Table of Contents

Last Updated: 23 Feb 2024

1. Prerequisite

Using Docker Environment:

Install Docker environment according to your environment.

Create sparko container:

Let us create a common network for our spark nodes.

#docker network create --driver bridge spark-net

#docker run -it --name sparko --hostname sparko --privileged --network spark-net -v /Users/henrypotsangbam/software/:/Software -p 8080:8080 -p 7077:7077 -p 4040:4040 -p 8081:8081 -p 8090:8090 -p 8888:8888 centos /usr/sbin/init

Download the required software

Apache Spark – Version 3.0.1 – Prebuilt for Apache Hadoop 3.2 and later.
File : spark-3.0.1-bin-hadoop3.2.tgz / **spark-3.2.1-bin-hadoop3.2.tgz**
Url : https://spark.apache.org/downloads.html
Download Location: (hadoop-3.2.2.tar.gz)
https://hadoop.apache.org/releases.html
python : 3.8

Inflate all require software in /opt folder.

JDK installation☹) (jdk-8u45-linux-x64.tar.gz)
https://www.oracle.com/in/java/technologies/javase/javase8-archive-downloads.html
Steps for deploying two node spark cluster in docker:

- Create two containers using the above image
  - Spark0
  - Spark1
- Create a network to connect between these two nodes.

  You should pull the following images from docker hub.(centos:7)

```
(base) Henrys-MacBook-Air:~ henrypotsangbam$ docker images
REPOSITORY          TAG                 IMAGE ID            CREATED             SIZE
spark-kafka         latest              a0c16a0aebc1        2 days ago          3.84GB
centos              7                   7e6257c9f8d8        4 weeks ago         203MB
(base) Henrys-MacBook-Air:~ henrypotsangbam$
```

Let us create a common network for our two nodes cluster.

#docker network create --driver bridge spark-net

Create first node, spark0 container

#docker run -it --name spark0 --hostname spark0 --privileged -p 8080:8080 -p 7077:7077 -p 4040:4040 -p 8081:8081 -p 8090:8090 centos /usr/sbin/init

Docker command with Host folder mounted. (Skip)

docker run -it --name spark0 --hostname spark0 --privileged --network spark-net -v /Volumes/Samsung_T5/software/:/Software -v /Volumes/Samsung_T5/software/install/:/opt -v /Volumes/Samsung_T5/software/data/:/data -p 8080:8080 -p 7077:7077 -p 4040:4040 -p 8081:8081 -p 8090:8090 centos:7 /usr/sbin/init

To connect a **running** container to an existing user-defined bridge, use the docker network connect command. If the spark0 is already started without the network being attached execute the following else skip the following step.

```
$ docker network connect spark-net spark0
```

Start the first container:

#docker start spark0

Connect to you first node:

docker exec -it spark0 /usr/bin/bash

Start the second node and perform the installation as specify in the first lab.

#docker run -dit --name spark1 -p 8082:8081 -p 4041:4040 --network spark-net --entrypoint /bin/bash centos:7

or

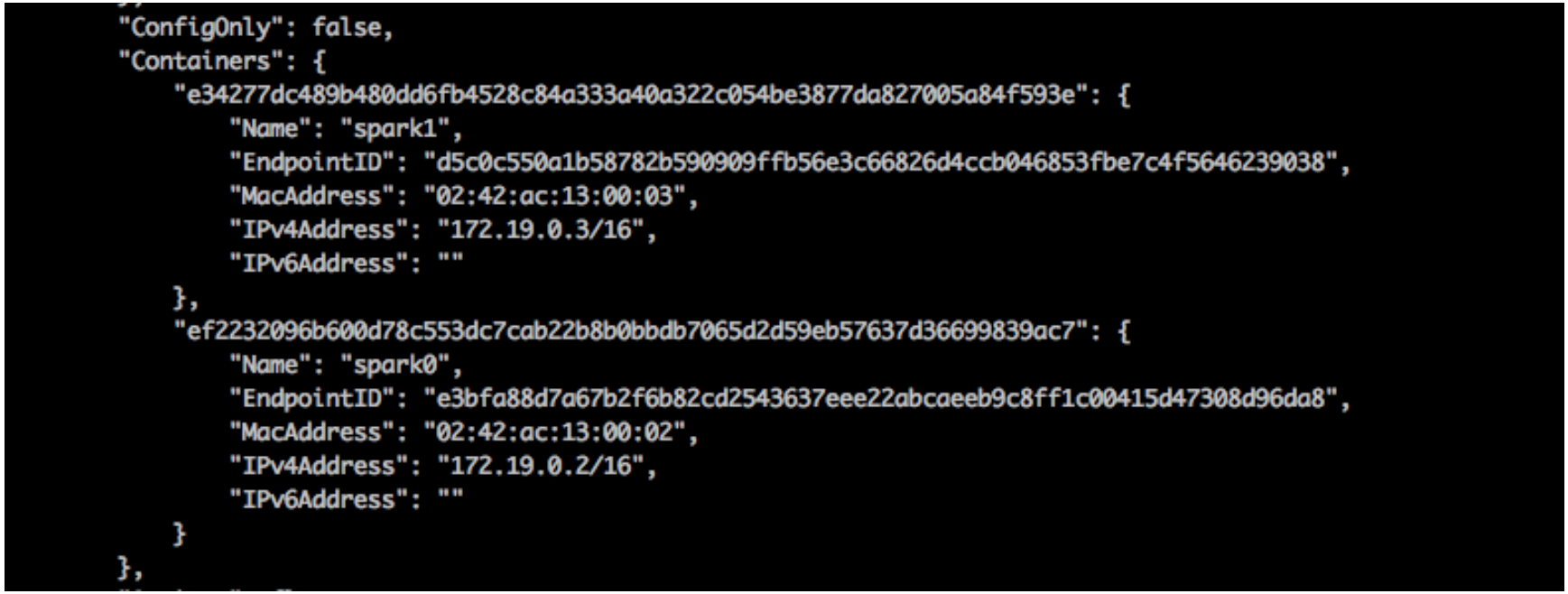
Docker command with Host folder mounted. (Skip)

docker run -it --name spark1 --hostname spark1 --privileged --network spark-net -v /Users/henrypotsangbam/Documents/Docker:/opt -p 4041:4040 -p 8082:8081 centos:7 /usr/sbin/init

Confirm the Network status:

Inspect the network and find the IP addresses of the two containers

```
#docker network inspect spark-net
```



Ensure to substitute IPs accordingly.

Attach to the spark-master container and test its communication to the spark-worker container using both it's IP address and then using its container name.
ping spark0

```
[root@ef2232096b60 /]# ping spark0
PING spark0 (172.19.0.2) 56(84) bytes of data.
64 bytes from ef2232096b60 (172.19.0.2): icmp_seq=1 ttl=64 time=0.062 ms
64 bytes from ef2232096b60 (172.19.0.2): icmp_seq=2 ttl=64 time=0.104 ms
64 bytes from ef2232096b60 (172.19.0.2): icmp_seq=3 ttl=64 time=0.062 ms
^C
--- spark0 ping statistics ---
3 packets transmitted, 3 received, 0% packet loss, time 2060ms
rtt min/avg/max/mdev = 0.062/0.076/0.104/0.019 ms
[root@ef2232096b60 /]# ping spark1
PING spark1 (172.19.0.3) 56(84) bytes of data.
64 bytes from spark1.spark-net (172.19.0.3): icmp_seq=1 ttl=64 time=0.202 ms
64 bytes from spark1.spark-net (172.19.0.3): icmp_seq=2 ttl=64 time=0.204 ms
^C
--- spark1 ping statistics ---
2 packets transmitted, 2 received, 0% packet loss, time 1004ms
rtt min/avg/max/mdev = 0.202/0.203/0.204/0.001 ms
#[root@ef2232096b60 /]#
```

Docker container for hadoop cluster.

#docker run -it --name hadoop0 --privileged -p 8088:8088 -p 9870:9870 -p 9864:9864 -p 8032:8032 -p 8188:8188 -p 8020:8020 --hostname hadoop0 centos /usr/sbin/init

docker run -it --name spark2 --hostname spark2 --privileged -v /Users/henrypotsangbam/Documents/Software/:/Software -p 8081:8080 -p 4042:4040 centos /usr/sbin/init

2. Spark Container

You can find the commands to create container for the lab

Start the docker desktop.

Define a network to connect the spark container.

#docker network create --driver bridge spark-net

Define spark0 container.

#docker run -it --name spark0 --hostname spark0 --privileged --network spark-net -v /tmp/:/Software -p 8080:8080 -p 7077:7077 -p 4040:4040 -p 8081:8081 -p 8090:8090 -p 8888:8888 centos /usr/sbin/init

Define Spark1 container

#docker run -dit --name spark1 -p 8082:8081 -p 4041:4040 --network spark-net -v /tmp/:/Software --entrypoint /bin/bash centos

Connect to you first node:

docker exec -it spark0 bash

To Start the first container after shutdown use the following command:

```
#docker start  sparko
```

In order to copy any file to the container, sparko : copy the file in the /tmp folder of the host. It is mounted as /Software in the container.

3. Install Spark in centos Linux – 60 Minutes(D)

Extract jdk and rename the folder to jdk. Its assume that all the required software is in the /Software folder.

Change to the folder where the required software is store.

```
#cd /Software
```

Un compress the jdk file in /opt folder. You need to replace the jdk file name appropriately

```
#tar -xvf jdk*.tar.gz -C /opt
```

Change the current directory to /opt and rename the jdk folder for brevity.

```
#cd /opt
#mv jdk* jdk
```

Extract spark-X.X.0-bin-hadoop.X.tar to /opt. Ensure to replace the spark file name according to your environment.

```
#cd /Software
# tar -xvf  spark-x-bin-hadoop.x.tgz.gz -C /opt/
```

It should create a folder spark.X, rename to spark folder.

```
#cd /opt
#mv  spark*  spark
```

Set the JAVA_HOME and initialize the PATH variable.

Open the profile and update with the following statements.

#vi ~/.bashrc

```
export  JAVA_HOME=/opt/jdk
export PATH=$PATH:$JAVA_HOME/bin
export PATH=$PATH:/opt/spark/bin
```

Install Python version 3.6.

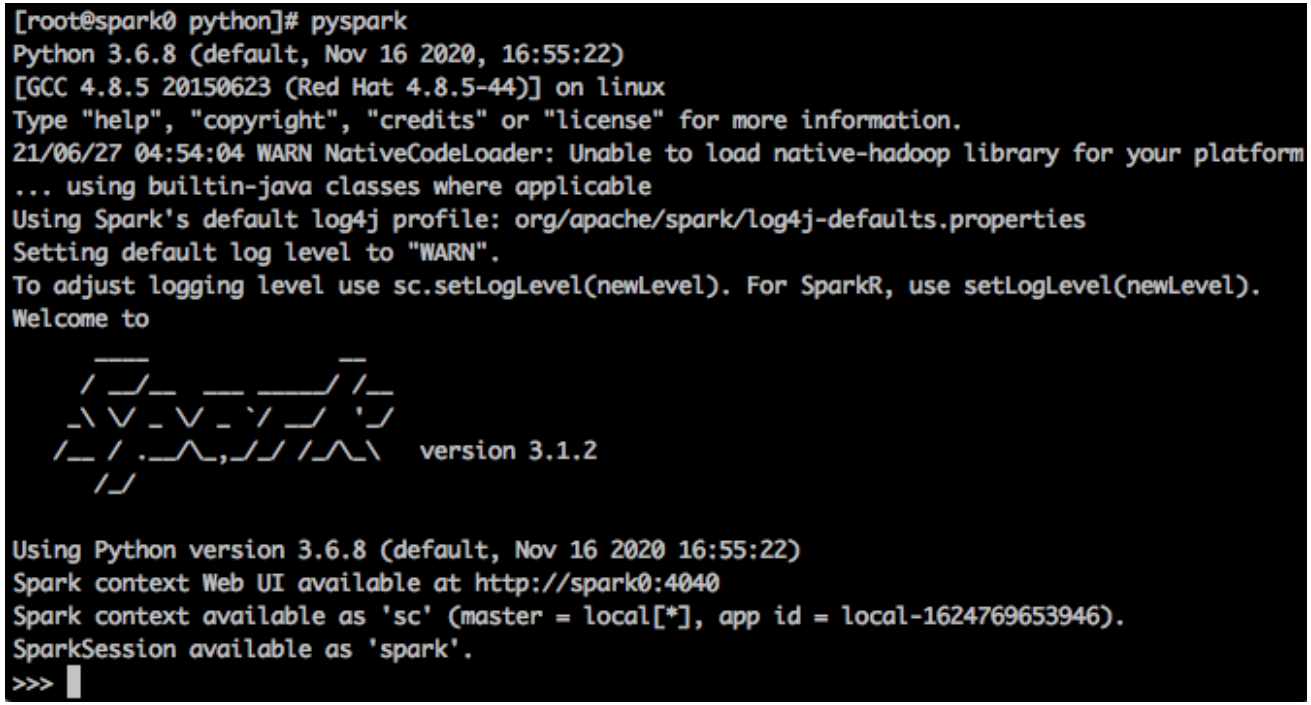
Python 3.6 or above is required to run PySpark program.

#yum install -y python3.8

Type bash, to initialize the profile.

Go to the installation directory:

pyspark



Enter the following command in the pyspark console to count each alphabets.
Notebook - Hello Pyspark

Let's look at a short example where we read in a text file as a DataFrame, show a sample of the strings read, and count the total number of lines in the file. This simple example illustrates the use of the high-level Structured APIs, which we will cover later. The show(10, false) operation on the DataFrame only displays the first 10 lines without truncating; by default the truncate Boolean flag is true

// Code Begin. **********

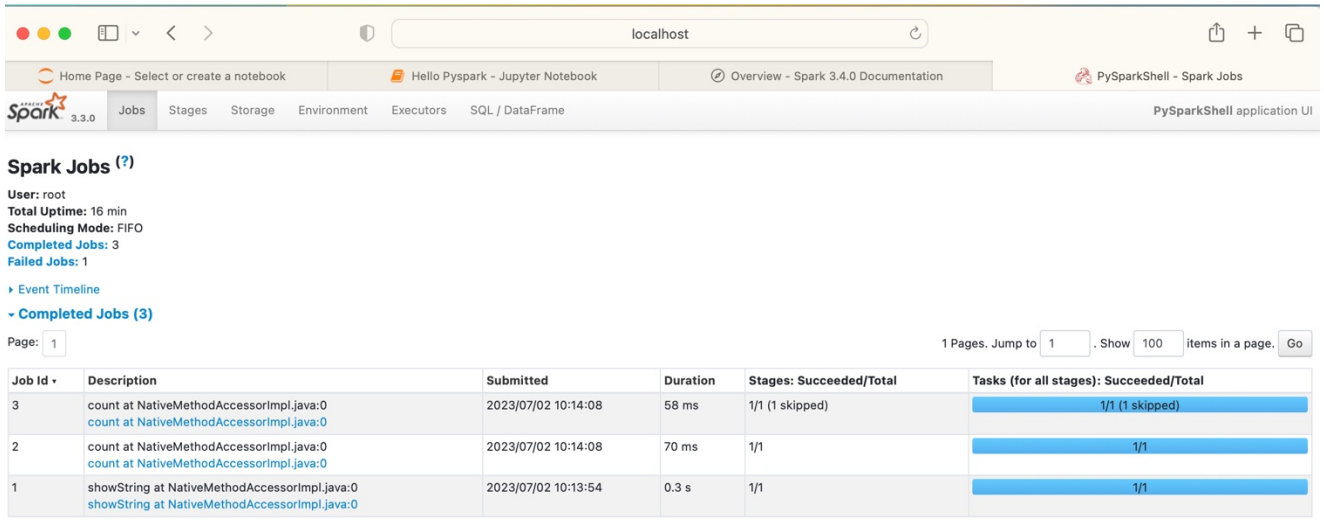
```
#Display the spark version
spark.version
#Reading file in the specified location
strings = spark.read.text("/opt/spark/README.md")
#show the first 10 lines
strings.show(10, truncate=False)
#Get the count of lines in the file
strings.count()
```

// Code Ends Here##################################

```
In [9]: #Display the spark version
        spark.version

Out[9]: '3.3.0'

In [13]: #Reading file in the specified location
         strings = spark.read.text("/opt/spark/README.md")

In [11]: #show the first 10 lines
         strings.show(10, truncate=False)

+------------------------------------------------------------------------------------------------------+
|value                                                                                                 |
+------------------------------------------------------------------------------------------------------+
|# Apache Spark                                                                                        |
|                                                                                                      |
|Spark is a unified analytics engine for large-scale data processing. It provides                      |
|high-level APIs in Scala, Java, Python, and R, and an optimized engine that                           |
|supports general computation graphs for data analysis. It also supports a                             |
|rich set of higher-level tools including Spark SQL for SQL and DataFrames,                            |
|pandas API on Spark for pandas workloads, MLlib for machine learning, GraphX for graph processing,|
|and Structured Streaming for stream processing.                                                       |
|                                                                                                      |
|<https://spark.apache.org/>                                                                           |
+------------------------------------------------------------------------------------------------------+
only showing top 10 rows

In [12]: #Get the count of lines in the file
         strings.count()

Out[12]: 124
```

Web UI of the spark shell can be accessed using the following URL. You can click on each tab and verify the screen.

http://spark0:4040/jobs/ or
http://localhost:4040/jobs/



Further details on this web UI will be discussed later.

