10] https://pandas.pydata.org/docs/
[11] https://spark.apache.org/docs/latest/api/python/index.html