You have successfully installed spark for local development.
Note: You can start with default cores by the following command.
pyspark --master local[*]
----------Lab Ends Here ----------

4. Analysis Using Spark- Overview

Demonstrate this after installation lab.
This Tutorial will demonstrate how we can use spark for data analytics - Overview.

Scenario - Upload the log file of a web access and find the following:
- Which IP request url the most?
- What is the max byte return from a server?
- How many requests receive from each client?

Import the necessary packages.

```
from pyspark.sql import Row
from pyspark.sql.functions import col
```

Let us intialize log entries, that will be used for analysis.

```
data = [('64.242.88.10 - - [07/Mar/2004:16:05:49 -0800] "GET
/twiki/bin/edit/Main/Double_bounce_sender?topicparent=Main.ConfigurationVariables HTTP/1.1"
401 12846'),\
      ('64.242.88.10 - - [07/Mar/2004:16:06:51 -0800] "GET
/twiki/bin/rdiff/TWiki/NewUserTemplate?rev1=1.3&rev2=1.2 HTTP/1.1" 200 4523'),\
('94.242.88.10 - - [07/Mar/2004:16:30:29 -0800] "GET /twiki/bin/attach/Main/OfficeLocations
HTTP/1.1" 401 12851')]
```

Convert the log entries into RDD

```
rdd = spark.sparkContext.parallelize(data)
```

Let us have a look how the RDD or data look like

```
rdd.collect()
```

I would like to access the column using a name. So Let us intitialize RDD with a schema colum.

```
parts = rdd.map(lambda l: l.split(" "))
log = parts.map(lambda p: Row(ip=p[0], ts=(p[3]), atype = p[5], url=p[6] , code = p[8] , byte = p[9]))
```

Have I split the record fields correctly? Let us review the transformation

```
parts.collect()
```

I would like to use the Dataframe API. Let us convert from RDD to DF

```
# Infer the schema, and register the DataFrame as a table.
mylog = spark.createDataFrame(log)
```

Have a view of our DF!

```
mylog.take(2)
```

Now, we have the data in spark, let us answer the queries we have define in the first paragraphs.

Which IP request url the most?

```
mylog.groupBy("ip").count().orderBy(col("count").desc()).first()
Row(ip=u'64.242.88.10', count=2)
```

What is the max byte return from a server?

```
mylog.select("ip","byte").orderBy("byte").show()
mylog.select("ip","byte").orderBy("byte").first()
```

How many request receives from each client?

```
mylog.select("ip","url").groupBy("ip").count().show()
```

```
In [20]: from pyspark.sql import Row
         from pyspark.sql.functions import col

In [35]: data = [('64.242.88.10 - - [07/Mar/2004:16:05:49 -0800] "GET /twiki/bin/edit/Main/Double_bounce_sender?topicparent=
                  ('64.242.88.10 - - [07/Mar/2004:16:06:51 -0800] "GET /twiki/bin/rdiff/TWiki/NewUserTemplate?rev1=1.3&rev2=1
                  ('94.242.88.10 - - [07/Mar/2004:16:30:29 -0800] "GET /twiki/bin/attach/Main/OfficeLocations HTTP/1.1" 401 1

In [36]: rdd = spark.sparkContext.parallelize(data)

In [37]: rdd.collect()

Out[37]: ['64.242.88.10 - - [07/Mar/2004:16:05:49 -0800] "GET /twiki/bin/edit/Main/Double_bounce_sender?topicparent=Main.Co
         nfigurationVariables HTTP/1.1" 401 12846',
          '64.242.88.10 - - [07/Mar/2004:16:06:51 -0800] "GET /twiki/bin/rdiff/TWiki/NewUserTemplate?rev1=1.3&rev2=1.2 HTTP
         /1.1" 200 4523',
          '94.242.88.10 - - [07/Mar/2004:16:30:29 -0800] "GET /twiki/bin/attach/Main/OfficeLocations HTTP/1.1" 401 12851']

In [28]: parts = rdd.map(lambda l: l.split(" "))
         log = parts.map(lambda p: Row(ip=p[0], ts=(p[3]), atype = p[5], url=p[6] , code = p[8] , byte = p[9]))

In [29]: parts.collect()

Out[29]: [['64.242.88.10',
           '-',
           '-',
           '[07/Mar/2004:16:05:49',
           '-0800]',
           '"GET',
           '/twiki/bin/edit/Main/Double_bounce_sender?topicparent=Main.ConfigurationVariables',
           'HTTP/1.1"',
           '401',
           '12846'],
          ['64.242.88.10',
```

```
In [30]: mylog = spark.createDataFrame(log)

In [31]: mylog.take(2)

Out[31]: [Row(ip='64.242.88.10', ts='[07/Mar/2004:16:05:49', atype='"GET', url='/twiki/bin/edit/Main/Double_bounce_sender?t
         opicparent=Main.ConfigurationVariables', code='401', byte='12846'),
          Row(ip='64.242.88.10', ts='[07/Mar/2004:16:06:51', atype='"GET', url='/twiki/bin/rdiff/TWiki/NewUserTemplate?rev1
         =1.3&rev2=1.2', code='200', byte='4523')]

In [32]: mylog.groupBy("ip").count().orderBy(col("count").desc()).first()
         Row(ip=u'64.242.88.10', count=2)

Out[32]: Row(ip='64.242.88.10', count=2)

In [33]: mylog.select("ip","byte").orderBy("byte").show()
         mylog.select("ip","byte").orderBy("byte").first()

         +------------+-----+
         |          ip| byte|
         +------------+-----+
         |64.242.88.10|12846|
         |94.242.88.10|12851|
         |64.242.88.10| 4523|
         +------------+-----+

Out[33]: Row(ip='64.242.88.10', byte='12846')

In [34]: mylog.select("ip","url").groupBy("ip").count().show()

         +------------+-----+
         |          ip|count|
         +------------+-----+
         |64.242.88.10|    2|
         |94.242.88.10|    1|
```

---------- Lab Ends Here ----------

5. Explore DataFrames using pyspark – 35 Minutes

Following features of Spark will be demonstrated here using pyspark:

- Loading json file.
- Understand its schema
- Select required fields.
- Apply filter.

Create a text file users.json which contains sample data as listed below in data folder:

```
{"name":"Alice", "pcode":"94304"}
{"name":"Brayden", "age":30, "pcode":"94304"}
{"name":"Carla", "age":19, "pcode":"10036"}
{"name":"Diana", "age":46}
{"name":"Etienne", "pcode":"94104"}
```

Start pyspark-shell

```
#pyspark
```

Initiate the pyspark-shell from the folder which you have created the above file.

```
#Define the data location file
dFile = "/opt/data/users.json"
```

#Read the users json file as a dataframe.
usersDF = spark.read.json(dFile)

#Find out the schema of the uploaded file
usersDF.printSchema()

As shown below, three fields will be displayed according to the json fields specified in the text file.

```
In [11]: #Define the data location file
         dFile = "/opt/data/users.json"

In [2]:  #Read the users json file as a dataframe.
          usersDF = spark.read.json(dFile)

In [4]:  #Find out the schema of the uploaded file
         usersDF.printSchema()

         root
          |-- age: long (nullable = true)
          |-- name: string (nullable = true)
          |-- pcode: string (nullable = true)
```

#Let us find out the first 3 records to have a sample data.
users = usersDF.take(3)
print(users)

```
In [6]: users = usersDF.take(3)
        print(users)

        [Row(age=None, name='Alice', pcode='94304'), Row(age=30, name='Brayden', pcode='94304'), Row(age=19, name='Carla',
        pcode='10036')]
```

usersDF.show()

```
In [7]: usersDF.show()

+----+-------+-----+
| age|   name|pcode|
+----+-------+-----+
|null|  Alice|94304|
|  30|Brayden|94304|
|  19|  Carla|10036|
|  46|  Diana| null|
|null|Etienne|94104|
+----+-------+-----+
```

Out of the three fields, we are interested in only name and age fields. So, let us create a dataframe with only these two fields and apply a filter expression in which only person greater than 20 years are there in the dataframe.

```
nameAgeDF = usersDF.select("name","age")
nameAgeOver20DF = nameAgeDF.where("age > 20")
nameAgeOver20DF.show()
```

```
In [8]: nameAgeDF = usersDF.select("name","age")
        nameAgeOver20DF = nameAgeDF.where("age > 20")
        nameAgeOver20DF.show()
```

```
+-------+---+
|   name|age|
+-------+---+
|Brayden| 30|
|  Diana| 46|
+-------+---+
```

usersDF.select("name","age").where("age > 20").show()

```
In [10]: # Apply the above transformation in a single line
         usersDF.select("name","age").where("age > 20").show()
```

```
+-------+---+
|   name|age|
+-------+---+
|Brayden| 30|
|  Diana| 46|
+-------+---+
```

You can also combine the functions as shown above. You will get the same result.

---------- Lab Ends Here----------

6. Explore DataFrame and Schema – 30 Minutes

You will understand the following:

- Defining schema and mapping to dataframe while loading json file.
- Saving the dataframe to json file.

Create an input text file /opt/data/people.csv

```
pcode,lastName,firstName,age
02134,Hopper,Grace,52
94020,Turing,Alan,32
94020,Lovelace,Ada,28
87501,Babbage,Charles,49
02134,Wirth,Niklaus,48
```

Execute the following in the pyspark-shell.

Import and define the Structure.

```
#Define the Data file Location.
dFile = "/opt/data/people.csv"

#Import and define the Structure.
from pyspark.sql.types import *
columnsList = [
```

```
    StructField("pcode", StringType()),
    StructField("lastName", StringType()),
    StructField("firstName", StringType()),
    StructField("age", IntegerType())]
peopleSchema = StructType(columnsList)
```

Schema of the file is defined before loading the file in spark session.

```
#Specify the schema along with the loading instruction.
usersDF  =  spark.read.option("header","true").schema(peopleSchema).csv(dFile)
```

Let us have a view of the schema of the file.

```
usersDF.printSchema()
```

```
In [2]: #Define the Data file Location.
        dFile = "/opt/data/people.csv"
```

```
In [4]: #Import and define the Structure.
        from pyspark.sql.types import *
        columnsList = [
            StructField("pcode", StringType()),
            StructField("lastName", StringType()),
            StructField("firstName", StringType()),
            StructField("age", IntegerType())]
        peopleSchema = StructType(columnsList)
```

```
In [5]: #Specify the schema along with the loading instruction.
        usersDF  =  spark.read.option("header","true").schema(peopleSchema).csv(dFile)
```

```
In [6]: usersDF.printSchema()
```

```
root
 |-- pcode: string (nullable = true)
 |-- lastName: string (nullable = true)
 |-- firstName: string (nullable = true)
 |-- age: integer (nullable = true)
```

// As shown above, age is an Integer, which will be mapped to String by default in case it's not define in the structure schema.

Let us perform projection, we are interested in two fields only. You can use select method for this.

```
nameAgeDF =  usersDF.select("firstname","age")
nameAgeDF.show()
```

```
In [7]: nameAgeDF =  usersDF.select("firstname","age")
        nameAgeDF.show()
```

```
+---------+----+
|firstname| age|
+---------+----+
|    Grace|null|
|     Alan|  32|
|      Ada|  28|
|  Charles|  49|
|  Niklaus|  48|
+---------+----+
```

You can save the dataframe consisting of First Name and age to a file.

```
# Save the dataframe in a folder - /opt/data/ages
destFolder = "/opt/data/ages"
nameAgeDF.write.json(destFolder)
```

Open a terminal and verify the file. It will create a folder by the name ages and inside that output will be there.

Change the location to the directory of data folder.

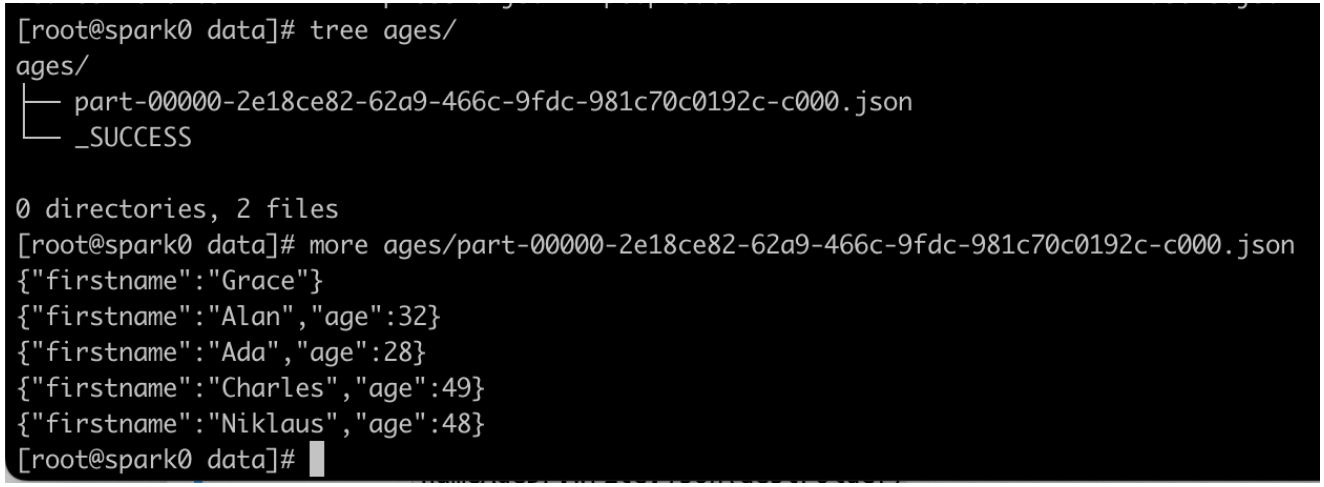
```
#cd /opt/data
```

Have a view of files inside the folder ages. Output may varies depending on your environment.

```
#tree ages/
```

Print the file. Replace the file with that of your system.

#more ages/part-00000-2e18ce82-62a9-466c-9fdc-981c70c0192c-c000.json



Assignment:

Try selecting first name and Last name of the data and save in a separate file.

---------- Lab Ends Here ----------

7. Parquet, Use User Defined Functions & SQL – 60 Minutes(D)

Notebook: Parquet , Use User Defined Functions & SQL

Let us write as json file into a parquet and read it using dataframe.

Open a spark-shell.

Read a json file and then save it to a parquet file.

```
peopleDF = spark.read.json("/Software/data/people.json")

peopleDF.printSchema()
peopleDF.show()
peopleDF.write.parquet ("/opt/data/people.parquet")
```

```
In [2]: peopleDF = spark.read.json("/Software/data/people.json")

In [3]: peopleDF.printSchema()
root
 |-- age: long (nullable = true)
 |-- name: string (nullable = true)

In [4]: peopleDF.show()
+----+-------+
| age|   name|
+----+-------+
|null|Michael|
|  30|   Andy|
|  19| Justin|
+----+-------+

In [5]: peopleDF.write.parquet ("/opt/data/people.parquet")
```

Read the parquet file created above, Parquet files are self-describing so the schema is preserved. The result of loading a Parquet file is also a DataFrame

```
parquetFileDF = spark.read.parquet("/opt/data/people.parquet")
parquetFileDF.show()
```

```
In [6]: parquetFileDF = spark.read.parquet("/opt/data/people.parquet")

In [7]: parquetFileDF.show()
+----+-------+
| age|   name|
+----+-------+
|null|Michael|
|  30|   Andy|
|  19| Justin|
+----+-------+
```

Parquet files can also be used to create a temporary view and then used in SQL statements

```
parquetFileDF.createOrReplaceTempView("parquetFile")

namesDF = spark.sql("SELECT name FROM parquetFile WHERE age BETWEEN
13 AND 19")
namesDF.show()
```

```
In [8]: parquetFileDF.createOrReplaceTempView("parquetFile")

In [9]: namesDF = spark.sql("SELECT name FROM parquetFile WHERE age BETWEEN 13 AND 19")

In [15]: namesDF.show()
+------+
|  name|
+------+
|Justin|
+------+
```

List the folders to view the parquet file created.

```
!ls -lt /opt/data/people.parquet/
```

```
In [51]: !ls -lt /opt/data/people.parquet/
total 4
-rw-r--r-- 1 root root   0 Apr 22 10:48 _SUCCESS
-rw-r--r-- 1 root root 738 Apr 22 10:48 part-00000-5bef6875-5754-4923-a1a8-bcd9287d68ea-c000.snappy.parquet
```

Next read another json file that contains movie information and then applied snappy compression while creating parquet file.

```
movieDF = spark.read.json("/Software/data/movies.json")
movieDF.write.option("compression",
"snappy").mode("overwrite").parquet("/opt/data/par_movies")
```

list the files.

```
!ls /opt/data/par_movies
```

```
In [17]: movieDF = spark.read.json("/Software/data/movies.json")

In [19]: movieDF.write.option("compression", "snappy").mode("overwrite").parquet("/opt/data/par_movies")

In [20]: !ls /opt/data/par_movies
         part-00000-1a500d9a-c9bf-4ac5-af47-93be3672ba83-c000.snappy.parquet  _SUCCESS
```

You can also view information about the parquet file using parquet tools.

Install the tools.

```
!pip install parquet-tools
```

```
In [21]: !pip install parquet-tools
Collecting parquet-tools
  Downloading parquet_tools-0.2.15-py3-none-any.whl (31 kB)
Collecting boto3<2.0.0,>=1.34.11 (from parquet-tools)
  Downloading boto3-1.34.40-py3-none-any.whl (139 kB)
     ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 139.3/139.3 kB 1.3 MB/s eta 0:00:00a 0:00:01
Collecting colorama<0.5.0,>=0.4.6 (from parquet-tools)
  Downloading colorama-0.4.6-py2.py3-none-any.whl (25 kB)
Collecting halo<0.0.32,>=0.0.31 (from parquet-tools)
  Using cached halo-0.0.31.tar.gz (11 kB)
  Preparing metadata (setup.py) ... done
INFO: pip is looking at multiple versions of parquet-tools to determine which version is compatible with othe
r requirements. This could take a while.
Collecting parquet-tools
  Downloading parquet_tools-0.2.14-py3-none-any.whl (31 kB)
Collecting halo<0.0.30,>=0.0.29 (from parquet-tools)
  Downloading halo-0.0.29-py3-none-any.whl (10 kB)
Requirement already satisfied: pandas>=1 in /usr/local/lib64/python3.8/site-packages (from parquet-tools) (2.
0.3)
```

To view the data insides the file. You need to substitute the parquet file with that of the above.

```
!parquet-tools show /opt/data/par_movies/part-00000-2119ab8b-593a-402d-a685-9d24159aac96-c000.snappy.parquet
```

```
!pip install parquet-tools
```

```
!parquet-tools show /opt/data/par_movies/part-00000-2119ab8b-593a-402d-a685-9d24159aac96-c000.snappy.parquet
```

```
+-------------------------------------------------------------------------------------------------------------------
-----------------------------------------------------------+-----------+--------------------------------+----------
--+-------------------------+
| Certification
| Label      | PeakChart                           | Released    | Title                         |
|-------------------------------------------------------------------------------------------------------------------
-----------------------------------------------------------+-----------+--------------------------------+----------
--+-------------------------|
| {'ARIA': '2x Platinum', 'BPI': '2x Platinum', 'BVMI': None, 'CRIA': 'Diamond', 'IFPI': 'Gold', 'NVPI': 'Gold', '
RIAA': '8x Platinum', 'SNEP': 'Gold'}                      | Atlantic   | {'AUS': 9, 'UK': 6, 'US': 10} | 01/12/196
9 | Led Zeppelin            |
| {'ARIA': '4xPlatinum', 'BPI': '4xPlatinum', 'BVMI': 'Platinum', 'CRIA': '9x  Platinum', 'IFPI': 'Gold', 'NVPI':
None, 'RIAA': 'Diamond', 'SNEP': 'Platinum'}               | Atlantic   | {'AUS': 1, 'UK': 1, 'US': 1}  | 10/22/196
9 | Led Zeppelin II         |
| {'ARIA': None, 'BPI': 'Platinum', 'BVMI': 'Gold', 'CRIA': '3x Platinum', 'IFPI': 'Gold', 'NVPI': 'Gold', 'RIAA':
'6x Platinum', 'SNEP': 'Platinum'}                        | Atlantic   | {'AUS': 1, 'UK': 1, 'US': 1}  | 10/5/1970
| Led Zeppelin III        |
| {'ARIA': '9x Platinum', 'BPI': '6x Platinum', 'BVMI': '3x Gold', 'CRIA': '2xDiamond', 'IFPI': '2x Platinum', 'NV
PI': 'Platinum', 'RIAA': 'Diamond', 'SNEP': '2x Platinum'} | Atlantic   | {'AUS': 2, 'UK': 1, 'US': 2}  | 11/8/1971
| Led Zeppelin IV         |
| {'ARIA': None, 'BPI': 'Platinum', 'BVMI': 'Gold', 'CRIA': None, 'IFPI': None, 'NVPI': None, 'RIAA': 'Diamond', '
SNEP': 'Gold'}                                             | Atlantic   | {'AUS': 1, 'UK': 1, 'US': 1}  | 03/28/197
3 | Houses of the Holy      |
```

To get the metadata about the file.

!parquet-tools inspect /opt/data/par_movies/part-00000-2119ab8b-593a-402d-a685-9d24159aac96-c000.snappy.parquet

```
In [62]: !parquet-tools inspect /opt/data/par_movies/part-00000-2119ab8b-593a-402d-a685-9d24159aac96-c000.snappy.parquet

############ file meta data ############

created_by: parquet-mr version 1.12.2 (build 77e30c8093386ec52c3cfa6c34b7ef3321322c94)

num_columns: 14

num_rows: 9

num_row_groups: 1

format_version: 1.0

serialized_size: 2951
```

As you can see above, there are 14 columns and 9 rows in the file.

Next.

Define UDF and invoke in the Query.

Load CSV data and convert into Dataframe

```
df = spark.read.format("csv") \
        .option("header", "true") \
        .load("/Software/data/sfpd.csv")
```

Register as a Table, so that we can perform SQL operation on it.

```
df.createOrReplaceTempView("sfpd")
```

You can execute an SQL query using the above table.

```
sql("select * from sfpd").show(false)
```

```
In [26]: df = spark.read.format("csv") \
             .option("header", "true") \
             .load("/Software/data/sfpd.csv")

In [28]: df.createOrReplaceTempView("sfpd")

In [34]: sql("select * from sfpd").show(truncate=False)
```

```
+---------+------------------------+----------------------------------------+--------+----------+---
--+---------+-------------+---------------------------+---------------+---------------+-------------
---------------------+-------------+
|IncidntNum|Category                |Descript                                |DayOfWeek|Date      |Tim
e |PdDistrict|Resolution    |Address                    |X              |Y              |Location
|PdId          |
+---------+------------------------+----------------------------------------+--------+----------+---
--+---------+-------------+---------------------------+---------------+---------------+-------------
---------------------+-------------+
|150467944 |LARCENY/THEFT           |GRAND THEFT FROM LOCKED AUTO            |Thursday |05/28/2015|23:
59|TENDERLOIN|NONE          |TAYLOR ST / OFARRELL ST    |-122.411328369311|37.7859963050476|(37.7859963050
476, -122.411328369311)|15046794406244|
|150468629 |VEHICLE THEFT           |STOLEN TRUCK                            |Thursday |05/28/2015|23:
59|MISSION   |NONE          |100 Block of PORTOLA DR    |-122.444276468858|37.7484965077695|(37.7484965077
695, -122.444276468858)|15046862907025|
|156133410 |LARCENY/THEFT           |PETTY THEFT OF PROPERTY                 |Thursday |05/28/2015|23:
55|NORTHERN  |NONE          |1300 Block of POLK ST      |-122.420422400634|37.7889233553137|(37.7889233553
137, -122.420422400634)|15613341006372|
|150478769 |VEHICLE THEFT           |STOLEN AUTOMOBILE                       |Thursday |05/28/2015|23:
50|CENTRAL   |NONE          |500 Block of UNION ST      |-122.407974943839|37.8006466385111|(37.8006466385
111, -122.407974943839)|15047876907021|
```

The **date** field in this dataset is a String of the form “mm/dd/yy”. We are going to create a function to extract the year from the date field. There are two ways to use user defined functions with Spark DataFrames. You can define it inline and use it within DataFrame operations or use it in SQL queries.

We can then find answers to questions such as: What is the number of incidents by year?

Define a function that extracts characters after the last ‘/’ from the string.

```
from dateutil.parser import parse
def getyear(s):
    dt = parse(s)
    year = dt.year
    return year
```

Register the function in the SQL Context

```
from pyspark.sql import *
sqlContext = SQLContext(sc)
sqlContext.udf.register("getyear",getyear)
```

Using the registered the udf in a SQL query, find the count of incidents by year.

```
incyearSQL = sql("SELECT getyear(sfpd.Date), count(sfpd.IncidntNum) AS
countbyyear " +
                                 " FROM sfpd GROUP BY getyear(sfpd.Date)
ORDER BY countbyyear DESC")
incyearSQL.show()
```

```
In [63]: from dateutil.parser import parse
         def getyear(s):
             dt = parse(s)
             year = dt.year
             return year

In [64]: from pyspark.sql import *
         sqlContext = SQLContext(sc)
         sqlContext.udf.register("getyear",getyear)

         24/02/13 14:34:59 WARN SimpleFunctionRegistry: The function getyear replaced a previously registered function
         .

Out[64]: <function __main__.getyear(s)>
```

Now you can use convertUDF() on a DataFrame column as a regular build-in function.

```
In [65]: incyearSQL = sql("SELECT getyear(sfpd.Date), count(sfpd.IncidntNum) AS countbyyear " +
                                    " FROM sfpd GROUP BY getyear(sfpd.Date) ORDER BY countbyyear DESC")

In [66]: incyearSQL.show()

         +-------------+-----------+
         |getyear(Date)|countbyyear|
         +-------------+-----------+
         |         2015|       9999|
         +-------------+-----------+
```

Find the addresses and resolution of VANDALISM incidents in 2015.

```
van2015 = sql("SELECT category,address,resolution, date FROM sfpd WHERE
getyear(date)='2015' " +
            " AND category='VANDALISM'")
van2015.show()
```

van2015.count()

```
In [72]: van2015 = sql("SELECT category,address,resolution, date FROM sfpd WHERE getyear(date)='2015' " +
                       " AND category='VANDALISM'")
         van2015.show()
```

```
+---------+--------------------+--------------+----------+
| category|             address|    resolution|      date|
+---------+--------------------+--------------+----------+
|VANDALISM|600 Block of 42ND AV|          NONE|05/28/2015|
|VANDALISM|HOLLIS ST / ELLIS ST|          NONE|05/28/2015|
|VANDALISM|1300 Block of POL...|          NONE|05/28/2015|
|VANDALISM|JACKSON ST / WALN...|          NONE|05/28/2015|
|VANDALISM|LINCOLN WY / 43RD AV|          NONE|05/28/2015|
|VANDALISM|200 Block of DUBO...|          NONE|05/28/2015|
|VANDALISM|2300 Block of PAC...|          NONE|05/28/2015|
|VANDALISM|  BAY ST / KEARNY ST|          NONE|05/28/2015|
|VANDALISM|100 Block of EDDY ST|ARREST, BOOKED|05/28/2015|
|VANDALISM|HARRISON ST / 13T...|          NONE|05/28/2015|
|VANDALISM|  GOUGH ST / OTIS ST|          NONE|05/28/2015|
|VANDALISM|20TH ST / ILLINOI...|          NONE|05/28/2015|
|VANDALISM|800 Block of HYDE ST|          NONE|05/28/2015|
|VANDALISM|900 Block of BROD...|ARREST, BOOKED|05/28/2015|
|VANDALISM|1100 Block of GOU...|          NONE|05/28/2015|
|VANDALISM|JOHNFKENNEDY DR /...|          NONE|05/28/2015|
|VANDALISM|3200 Block of 22N...|ARREST, BOOKED|05/28/2015|
|VANDALISM|1900 Block of KEA...|          NONE|05/28/2015|
|VANDALISM|3000 Block of 16T...|          NONE|05/28/2015|
|VANDALISM|  8TH ST / HOOPER ST|          NONE|05/28/2015|
+---------+--------------------+--------------+----------+
only showing top 20 rows
```

```
In [74]: van2015.count()
Out[74]: 513
```

SQL Engine:

In this mode, end-users or applications can interact with Spark SQL directly to run SQL queries, without the need to write any code.

To start the JDBC/ODBC server, run the following in the Spark directory:

```
#cd /opt/spark
#./sbin/start-thriftserver.sh
```

You can list the port running thriftserver using the following command.

```
#lsof -i:10000
```

If it display as shown above, then the services is up.

Now you can use beeline to test the Thrift JDBC/ODBC server:

```
#beeline
```

Connect to the JDBC/ODBC server in beeline with:

```
beeline> !connect jdbc:hive2://localhost:10000
```

It will ask for the username, enter any say – henry leave the password blank.

```
[root@spark0 spark]# beeline
Beeline version 2.3.9 by Apache Hive
beeline> !connect jdbc:hive2://localhost:10000
Connecting to jdbc:hive2://localhost:10000
Enter username for jdbc:hive2://localhost:10000: henry
Enter password for jdbc:hive2://localhost:10000:
Connected to: Spark SQL (version 3.3.0)
Driver: Hive JDBC (version 2.3.9)
Transaction isolation: TRANSACTION_REPEATABLE_READ
0: jdbc:hive2://localhost:10000>
```

Let us create a table and execute a query on it.

```
CREATE TABLE  PEOPLE (name String, age int) using org.apache.spark.sql.json
OPTIONS (path "/Software/data/people.json");

select * from people;
```

```
Transaction isolation: TRANSACTION_REPEATABLE_READ
0: jdbc:hive2://localhost:10000> CREATE TABLE  PEOPLE (name STring, age int) using org.apache.spark.sql.jso
n OPTIONS (path "/software/people.json");
+---------+
| Result  |
+---------+
+---------+
No rows selected (1.866 seconds)
0: jdbc:hive2://localhost:10000> select * from people;
+----------+-------+
|   name   |  age  |
+----------+-------+
| Michael  | NULL  |
| Andy     | 30    |
| Justin   | 19    |
+----------+-------+
3 rows selected (3.677 seconds)
0: jdbc:hive2://localhost:10000>
```

---------- Lab Ends Here ----------

8. Explore Data with DataFrame Queries – 60 Minutes

We will understand the following in this lab:

- Join
- Accessing Columns in DF

Use the following data for this lab:

/opt/data/people.csv

```
pcode,lastName,firstName,age
02134,Hopper,Grace,52
94020,Turing,Alan,32
94020,Lovelace,Ada,28
87501,Babbage,Charles,49
02134,Wirth,Niklaus,48
```

Load the people data and fetch column, age in the following way:

```
dataFile = "/opt/data/people.csv"

#Import and define the Structure.
from pyspark.sql.types import *
columnsList = [
   StructField("pcode", StringType()),
   StructField("lastName", StringType()),
   StructField("firstName", StringType()),
   StructField("age", IntegerType())]
```

peopleSchema = StructType(columnsList)

peopleDF = spark.read.option("header","true").schema(peopleSchema).csv(dataFile)

```
In [12]: dataFile = "/opt/data/people.csv"

In [13]: #Import and define the Structure.
         from pyspark.sql.types import *
         columnsList = [
             StructField("pcode", StringType()),
             StructField("lastName", StringType()),
             StructField("firstName", StringType()),
             StructField("age", IntegerType())]
         peopleSchema = StructType(columnsList)

In [14]: peopleDF = spark.read.option("header","true").schema(peopleSchema).csv(dataFile)
```

Reload this page

Different way of fetching column in a dataframe. Here retrieves only age.

peopleDF["age"]
peopleDF.age

```
In [19]: print(peopleDF['age'])
         Column<'age'>

In [16]: peopleDF.age
Out[16]: Column<'age'>
```

peopleDF.select(peopleDF["age"]).show()
peopleDF.select(peopleDF.age).show()

```
In [17]: peopleDF.select(peopleDF["age"]).show()
```

```
+----+
| age|
+----+
|null|
|  32|
|  28|
|  49|
|  48|
+----+
```

```
In [24]: peopleDF.select(peopleDF.age).show()
```

```
+----+
| age|
+----+
|null|
|  32|
|  28|
|  49|
|  48|
+----+
```

Manipulate the column age i.e multiple age by 10.

peopleDF.select("lastName", peopleDF.age * 10).show()

```
In [20]: peopleDF.select("lastName", peopleDF.age * 10).show()
+--------+----------+
|lastName|(age * 10)|
+--------+----------+
|  Hopper|      null|
|  Turing|       320|
|Lovelace|       280|
| Babbage|       490|
|   Wirth|       480|
+--------+----------+
```

You can chain the Queries. Select last name, multiply the age by 10 times and show the result. Assign column name as age_10 for the derived column.

peopleDF.select("lastName",(peopleDF.age * 10).alias("age_10")).show()

```
In [21]: peopleDF.select("lastName",(peopleDF.age * 10).alias("age_10")).show()
```

```
+--------+------+
|lastName|age_10|
+--------+------+
|  Hopper|  null|
|  Turing|   320|
|Lovelace|   280|
| Babbage|   490|
|   Wirth|   480|
+--------+------+
```

Perform aggregation. Find the no of people in a pincode.

peopleDF.groupBy("pcode").count().show()

```
In [22]: peopleDF.groupBy("pcode").count().show()
```

```
+-----+-----+
|pcode|count|
+-----+-----+
|87501|    1|
|94020|    2|
|02134|    2|
+-----+-----+
```

Next let us join two dataframes:

people-no-pcode.csv -> Contains information of person along with a pincode.

pcodes.csv -> Contains information about an area along with a pincode.

/opt/data/people-no-pcode.csv

```
pcode,lastName,firstName,age
02134,Hopper,Grace,52
,Turing,Alan,32
94020,Lovelace,Ada,28
87501,Babbage,Charles,49
02134,Wirth,Niklaus,48
```

/opt/data/pcodes.csv

```
pcode,city,state
02134,Boston,MA
94020,Palo Alto,CA
87501,Santa Fe,NM
60645,Chicago,IL
```

We will determine the city of every person by joining the above two files.
Load the people and code files in DF.

```
peopleDF = spark.read.option("header","true").csv("/opt/data/people-no-pcode.csv")
pcodesDF = spark.read.option("header","true").csv("/opt/data/pcodes.csv")
```

Have a glimpse of the datasets.

peopleDF.take(2)
pcodesDF.take(2)

```
In [25]: peopleDF = spark.read.option("header","true").csv("/opt/data/people-no-pcode.csv")
         pcodesDF = spark.read.option("header","true").csv("/opt/data/pcodes.csv")

In [26]: peopleDF.take(2)

Out[26]: [Row(pcode='02134', lastName='Hopper', firstName='Grace', age='52'),
          Row(pcode=None, lastName='Turing', firstName='Alan', age='32')]

In [27]: pcodesDF.take(2)

Out[27]: [Row(pcode='02134', city='Boston', state='MA'),
          Row(pcode='94020', city='Palo Alto', state='CA')]
```

Perform Inner Join on pincode -> pcode.

peopleDF.join(pcodesDF, "pcode").show()

Reload this page

```
eDF.join(pcodesDF, "pcode").show()
```

```
+-----+--------+---------+---+---------+-----+
|pcode|lastName|firstName|age|     city|state|
+-----+--------+---------+---+---------+-----+
|02134|  Hopper|    Grace| 52|   Boston|   MA|
|94020|Lovelace|      Ada| 28|Palo Alto|   CA|
|87501| Babbage|  Charles| 49| Santa Fe|   NM|
|02134|   Wirth|  Niklaus| 48|   Boston|   MA|
+-----+--------+---------+---+---------+-----+
```

Perform the Left outer join.

Find all person along with city information in case the area information is available.

peopleDF.join(pcodesDF,peopleDF["pcode"] == pcodesDF.pcode, "left_outer").show()

```
In [29]: peopleDF.join(pcodesDF,peopleDF["pcode"] == pcodesDF.pcode,  "left_outer").show()
```

```
+-----+--------+---------+---+-----+---------+-----+
|pcode|lastName|firstName|age|pcode|     city|state|
+-----+--------+---------+---+-----+---------+-----+
|02134|  Hopper|    Grace| 52|02134|   Boston|   MA|
| null|  Turing|     Alan| 32| null|     null| null|
|94020|Lovelace|      Ada| 28|94020|Palo Alto|   CA|
|87501| Babbage|  Charles| 49|87501| Santa Fe|   NM|
|02134|   Wirth|  Niklaus| 48|02134|   Boston|   MA|
+-----+--------+---------+---+-----+---------+-----+
```

You can see null value in the pcode of the second row. Since there is no corresponding city information.

Joining on Columns with Different Names

Here, the people file contains pin code and its refer as zip in the area location file.

/opt/data/zcodes.csv

```
zip,city,state
02134,Boston,MA
94020,Palo Alto,CA
87501,Santa Fe,NM
60645,Chicago,IL
```

Join with the pcode and zip of the second file.

```
zcodesDF = spark.read.option("header","true").csv("/opt/data/zcodes.csv")
peopleDF.join(zcodesDF, peopleDF.pcode == zcodesDF.zip).show()
```

```
In [30]: zcodesDF = spark.read.option("header","true").csv("/opt/data/zcodes.csv")
         peopleDF.join(zcodesDF, peopleDF.pcode == zcodesDF.zip).show()
```

```
+-----+--------+---------+---+-----+---------+-----+
|pcode|lastName|firstName|age|  zip|     city|state|
+-----+--------+---------+---+-----+---------+-----+
|02134|  Hopper|    Grace| 52|02134|   Boston|   MA|
|94020|Lovelace|      Ada| 28|94020|Palo Alto|   CA|
|87501| Babbage|  Charles| 49|87501| Santa Fe|   NM|
|02134|   Wirth|  Niklaus| 48|02134|   Boston|   MA|
+-----+--------+---------+---+-----+---------+-----+
```

Try performing to get all person information even if the city information is not available in the above

query. Output should be as shown below.

```
+-----+--------+---------+---+-----+---------+-----+
|pcode|lastName|firstName|age|  zip|     city|state|
+-----+--------+---------+---+-----+---------+-----+
|02134|  Hopper|    Grace| 52|02134|   Boston|   MA|
| null|  Turing|     Alan| 32| null|     null| null|
|94020|Lovelace|      Ada| 28|94020|Palo Alto|   CA|
|87501| Babbage|  Charles| 49|87501| Santa Fe|   NM|
|02134|   Wirth|  Niklaus| 48|02134|   Boston|   MA|
+-----+--------+---------+---+-----+---------+-----+
```

---------- Lab Ends Here ----------

9. Explore Interactive Analysis with pySpark – 30 Minutes

Optional : export PYSPARK_PYTHON=python3.6 (In case you want to change the python version. Update in the bin\pyspark scripts of load environment sh file)

Start it by running the following in the Spark directory:

```
#pyspark

#Load a text file to perform some of the transformations provided by spark.
textFile = sc.textFile("/opt/spark/README.md")

#Count the no of lines in the file.
textFile.count()

#Get the first line
textFile.first()

#Fetch the lines which begins with Spark.
linesWithSpark = textFile.filter(lambda line: "Spark" in line)

#Get the number of rows
linesWithSpark.count()
```

```
      ____              __
     / __/__  ___ _____/ /__
    _\ \/ _ \/ _ `/ __/  '_/
   /__ / .__/\_,_/_/ /_/\_\   version 2.1.0
      /_/

Using Python version 2.6.6 (r266:84292, Oct 12 2012 14:23:48)
SparkSession available as 'spark'.
>>> textFile = sc.textFile("README.md")
>>> textFile.count()
104
>>> textFile.first()
u'# Apache Spark'
```

```
>>> linesWithSpark = textFile.filter(lambda line: "Spark" in line)
>>> linesWithSpark.count()
20
>>>
```

Sometimes there is a need to create RDD from a given Collection.

```
myData = ["Alice","Carlos","Frank","Barbara"]
myRDD = sc.parallelize(myData)
```

#Print all the element in RDD
for make in myRDD.collect(): print(make)

#Print the first 2 elements only.
for make in myRDD.take(2): print(make)

#Save the RDD to a file.
myRDD.saveAsTextFile("/opt/data/mydata/")

```
In [6]: myData = ["Alice","Carlos","Frank","Barbara"]
        myRDD = sc.parallelize(myData)

In [8]: for make in myRDD.collect(): print(make)

        Alice
        Carlos
        Frank
        Barbara

In [9]: for make in myRDD.take(2): print (make)

        Alice
        Carlos

In [10]: myRDD.saveAsTextFile("/opt/data/mydata/")
```

You can verify the data in the folder /opt/data/mydata/
tree mydata/

No. of files depend on the cores of your system.
more mydata/part-00001

```
[root@spark0 data]# tree mydata/
mydata/
├── part-00000
├── part-00001
├── part-00002
├── part-00003
├── part-00004
├── part-00005
└── _SUCCESS

0 directories, 7 files
[root@spark0 data]# more mydata/part-00000
[root@spark0 data]# more mydata/part-00001
Alice
[root@spark0 data]# more mydata/part-00002
Carlos
[root@spark0 data]#
```

Add one more RDD

```
myData1 = ["Ram","Shyam","Krishna","Vishnu"]
myRDD1 = sc.parallelize(myData1)
```

create a new RDD by combining the second RDD to the previous RDD.

myNames = myRDD.union(myRDD1)

Collect and display the contents of the new myNames RDD.

for name in myNames.collect(): print(name)

```
In [10]: myRDD.saveAsTextFile("/opt/data/mydata/")

In [11]: myData1 = ["Ram","Shyam","Krishna","Vishnu"]
         myRDD1 = sc.parallelize(myData1)

In [12]: myNames = myRDD.union(myRDD1)

In [13]: for name in myNames.collect(): print(name)
         Alice
         Carlos
         Frank
         Barbara
         Ram
         Shyam
         Krishna
         Vishnu
```

----------Lab Ends Here ----------

10. Explore Transformation and Action – 45 Minutes

In this lab, we will explore various transformation method provided by spark RDD

- Map
- Mapfilter
- GroupBy etc

Let's make a new RDD from the text of the README file in the Spark source directory:
(SPARK_HOME/README.md)

```
textFile = sc.textFile("/opt/spark/README.md")
```

Let's start with a few actions:

```
textFile.count() # Number of items in this RDD


textFile.first() # First item in this RDD
```

```
In [5]: #Load the data file
        textFile = sc.textFile("/opt/spark/README.md")

In [6]: # Number of items in this RDD
        textFile.count()

Out[6]: 124

In [7]: textFile.first() # First item in this RDD

Out[7]: '# Apache Spark'
```

Now let's use a transformation. We will use the filter transformation to return a new RDD with a subset of the items in the file.

```
linesWithSpark = textFile.filter(lambda line: "Spark" in line)
linesWithSpark.collect()
```

```
In [8]: linesWithSpark = textFile.filter(lambda line: "Spark" in line)
        linesWithSpark.collect()

Out[8]: ['# Apache Spark',
         'Spark is a unified analytics engine for large-scale data processing. It provides',
         'rich set of higher-level tools including Spark SQL for SQL and DataFrames,',
         'pandas API on Spark for pandas workloads, MLlib for machine learning, GraphX for graph processing,',
         '[![PySpark Coverage](https://codecov.io/gh/apache/spark/branch/master/graph/badge.svg)](https://codecov.io/gh/apache/spark)',
         'You can find the latest Spark documentation, including a programming',
         '## Building Spark',
         'Spark is built using [Apache Maven](https://maven.apache.org/).',
         'To build Spark and its example programs, run:',
         '["Building Spark"](https://spark.apache.org/docs/latest/building-spark.html).',
         'For general development tips, including info on developing Spark using an IDE, see ["Useful Developer Tools"](https://spark.apache.org/developer-tools.html).',
         'The easiest way to start using Spark is through the Scala shell:',
         'Spark also comes with several sample programs in the `examples` directory.',
         './bin/run-example SparkPi',
         'MASTER=spark://host:7077 ./bin/run-example SparkPi',
         'Testing first requires [building Spark](#building-spark). Once Spark is built, tests',
         'Spark uses the Hadoop core library to talk to HDFS and other Hadoop-supported',
         'Hadoop, you must build Spark against the same version that your cluster runs.',
         'in the online documentation for an overview on how to configure Spark.',
         'Please review the [Contribution to Spark guide](https://spark.apache.org/contributing.html)']
```

We can chain together transformations and actions:

textFile.filter(lambda line : "Spark" in line).count() # How many lines contain "Spark"?

Let's say we want to find the line with the most words

textFile.map(lambda line : len(line.split(" "))). reduce(lambda a, b: a if (a > b) else b)

```
In [9]: textFile.filter(lambda line : "Spark" in line).count() # How many lines contain "Spark"?
Out[9]: 20

In [11]: textFile.map(lambda line : len(line.split(" "))).reduce(lambda a, b: a if (a > b) else b)
Out[11]: 16
```

One common data flow pattern is MapReduce, as popularized by Hadoop. Spark can implement MapReduce flows easily:

```
wordCounts = textFile.flatMap(lambda line: line.split()).map(lambda word: (word, 1)).reduceByKey(lambda a, b: a+b)
```

Here, we combined the flatMap, map and reduceByKey transformations to compute the per-word counts in the file as an RDD of (String, Int) pairs. To collect the word counts in our shell, we can use the collect action:

```
wordCounts.collect()
```

```
In [8]: wordCounts.collect()

Out[8]: [('#', 1),
         ('Apache', 1),
         ('Spark', 15),
         ('is', 7),
         ('unified', 1),
         ('analytics', 1),
         ('engine', 2),
         ('It', 2),
         ('provides', 1),
         ('high-level', 1),
         ('APIs', 1),
         ('in', 5),
```

let's mark our linesWithSpark dataset to be cached:

```
linesWithSpark.cache()
```

linesWithSpark.count()

```
In [14]: linesWithSpark.cache()
         linesWithSpark.count()

Out[14]: 20
```

Next, we will convert RDD to Dataframe.

Create a file /opt/data/people.txt

```
02134,Hopper,Grace,52
94020,Turing,Alan,32
94020,Lovelace,Ada,28
87501,Babbage,Charles,4
```

Import the necessary packages.

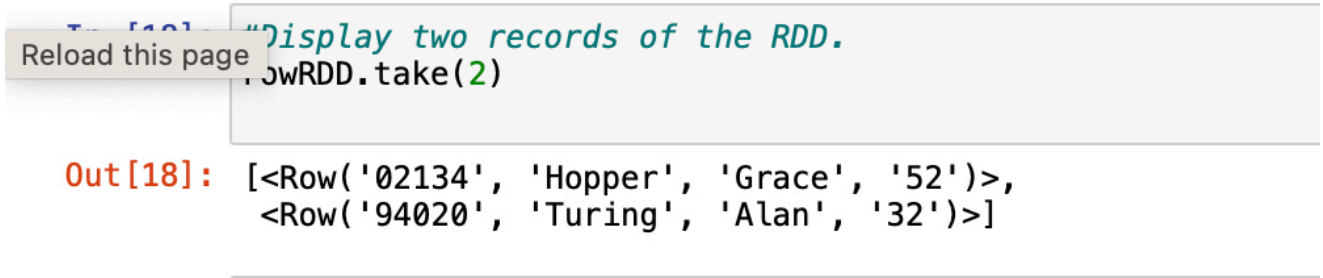
```
from pyspark.sql.types import *

from pyspark.sql import Row
```

Load the data file and convert into Row Class.

```
rowRDD = sc.textFile("/opt/data/people.txt").map(lambda line : line.split(",")).map(lambda values :
Row(values[0],values[1],values[2],values[3]))
```

```
In [15]: from pyspark.sql.types import *
         from pyspark.sql import Row

In [16]: rowRDD = sc.textFile("/opt/data/people.txt").map(lambda line : line.split(",")).map(lambda values :
         Row(values[0],values[1],values[2],values[3]))

In [18]: #Display two records of the RDD.
         rowRDD.take(2)

Out[18]: [<Row('02134', 'Hopper', 'Grace', '52')>,
          <Row('94020', 'Turing', 'Alan', '32')>]
```

```
# Display two records of the RDD.
rowRDD.take(2)
```




```
# Convert the RDD to data Frame.
myDF = rowRDD.toDF()
#Display two records of the data frame.
myDF.show(2)
```

```
In [20]: #Display two records of the data frame.
         myDF.show(2)
```

```
+-----+------+-----+---+
|   _1|    _2|   _3| _4|
+-----+------+-----+---+
|02134|Hopper|Grace| 52|
|94020|Turing| Alan| 32|
+-----+------+-----+---+
only showing top 2 rows
```

---------- Lab Ends Here ----------

11. Explore with Pair RDD – 90 Minutes

Lab Overview

In this activity, you will load SFPD data from a CSV file. You will create pair RDD and apply pair RDD operations to explore the data.

Scenario:
Our dataset is a .csv file that consists of SFPD incident data from SF OpenData (https://data.sfgov.org/). For each incident, we have the following information:

Field	Description	Example Value
IncidentNum	Incident number	150561637
Category	Category of incident	NON-CRIMINAL
Descript	Description of incident	FOUND_PROPERTY
DayOfWeek	Day of week that incident occurred	Sunday
Date	Date of incident	6/28/15
Time	Time of incident	23:50
PdDistrict	Police Department District	TARAVAL

Resolution	Resolution	NONE
Address	Address	1300_Block_of_LA_PLAYA_ST
X	X-coordinate of location	-122.5091348
Y	Y-coordinate of location	37.76119777
PdID	Department ID	15056163704013

The dataset has been modified to decrease the size of the files and also to make it easier to use. We use this same dataset for all the labs.

Load Data into Apache Spark
Objectives

- Launch the Spark interactive shell
- Load data into Spark
- Explore data in Apache Spark

Launch the Spark Interactive Shell

1. To launch the Interactive Shell, at the command line, run the following command:

```
#pyspark --master local[2]
```

Load Data into Spark

To load the data we are going to use the `SparkContext` method `textFile`. The SparkContext is available in the interactive shell as the variable **`sc`**. We also want to split the file by the separator ",".

We define the mapping for our input variables. While this isn't a necessary step, it makes it easier to refer to the different fields by names.

```
val IncidntNum = 0 val Category = 1 val
Descript = 2 val DayOfWeek = 3 val
Date = 4
val Time = 5
val PdDistrict = 6 val Resolution = 7
val Address = 8 val X = 9
val Y = 10 val PdId = 11
```

To load data into Spark, at the pyspark command prompt:

```
sfpdRDD = sc.textFile("/Software/data/sfpd_no_header.csv").map(lambda line: line.split(","))
```

Explore data using RDD operations

What transformations and actions would you use in each case? Complete the command with the appropriate transformations and actions.

How do you see the first element of the inputRDD (sfpdRDD)?

```
sfpdRDD.first()
```

```
In [7]: sfpdRDD = sc.textFile("/Software/data/sfpd_no_header.csv").map(lambda line: line.split(","))

In [8]: sfpdRDD.first()

Out[8]: ['150467944',
         'LARCENY/THEFT',
         'GRAND THEFT FROM LOCKED AUTO',
         'Thursday',
         '05/28/2015',
         '23:59',
         'TENDERLOIN',
         'NONE',
         'TAYLOR ST / OFARRELL ST',
         '-122.411328369311',
         '37.7859963050476',
         '"(37.7859963050476',
         ' -122.411328369311)"',
         '15046794406244']
```

What do you use to see the first 5 elements of the RDD?

sfpdRDD.take(5)

```
In [9]: sfpdRDD.take(5)
Out[9]: [['150467944',
          'LARCENY/THEFT',
          'GRAND THEFT FROM LOCKED AUTO',
          'Thursday',
          '05/28/2015',
          '23:59',
          'TENDERLOIN',
          'NONE',
          'TAYLOR ST / OFARRELL ST',
          '-122.411328369311',
          '37.7859963050476',
          '"(37.7859963050476',
          ' -122.411328369311)"',
          '15046794406244'],
         ['150468629',
          'VEHICLE THEFT',
          'STOLEN TRUCK',
          'Thursday',
          '05/28/2015',
          '23:59',
          'MISSION',
          'NONE',
          '100 Block of PORTOLA DR',
          '-122.444276468858',
```

What is the total number of incidents?

```
totincs = sfpdRDD.count()
print(totincs)
```

```
In [6]: totincs = sfpdRDD.count()
        print(totincs)

        9999
```

What is the total number of distinct resolutions?

```
totres = sfpdRDD.map(lambda inc : inc[7]).distinct().count()
totres
```

```
In [7]: totres = sfpdRDD.map(lambda inc : inc[7]).distinct().count()
        totres

Out[7]: 150
```

List the distinct PdDistricts.

```
totresdistricts =sfpdRDD.map(lambda inc : inc[6]).collect()
totresdistricts
```

```
In [18]: totresdistricts =sfpdRDD.map(lambda inc : inc[6]).collect()

In [19]: totresdistricts

Out[19]: ['TENDERLOIN',
          'MISSION',
          'NORTHERN',
          'CENTRAL',
          'BAYVIEW',
          'MISSION',
          'NORTHERN',
          'MISSION',
          'MISSION',
          'MISSION',
          'SOUTHERN',
          '22:55',
          'MISSION',
          '22:55',
          '22:52',
          'PARK',
```

In the previous activity we explored the data in the sfpdRDD. We used RDD operations. In this activity, we will create pairRDD to find answers to questions about the data.

Objectives

- Create pairRDD & apply pairRDD operations
- Join pairRDD

Create pair RDD & apply pair RDD operations

```
# sfpdRDD = sc.textFile("/Sofwtare/data/sfpd_no_header.csv").map(lambda rec: rec.split(","))
```

Which five districts have the highest incidents?

Note: This is similar to doing a word count. First, use the **`map`** transformation to create a pair RDD with the key being the field on which you want to count. In this case, the key would be PdDistrict and the value is "1" for each count of the district.

To get the total count, use **`reduceByKey((a,b)=>a+b)`**.

To find the **top** 5, you have to do a sort in descending. However, sorting on the result of the reduceByKey will sort on the District rather than the count. Apply the **`map`** transformation to create a pairRDD with the count being the key and the value being the district.

Step to be follow (Hints)

a. Use a **`map`** transformation to create pair RDD from sfpdRDD of the form: [(PdDistrict, 1)]

b. Use **`reduceByKey((a,b)=>a+b)`** to get the count of incidents in each district. Your result will be a pairRDD of the form [(PdDistrict, count)]

c. Use map again to get a pairRDD of the form [(count, PdDistrict)]

d. Use **`sortByKey(false)`** on [(count, PdDistrict)]

e. Use **`take(5)`** to get the top 5.

Answer:

```
top5Dists = sfpdRDD.filter(lambda incident: len(incident) == 14) \
        .map(lambda incident: (incident[6],1) ).reduceByKey(lambda x,y : x+y) \
        .map(lambda incinfo: (incinfo[1], incinfo[0]))      \
        .reduceByKey(lambda x,y : x+y)                      \
        .sortByKey(False)

top5Dists.take(5)
```

```
In [84]: sfpdRDD = sc.textFile("/Software/data/sfpd_no_header.csv").map(lambda rec: rec.split(","))

In [85]: top5Dists = sfpdRDD.filter(lambda incident: len(incident) == 14) \
                    .map(lambda incident: (incident[6],1) ).reduceByKey(lambda x,y : x+y) \
                    .map(lambda incinfo: (incinfo[1], incinfo[0]))       \
                    .reduceByKey(lambda x,y : x+y)                        \
                    .sortByKey(False)

In [86]: top5Dists.take(5)

Out[86]: [(1000, 'SOUTHERN'),
          (801, 'NORTHERN'),
          (704, 'CENTRAL'),
          (604, 'TARAVAL'),
          (582, 'MISSION')]
```

Add filter to validate proper record i.e it should have exactly 14 fields only in each record.

Which five addresses have the highest incidents?

f. Create pairRDD (map)

g. Get the count for key (reduceByKey)

h. Pair RDD with key and count switched (map

i. Sort in descending order (sortByKey

j. Use **`take(5)`** to get the top 5

Answer:

```
top5Adds = sfpdRDD \
      .map(lambda incident : (incident[8],1))  \
      .reduceByKey(lambda x,y : x+y) \
      .map(lambda ad_count : (ad_count[1],ad_count[0])) \
      .sortByKey(False).take(5)

top5Adds
```

```
In [68]: top5Adds = sfpdRDD \
                .map(lambda incident : (incident[8],1))  \
                .reduceByKey(lambda x,y : x+y) \
                .map(lambda ad_count : (ad_count[1],ad_count[0])) \
                .sortByKey(False).take(5)

In [70]: top5Adds

Out[70]: [(1783, ' BOOKED"'),
          (1535, 'NONE'),
          (628, '"ARREST'),
          (154, '800 Block of BRYANT ST'),
          (35, '1000 Block of POTRERO AV')]
```

What are the top **three** categories of incidents?

Answer:

```
top3Cat = sfpdRDD.filter(lambda incident: len(incident) == 14) \
        .map(lambda incident: (incident[1],1))  \
        .reduceByKey(lambda x,y : x+y)  \
        .map(lambda cat_count : (cat_count[1],cat_count[0])) \
        .sortByKey(False).take(3)

top3Cat
```

```
In [76]: top3Cat = sfpdRDD.filter(lambda incident: len(incident) == 14) \
                    .map(lambda incident: (incident[1],1))  \
                    .reduceByKey(lambda x,y : x+y)  \
                    .map(lambda cat_count : (cat_count[1],cat_count[0])) \
                    .sortByKey(False).take(3)

In [77]: top3Cat

Out[77]: [(2669, 'LARCENY/THEFT'), (633, 'NON-CRIMINAL'), (627, 'VEHICLE THEFT')]
```

What is the count of incidents by district?

Answer:

```
num_inc_dist = sfpdRDD.filter(lambda incident: len(incident) == 14) \
        .map(lambda incident:(incident[6],1)) \
        .countByKey()

num_inc_dist
```

```
In [89]: num_inc_dist = sfpdRDD.filter(lambda incident: len(incident) == 14) \
             .map(lambda incident:(incident[6],1)) \
             .countByKey()

In [90]: num_inc_dist

Out[90]: defaultdict(int,
                     {'TENDERLOIN': 306,
                      'MISSION': 582,
                      'NORTHERN': 801,
                      'CENTRAL': 704,
                      'BAYVIEW': 493,
                      'PARK': 385,
                      'SOUTHERN': 1000,
                      'TARAVAL': 604,
                      'INGLESIDE': 511,
                      'RICHMOND': 404})
```

Caution! For large datasets, don't use countByKey.

Join Pair RDDs

This activity illustrates how joins work in Spark (python). There are two small datasets provided for this activity - J_AddCat.csv and J_AddDist.csv.

J_AddCat.csv - Category; Address			J_AddDist.csv - PdDistrict; Address		
1.	EMBEZZLEMENT	100_Block_of_JEFFERSON_ST	1.	INGLESIDE	100_Block_of_ROME_ST
2.	EMBEZZLEMENT	SUTTER_ST/MASON_ST	2.	SOUTHERN	0_Block_of_SOUTHPARK_AV
3.	BRIBERY	0_Block_of_SOUTHPARK_AV	3.	MISSION	1900_Block_of_MISSION_ST
4.	EMBEZZLEMENT	1500_Block_of_15TH_ST	4.	RICHMOND	1400_Block_of_CLEMENT_ST
5.	EMBEZZLEMENT	200_Block_of_BUSH_ST	5.	SOUTHERN	100_Block_of_BLUXOME_ST
6.	BRIBERY	1900_Block_of_MISSION_ST	6.	SOUTHERN	300_Block_of_BERRY_ST

7.	EMBEZZLEMENT	800_Block_of_MARKET_ST	7.	BAYVIEW	1400_Block_of_VANDYKE_AV
8.	EMBEZZLEMENT	2000_Block_of_MARKET_ST	8.	SOUTHERN	1100_Block_of_MISSION_ST
9.	BRIBERY	1400_Block_of_CLEMENT_ST	9.	TARAVAL	0_Block_of_CHUMASERO_DR
10.	EMBEZZLEMENT	1600_Block_of_FILLMORE_ST			
11.	EMBEZZLEMENT	1100_Block_of_SELBY_ST			
12.	BAD CHECKS	100_Block_of_BLUXOME_ST			

Based on the data above, answer the following questions:

1. Given these two datasets, you want to find the type of incident and district for each address. What is one way of doing this? (HINT: An operation on pairs or pairRDDs)

What should the keys be for the two pairRDDs?
[You can use joins on pairs or pairRDD to get the information. The key for the pairRDD is the address.]

2. What is the size of the resulting dataset from a join? Why?

Note: Look at the datasets above and estimate what a join on the two would return if they were joined on the key - from #1.

Remember that a join is the same as an inner join and only keys

[A join is the same as an inner join and only keys that are present in both RDDs are output. If you compare the addresses in both the datasets, you find that there are five addresses in common and they are unique. Thus the resulting dataset will contain five elements. If there are multiple values for the same key, the resulting RDD will have an entry for every possible pair of values with that key from the two RDDs.]

3. If you did a right outer join on the two datasets with Address/Category being the source

Note: Look at the datasets above and estimate what a join on the two would return if they were joined on the key - from #1.

Remember that a right outer join results in a pair RDD that has

RDD, what would be the size of the resulting dataset? Why?

[A right outer join results in a pair RDD that has entries for each key in the other pairRDD. If the source RDD contains data from J_AddCat.csv and the "other" RDD is represented by J_AddDist.csv, then since "other" RDD has 9 distinct addresses, the size of the result of a right outer join is 9.]

4. If you did a left outer join on the two datasets with Address/Category being the source RDD, what would be the size of the resulting dataset? Why?

Note: Look at the datasets above and estimate what a join on the two would return if they were joined on the key - from #1.

Remember that a left outer join results in a pair RDD that has

[A left outer join results in a pair RDD that has entries for each key in the source pairRDD. If thesource RDD contains data from J_AddCat.csv and the "other" RDD is represented by J_AddDist.csv,then since "source" RDD has 13 distinct addresses, the size of the result of a left outer join is 13.]

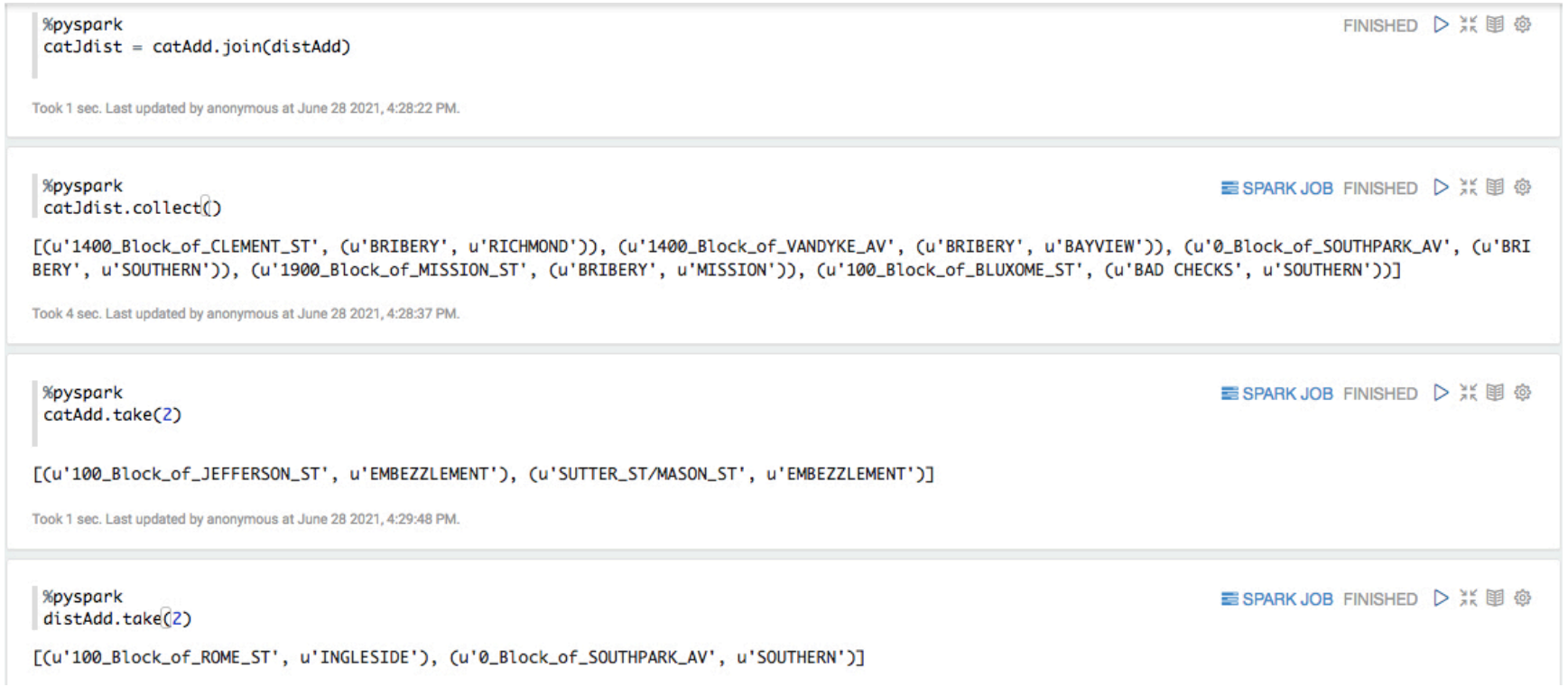
Load each dataset into separate pairRDDs with “address” being the key.

Note: once you load the text file, split on the “,” and then apply the `map` transformation to create a pairRDD where address is

```
# catAdd = sc.textFile("/Software/data/J_AddCat.csv").map(lambda x :
x.split(",")).map(lambda x : (x[1],x[0]))
# distAdd = sc.textFile("/Software/data/J_AddDist.csv").map(lambda x :
x.split(",")).map(lambda x : (x[1],x[0]))
catAdd.take(2)
distAdd.take(2)
```

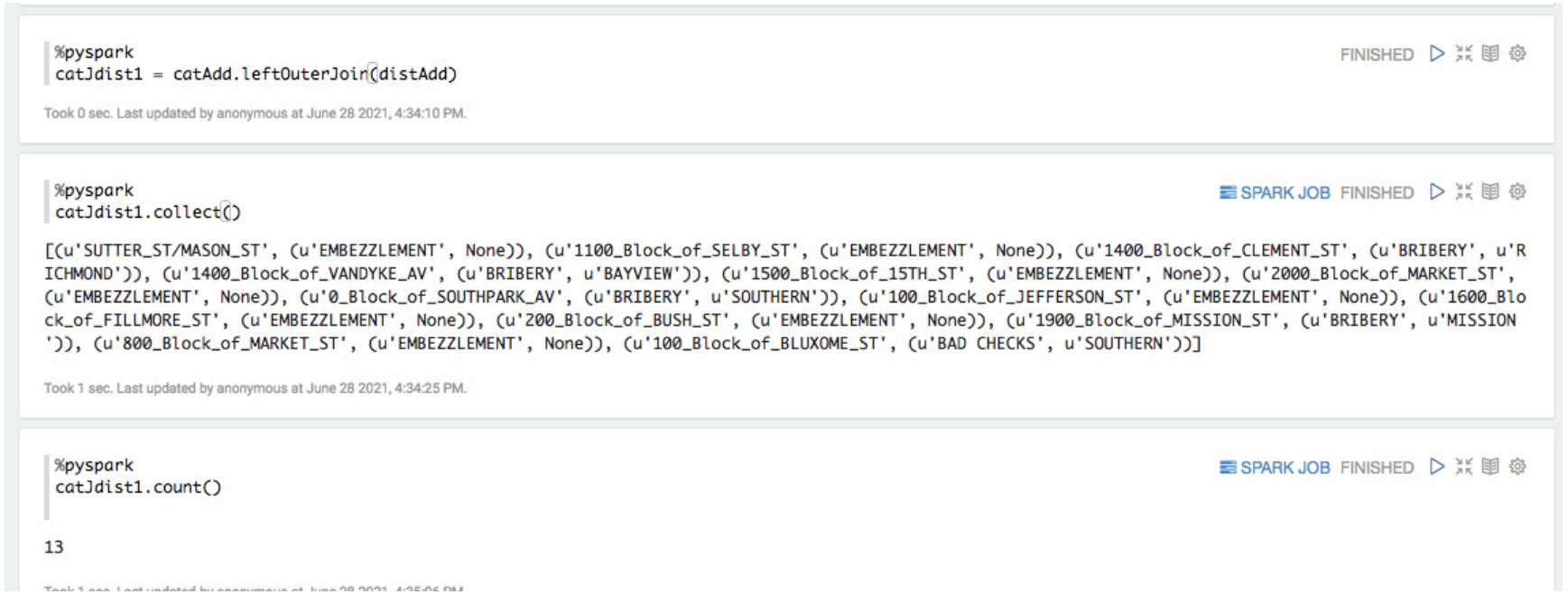
List the incident category and district for those addresses that have both category and district information. Verify that the size estimated earlier is correct.

```
catJdist = catAdd.join(distAdd)
catJdist.collect()
catJdist.count()
catJdist.take(5)
```



List the incident category and district for all addresses irrespective of whether each address has category and district information.

```
catJdist1 = catAdd.leftOuterJoin(distAdd)
catJdist1.collect()
catJdist1.count()
```



List the incident district and category for all addresses irrespective of whether each address has category and district information. Verify that the size estimated earlier is correct.

```
catJdist2 = catAdd.rightOuterJoin(distAdd)
catJdist2.collect()
catJdist2.count()
```

```
%pyspark
catJdist2 = catAdd.rightOuterJoin(distAdd)
```

FINISHED

Took 1 sec. Last updated by anonymous at June 28 2021, 4:35:26 PM.

```
%pyspark
catJdist2.collect()
```

SPARK JOB FINISHED

```
[(u'1400_Block_of_CLEMENT_ST', (u'BRIBERY', u'RICHMOND')), (u'0_Block_of_CHUMASERO_DR', (None, u'TARAVAL')), (u'1400_Block_of_VANDYKE_AV', (u'BRIBERY', u'BAYVIEW')), (u'0_Block_of_SOUTHPARK_AV', (u'BRIBERY', u'SOUTHERN')), (u'1100_Block_of_MISSION_ST', (None, u'SOUTHERN')), (u'1900_Block_of_MISSION_ST', (u'BRIBERY', u'MISSION')), (u'300_Block_of_BERRY_ST', (None, u'SOUTHERN')), (u'100_Block_of_ROME_ST', (None, u'INGLESIDE')), (u'100_Block_of_BLUXOME_ST', (u'BAD CHECKS', u'SOUTHERN'))]
```

Took 1 sec. Last updated by anonymous at June 28 2021, 4:35:40 PM.

```
%pyspark
catJdist2.count()
```

SPARK JOB FINISHED

```
9
```

Took 1 sec. Last updated by anonymous at June 28 2021, 4:35:48 PM.

Explore Partitioning

In this activity we see how to determine the number of partitions, the type of partitioner and how to specify partitions in a transformation.

Objective

- Explore partitioning in RDDs

Explore partitioning in RDDs

Note To find partition size: rdd.partitions.size (Scala); rdd.getNumPartitions() (in Python) To determine the partitioner: rdd.partitioner (Scala);

Note: Ensure that you have started the spark shell with --master local[*] (Refer the First Lab)

1. How many partitions are there in the sfpdRDD?
   ```
   sfpdRDD.getNumPartitions()
   ```
2. How do you find the type of partitioner for sfpdRDD?
   ```
   sfpdRDD.partitioner
   ```

```
%pyspark
sfpdRDD.getNumPartitions()
```

```
2
```

Took 0 sec. Last updated by anonymous at June 29 2021, 9:10:17 AM.

```
%pyspark
print(sfpdRDD.partitioner)
```

```
None
```

Took 0 sec. Last updated by anonymous at June 28 2021, 4:40:24 PM.

The above result will depend on the no of cores. In my case its 2 cores so 2.
If there is **no partitioner** the partitioning is not based upon characteristic of data but distribution is random and uniformed across nodes.

3. Create a pair RDD when only the length of the items is 14 per record that its 14 fields.

```
incByDists = sfpdRDD.filter(lambda rec : len(rec) == 14 ).map(lambda incident : (incident(6),1)).reduceByKey(lambda x,y : x+y)
```

How many partitions does incByDists have?

```
incByDists.getNumPartitions()
```

What type of partitioner does incByDists have?

```
print(incByDists.partitioner)
```

Q: Why does incByDists have that partitioner?

A: reduceByKey automatically uses the Hash Partitioner

By default PySpark implementation uses *hash partitioning* as the partitioning function.

```
%pyspark
incByDists.getNumPartitions()
```

```
2
```

Took 0 sec. Last updated by anonymous at June 29 2021, 9:18:33 AM.

```
%pyspark
print(incByDists.partitioner)
```

```
<pyspark.rdd.Partitioner object at 0x7f5acb8ac0d0>
```

Took 0 sec. Last updated by anonymous at June 29 2021, 9:24:51 AM.

4. Add a map

```
inc_map = incByDists.map(lambda (incidence, district) : (district,incidence))
```

How many partitions does inc_map have? `inc_map.getNumPartitions()`

What type of partitioner does incByDists have? `print(incByDists.partitioner)`

Q: Why does inc_map not have the same partitioner as its parent?

A: Transformations such as map() cause the new RDD to forget the parent's partitioning information because a map() can modify the key of each record.

```
%pyspark
inc_map = incByDists.map(lambda (incidence, district) : (district,incidence))
```

Took 0 sec. Last updated by anonymous at June 29 2021, 9:35:33 AM.

```
%pyspark
inc_map.getNumPartitions()
```

```
2
```

Took 0 sec. Last updated by anonymous at June 29 2021, 9:35:37 AM.

```
%pyspark
print(inc_map.partitioner)
```

```
None
```

Took 0 sec. Last updated by anonymous at June 29 2021, 9:36:06 AM.

5. Add groupByKey

```
inc_group = sfpdRDD.map(lambda incident: (incident[6],1)).groupByKey()
```

What type of partitioner does inc_group have?

```
inc_group.partitioner
```

Q: Why does inc_group have this type of partitioner?

A: This is because groupByKey will automatically result in a hash partitioned RDD..

```
%pyspark
inc_group = sfpdRDD.map(lambda incident: (incident[6],1)).groupByKey()
```

Took 1 sec. Last updated by anonymous at June 28 2021, 4:52:39 PM.

```
%pyspark
inc_group.partitioner
```

```
<pyspark.rdd.Partitioner object at 0x7f42a6f8d8d0>
```

Took 0 sec. Last updated by anonymous at June 28 2021, 4:55:45 PM.

6. Create two pairRDD

```
catAdd = sc.textFile("/Software/data/J_AddCat.csv").map(lambda x : x.split(",")).map(lambda x :(x[1],x[0]))
distAdd = sc.textFile("/Software/data/J_AddDist.csv").map(lambda x : x.split(",")).map(lambda x : (x[1],x[0]))
```

7. You can specify the number of partitions when you use the join operation.

```
catJdist = catAdd.join(distAdd,8)
```

How many partitions does the joined RDD have?

```
catJdist.getNumPartitions()
```

What type of partitioner does catJdist have?

```
catJdist.partitioner
```

```
%pyspark
catAdd = sc.textFile("/opt/data/J_AddCat.csv").map(lambda x : x.split(",")).map(lambda x :(x[1],x[0]))
distAdd = sc.textFile("/opt/data/J_AddDist.csv").map(lambda x : x.split(",")).map(lambda x : (x[1],x[0]))
```

Took 0 sec. Last updated by anonymous at June 28 2021, 4:58:42 PM.

```
%pyspark
catJdist = catAdd.join(distAdd,8)
```

Took 1 sec. Last updated by anonymous at June 28 2021, 4:59:02 PM.

```
%pyspark
catJdist.getNumPartitions()
```

```
8
```

Took 0 sec. Last updated by anonymous at June 28 2021, 4:59:35 PM.

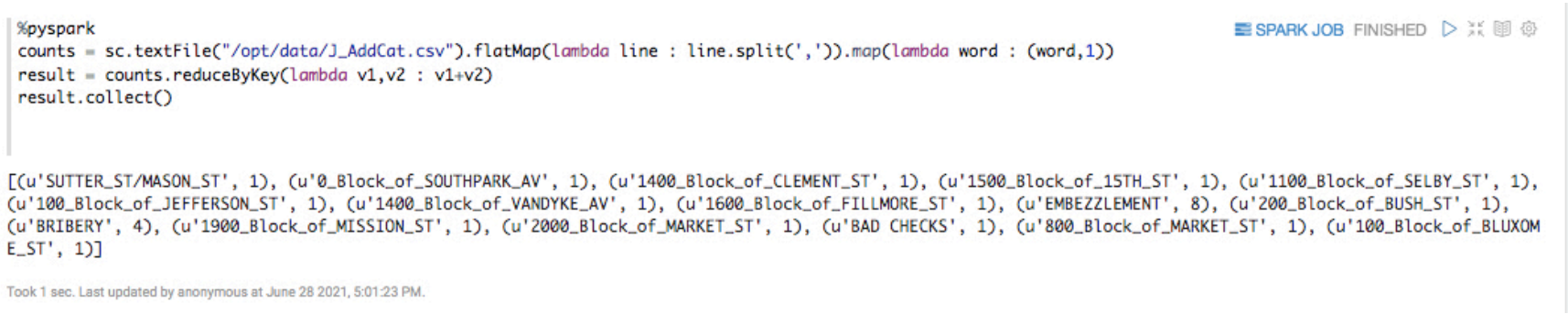
```
%pyspark
catJdist.partitioner
```

```
<pyspark.rdd.Partitioner object at 0x7f42a2454510>
```

Word Count Using Pair.

Finally, let us perform the word count application using the Pair data model.

```
counts = sc.textFile("/Software/data/J_AddCat.csv") \
      .flatMap(lambda line : line.split(',')) \
      .map(lambda word : (word,1))
result = counts.reduceByKey(lambda v1,v2 : v1+v2)
result.collect()
```



Errata: Lambda parameter errors. Sol – Remove the enclosing bracket.

```
>>> incByDists = sfpdRDD.filter(lambda rec : len(rec) == 14 ).map(lambda incident : (incident(6),1)).reduce
ByKey(lambda (x,y) : x+y)
  File "<stdin>", line 1
    incByDists = sfpdRDD.filter(lambda rec : len(rec) == 14 ).map(lambda incident : (incident(6),1)).reduce
ByKey(lambda (x,y) : x+y)
            ^
SyntaxError: invalid syntax
>>> incByDists = sfpdRDD.filter(lambda rec : len(rec) == 14 ).map(lambda incident : (incident(6),1)).reduce
ByKey(lambda x,y : x+y)
>>> incByDists.getNumPartitions()
2
>>> print(incByDists.partitioner)
```

---------- Lab Ends Here ----------

12. Explore Spark SQL – 45 Minutes

Spark SQL can convert an RDD of Row objects to a DataFrame, inferring the datatypes. Rows are constructed by passing a list of key/value pairs as kwargs to the Row class.

Copy the person.txt file to /Software/data/ folder.

```
Henry,42
Rajnita,40
Henderson,14
Tiraj,5
```

Open a terminal from /Software/data folder and enter the following command.

Using Spark SQL – RDD data structure. (Inferring the Schema Using Reflection)

```
#pyspark

Create an RDD of Person objects and register it as a table.

peopleL = sc.textFile("/Software/data/person.txt")
peopleL.take(4)

from pyspark.sql import Row
parts = peopleL.map(lambda l: l.split(","))
people = parts.map(lambda p: Row(name=p[0], age=int(p[1])))
```

```
# Infer the schema, and register the DataFrame as a table.
schemaPeople = spark.createDataFrame(people)
schemaPeople.createOrReplaceTempView("people")
```

SQL statements can be run by using the sql methods provided by sqlContext.

```
# SQL can be run over DataFrames that have been registered as a table.
kids = spark.sql("SELECT name FROM people WHERE age >= 1 AND age <= 9")
```

The results of SQL queries are DataFrames and support all the normal RDD operations.

```
# The results of SQL queries are Dataframe objects.
# rdd returns the content as an :class:`pyspark.RDD` of :class:`Row`.
kidNames = kids.rdd.map(lambda p: "Name: " + p.name).collect()
for name in kidNames:
    print(name)
```

In [1]:
```
peopleL = sc.textFile("/Software/data/person.txt")
peopleL.take(4)
```

Out[1]:
```
['Henry,42', 'Rajnita,40', 'Henderson,14', 'Tiraj,5']
```

In [2]:
```
parts = peopleL.map(lambda l: l.split(","))
people = parts.map(lambda p: Row(name=p[0], age=int(p[1])))
```

In [4]:
```
from pyspark.sql import Row
```

In [5]:
```
# Infer the schema, and register the DataFrame as a table.
schemaPeople = spark.createDataFrame(people)
schemaPeople.createOrReplaceTempView("people")
```

In [6]:
```
# SQL can be run over DataFrames that have been registered as a table.
kids = spark.sql("SELECT name FROM people WHERE age >= 1 AND age <= 9")
```

In [8]:
```
# The results of SQL queries are Dataframe objects.
# rdd returns the content as an :class:`pyspark.RDD` of :class:`Row`.
kidNames = kids.rdd.map(lambda p: "Name: " + p.name).collect()
for name in kidNames:
    print(name)
```

```
Name: Tiraj
```

Create a temporary view:

```
# Register the DataFrame as a SQL temporary view
schemaPeople.createTempView("kids")
```

Display the output.

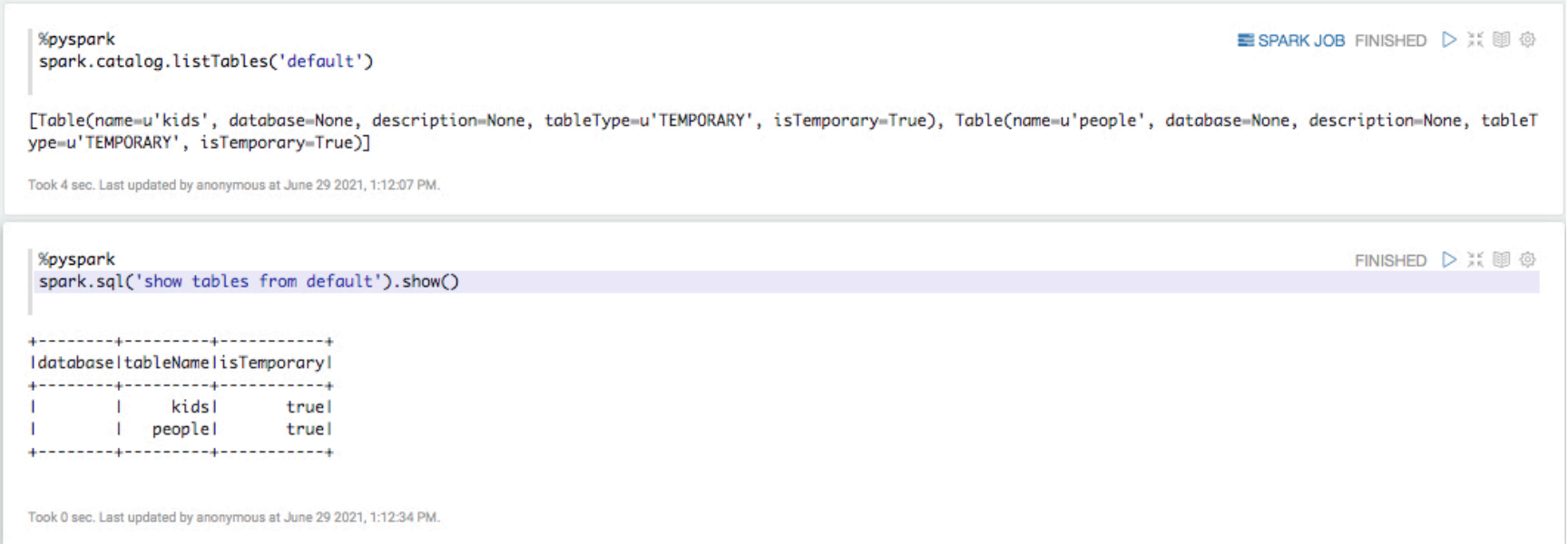
```
spark.sql("select * from kids").show()
```

Show the Tables or View List.

spark.catalog.listTables('default')

or

spark.sql('show tables from default').show()



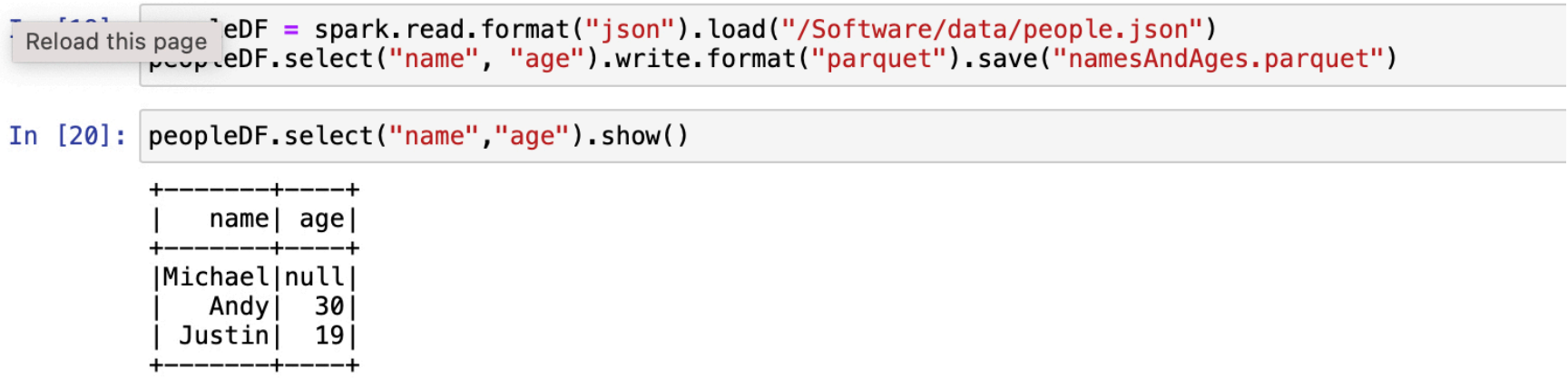
Using DataFrame and SQL:

/Software/data/people.json

```
{"name":"Michael"}
{"name":"Andy", "age":30}
{"name":"Justin", "age":19}
```

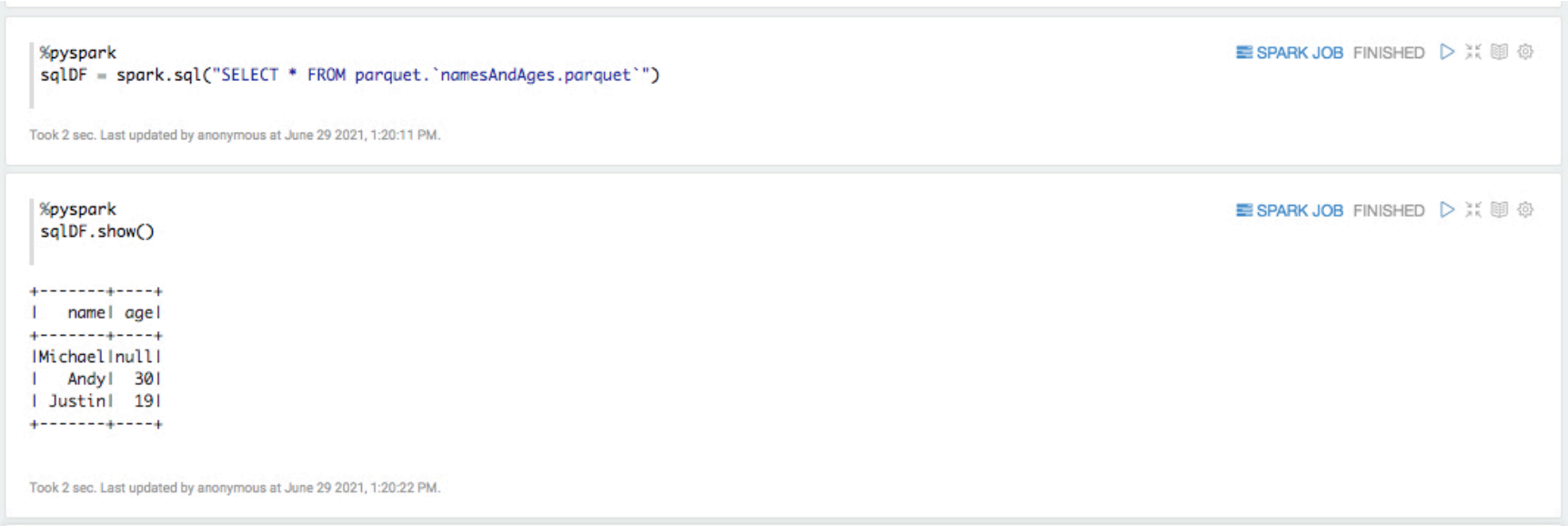
Load the JSON file and store it as a parquet file

```
peopleDF = spark.read.format("json").load("/Software/data/people.json")
peopleDF.select("name", "age").write.format("parquet").save("namesAndAges.parquet")
peopleDF.select("name","age").show
```



With a parquet file, it can Query directly with SQL.

```
sqlDF = spark.sql("SELECT * FROM parquet.`namesAndAges.parquet`")
sqlDF.show()
```



Perform some operations on the Dataframe.

In Python, it's possible to access a DataFrame's columns either by attribute (`df.age`) or by indexing (`df['age']`).

```
#convert the people RDD to Dataframe
df = people.toDF()

# Select everybody, but increment the age by 1
df.select(df['name'], df['age'] + 1).show()

# Select people older than 21
df.filter(df['age'] > 21).show()

# Count people by age
df.groupBy("age").count().show()
```

```
%pyspark
#convert the people RDD to Dataframe
df = people.toDF()
```

Took 0 sec. Last updated by anonymous at June 29 2021, 1:23:13 PM. (outdated)

```
%pyspark
df.select(df['name'], df['age'] + 1).show()
```

```
+---------+---------+
|     name|(age + 1)|
+---------+---------+
|    Henry|       43|
|  Rajnita|       41|
|Henderson|       15|
|    Tiraj|        6|
+---------+---------+
```

Took 1 sec. Last updated by anonymous at June 29 2021, 1:23:24 PM.

```
%pyspark
df.filter(df['age'] > 21).show()
```

```
+---+-------+
|age|   name|
+---+-------+
| 42|  Henry|
| 40|Rajnita|
+---+-------+
```

```
%pyspark
df.groupBy("age").count().show()
```

```
+---+-----+
|age|count|
+---+-----+
|  5|    1|
| 14|    1|
| 42|    1|
| 40|    1|
+---+-----+
```

Took 11 sec. Last updated by anonymous at June 29 2021, 1:23:57 PM.

Using aggregrate functions:

Determine the max and min age.

spark.sql("select min(age) from kids ").show()

spark.sql("select max(age) from kids ").show()

```
%pyspark
spark.sql("select min(age) from kids ").show()
```

```
+--------+
|min(age)|
+--------+
|       5|
+--------+
```

Took 1 sec. Last updated by anonymous at June 29 2021, 2:01:51 PM.

```
%pyspark
spark.sql("select max(age) from kids ").show()
```

```
+--------+
|max(age)|
+--------+
|      42|
+--------+
```

Took 1 sec. Last updated by anonymous at June 29 2021, 2:02:16 PM.

---------- **Lab Ends Here** ----------

13. Explore Pyspark Applications – 30 Minutes

In this lab, let us develop a python application and submit to Spark for execution. Ensure that you have created a folder /opt/code/pyspark for storing all the python code inside it.

Let us create a simple Spark application, SimpleApp.py:

```
"""SimpleApp.py"""
from pyspark import SparkContext

logFile = "/opt/spark/README.md"  # Should be some file on your system
sc = SparkContext("local", "Simple App")
logData = sc.textFile(logFile).cache()

numAs = logData.filter(lambda s: 'a' in s).count()
numBs = logData.filter(lambda s: 'b' in s).count()

print("Lines with a: %i, lines with b: %i" % (numAs, numBs))

sc.stop()
```

This program just counts the number of lines containing ‘a’ and the number containing ‘b’ in a text file. Note that you’ll need to replace YOUR_SPARK_HOME /logFile with the location where Spark is installed in your machine.

We can run this application using the bin/spark-submit script:

Use spark-submit to run your application, change directory to /spark before executing the following command

$ spark-submit --master local[2] SimpleApp.py

```
[root@localhost spark]# ./spark-2.1.0/bin/spark-submit --master local[2] workspa
ce/SimpleApp.py
Using Spark's default log4j profile: org/apache/spark/log4j-defaults.properties
17/04/14 09:30:52 WARN Utils: Your hostname, localhost.localdomain resolves to a
 loopback address: 127.0.0.1; using 192.168.150.128 instead (on interface eth0)
17/04/14 09:30:52 WARN Utils: Set SPARK_LOCAL_IP if you need to bind to another
address
```

You can view the job status with the following URl

http://localhost:4040/jobs/

```
 649 ms on localhost (executor driver) (1/1)
17/04/14 09:32:21 INFO TaskSchedulerImpl: Removed TaskSet 1.0, whose tasks have
all completed, from pool
Lines with a: 62, lines with b: 30
17/04/14 09:32:22 INFO SparkUI: Stopped Spark web UI at http://192.168.150.128:4
040
```

In this way, you can deploy any python application in the spark cluster.

---------- Lab Ends Here ----------

14. Install Jupyter for Spark – 35 Minutes.(D)

You can install Jupyter using pip or anaconda.

Using pip – We will use this for our lab.

```
#yum install epel-release
```

Install python 3.8 first. Skip this if done before.

```
#yum install python3.8 pr 3.9
```

Install pip tools as follow:

```
#yum install wget
#wget https://bootstrap.pypa.io/get-pip.py
#python3.8 get-pip.py
```

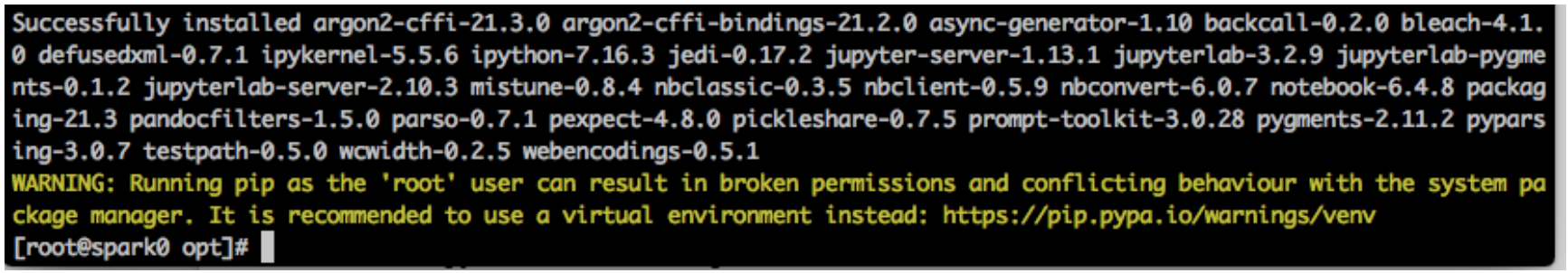
Any issue refer the following for installation steps.

https://pip.pypa.io/en/stable/installation/

Install required dependencies libraries

```
# yum install -y python38 python38-devel

#pip3.8 install --upgrade setuptools
```

```
#pip3.8 install --upgrade pip3.8
#pip3.8 install jupyterlab
#pip3.8 install jupyter
```



Start Jupyter in the different port.

```
#jupyter notebook --generate-config
```

[Writing default config to: /root/.jupyter/jupyter_notebook_config.py]

Update the following properties.
Look for the following entries in the file, uncomment the line and update in the same line only.

```
#vi ~/.jupyter/jupyter_notebook_config.py
```

```
c.ServerApp.ip = 'spark0'
```

```
c.ServerApp.open_browser = False
c.ServerApp.allow_remote_access = True
c.ServerApp.allow_root = True
```

All the configuration above should be left most align.
If you want to update the port no.

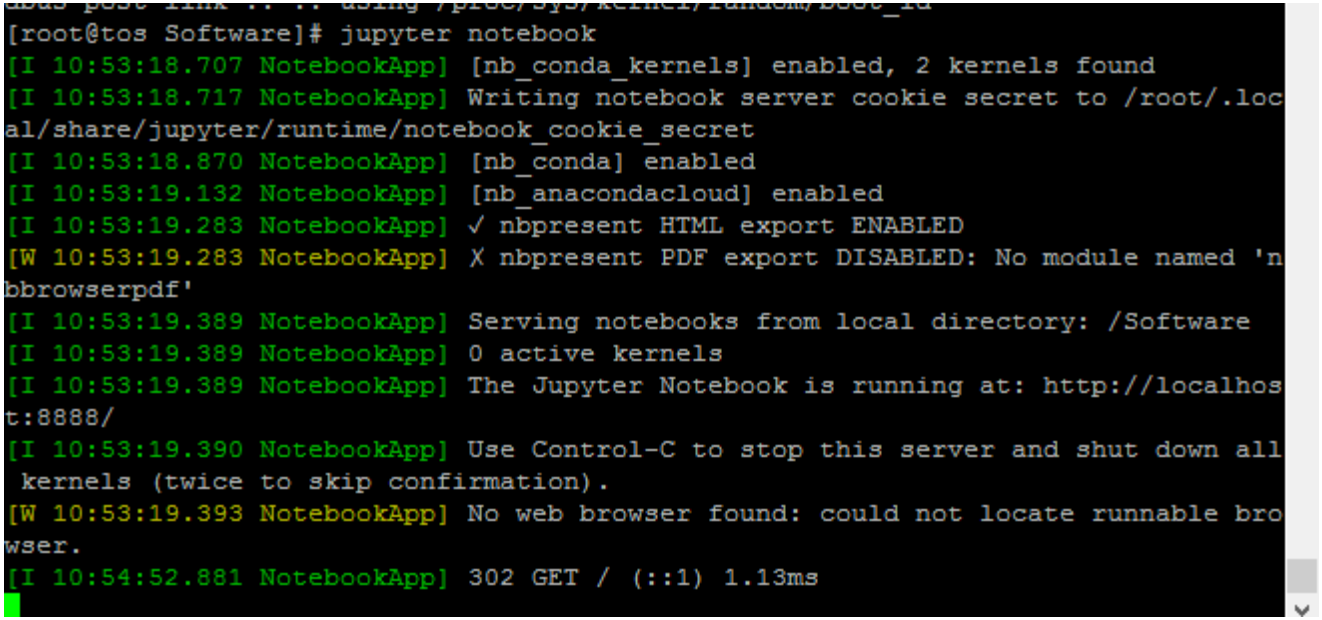
```
c.ServerApp.port = 8888
```

```
## The port the notebook server will listen on (env: JUPYTER_PORT).
#  Default: 8888
 c.NotebookApp.port = 8200
```

Start with config parameter.

```
#jupyter lab
```

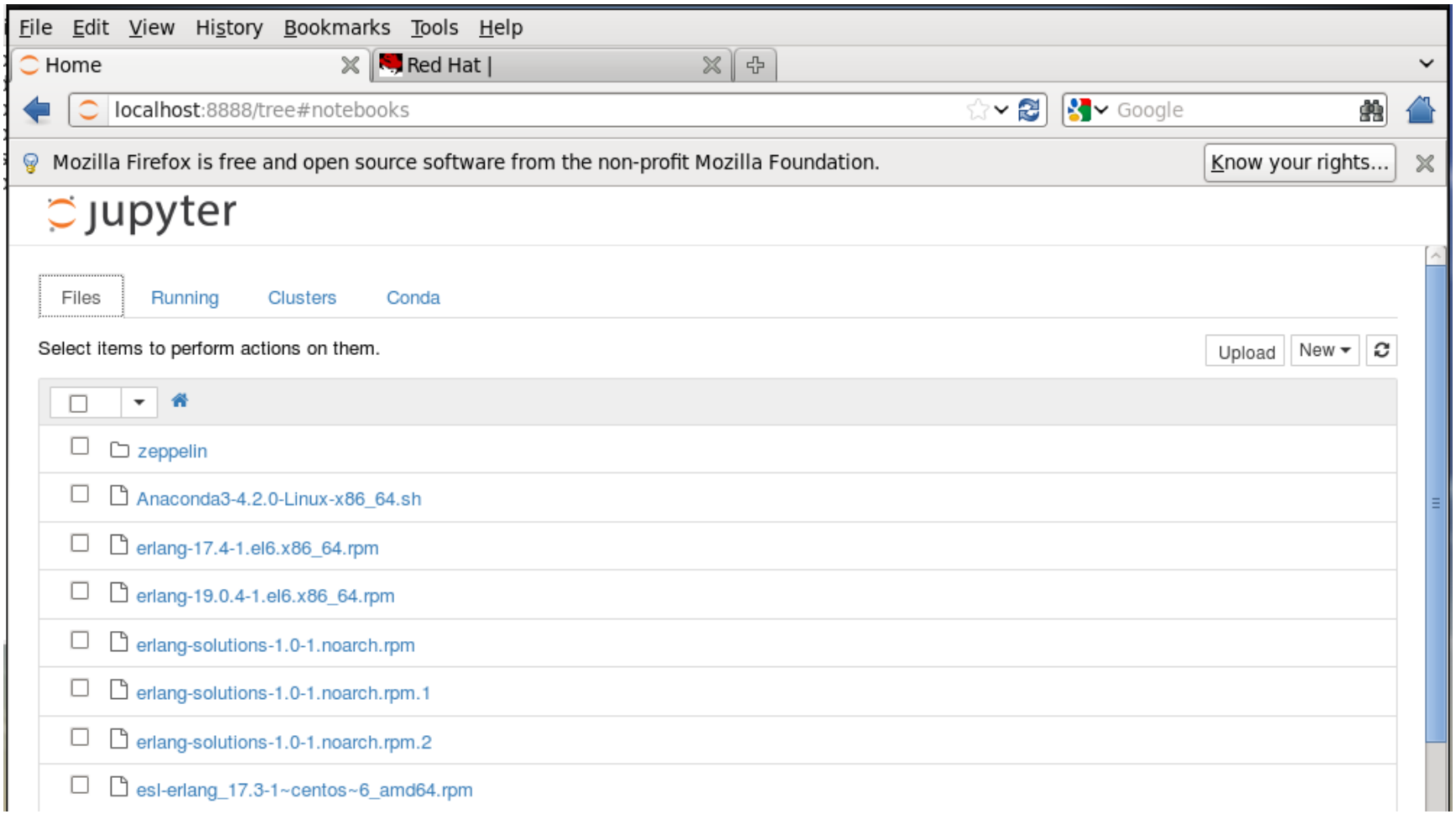
Copy the URL in the web browser.



Use the following if unable to configure the above configuration

Else skip

```
#jupyter lab --ServerApp.port=8080 --allow-root  --
ServerApp.allow_remote_access=True
```


File Edit View History Bookmarks Tools Help
Home
Red Hat |
localhost:8888/tree#notebooks
Google
Mozilla Firefox is free and open source software from the non-profit Mozilla Foundation.
Know your rights...
jupyter
Files
Running
Clusters
Conda
Select items to perform actions on them.
Upload
New
zeppelin
Anaconda3-4.2.0-Linux-x86_64.sh
erlang-17.4-1.el6.x86_64.rpm
erlang-19.0.4-1.el6.x86_64.rpm
erlang-solutions-1.0-1.noarch.rpm
erlang-solutions-1.0-1.noarch.rpm.1
erlang-solutions-1.0-1.noarch.rpm.2
esl-erlang_17.3-1~centos~6_amd64.rpm

Let us configure Notebook for Pyspark.

Update PySpark driver environment variables: add these lines to your **~/.bashrc** (or **~/.zshrc**) file.

```
export PYSPARK_PYTHON=python3.8
export PYSPARK_DRIVER_PYTHON=jupyter
export PYSPARK_DRIVER_PYTHON_OPTS='lab'
```

Restart your terminal and launch PySpark again:

```
$ pyspark
```

Now, this command should start a Jupyter Notebook in your web browser. Create a new notebook by clicking on 'New' > 'Notebooks Python [default]'.
Copy and paste Pi calculation script and run it by pressing Shift + Enter.

// Code Begin

```
import random
num_samples = 100000000

def inside(p):
  x, y = random.random(), random.random()
  return x*x + y*y < 1

count = sc.parallelize(range(0, num_samples)).filter(inside).count()

pi = 4 * count / num_samples
print(pi)

sc.stop()
```

// Code Ends.

```
In [1]: import random
num_samples = 100000000

def inside(p):
  x, y = random.random(), random.random()
  return x*x + y*y < 1

count = sc.parallelize(range(0, num_samples)).filter(inside).count()

pi = 4 * count / num_samples
print(pi)

sc.stop()
```

```
3.14156176
```

You have successfully configured pyspark on Jupyter.

Add the following in the bash profile and open jupyter with pnotebook for integrating hive commands with Jupyter.

#Required for pyspark+kafka+hive integration.

```
alias pnotebook='pyspark --packages org.apache.spark:spark-sql-kafka-0-10_2.12:3.3.0,org.apache.spark:spark-streaming-kafka-0-10_2.12:3.3.0
 --conf spark.sql.catalogImplementation=hive'
```