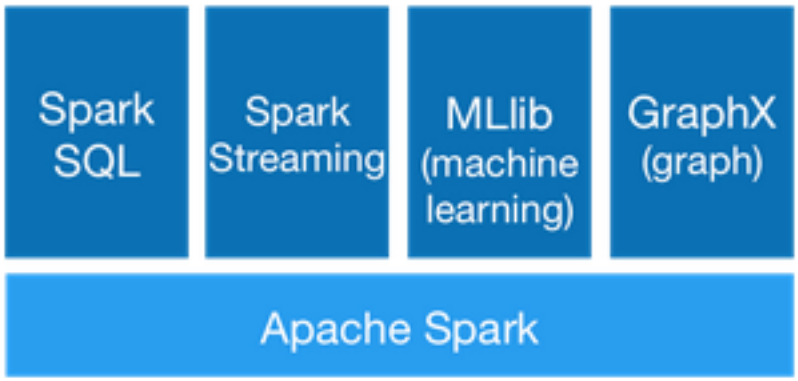
MIDS W205

Lab #	6	Lab Title	An Introduction to Apache Spark and Spark SQL.
Related Module(s)	6	Goal	Get you started on Spark, Pyspark, and Spark SQL
Last Updated	9/29/15	Expected duration	60-90 minutes

Introduction

Apache Spark is an open source distributed computing framework. Spark uses in-memory processing and can in some situations be up to 100 times faster than regular Hadoop MapReduce. The core of the Spark architecture is the concept of RDDs. You should read about them and why they enable scale and resiliency in a distributed environment with unreliable nodes.

Apache Spark has a basic computing substrate and several frameworks built on top of it. There is a framework for querying structured data (Spark SQL), an analytics framework for microbatching (they call it streaming), a machine-learning framework, and so on. In this lab you will be learning about basic RDDs as well as about Spark SQL.



Spark SQL assumes that data are structured according to a relational model, which enables us to use SQL to query the data. It provides a programming abstraction based on what is called DataFrames. Spark SQL acts as a distributed SQL query engine.

Spark can be used with several different programming languages. We will be using Python as our preferred way of interacting with Spark. Spark is commonly utilized in a programmatic way. There are also command-line interfaces (CLIs) that provide convenient ways of interactively using RDDs. In this lab we will use both.

Instructions, Resources, and Prerequisites

You can perform this lab on one of the course-provided AMIs, but you need to have Hadoop set up properly. Follow the instructions provided in other sections of the course. You can also perform it on another computer, such as your laptop, by installing Spark from the link in the table below.

Since the AMIs use CDH 5.4.5 and Spark SQL is not officially supported on that version, you may encounter problems with the CLI portion of the lab. If you have problems, you can skip the Spark SQL CLI portion (Step 5 and Step 6), but you still need to try the programmatic way of using Spark SQL shown in Step 7.

Resource	**What**
Spark download (for your own installation)	http://spark.apache.org/downloads.html
http://spark.apache.org/docs/latest/programming-guide.html	This guide shows each of the features in each of Spark's supported languages. It is easiest to follow if you launch Spark's interactive shell. This guide includes references to the basic commands you can perform on RDDs, such as filter records, count records, and join of datasets.
https://spark.apache.org/docs/1.1.0/sql-programming-guide.html	Guide for using Spark SQL programmatically.
https://spark.apache.org/docs/latest/sql-programming-guide.html#running-the-spark-sql-cli	Guide to Spark SQL CLI Shell.
https://spark.apache.org/docs/0.9.0/python-programming-guide.html	Python Spark programming guide. For operations on RDD's see the Scala programming guide.
https://spark.apache.org/docs/0.9.0/scala-programming-guide.html	This is the scala programming guide. Look here for transformations and actions on Spark RDD's.
http://spark.apache.org/docs/latest/api/scala/index.html#org.apache.spark.SparkContext	Programming guide for the Spark Context object. Here you can find actions available on the Spark Contexts.

Step 0. Check Installation and Prepare Data

In this section we will help you understand the basics of your Spark installation. We will also help you download and assemble a dataset we will use later in the lab. Downloading the dataset takes a couple of steps because it is reasonably large and stored in GitHub. GitHub has limitations on file size, so we

needed to split the dataset into manageable chunks to upload it. Your instructor may provide you with an alternative way of getting the same dataset.

First, if an example starts with the "$" prompt, it is run in the Linux shell. If it starts with the ">>>" prompt, it is run in `pyspark` shell.

Echo your `SPARK_HOME` environment variable to see where your Spark is installed.

```
$ echo $SPARK_HOME
```

You should see something like the below. Observe that this may differ depending on were you are running this lab.

```
$ echo $SPARK_HOME
/user/lib/spark
```

Navigate to that directory, and examine the contents.

```
$ cd $SPARK_HOME
$ ls
CHANGES.txt    NOTICE    README.md bin  data ec2  lib
python
LICENSE   R         RELEASE   conf derby.log examples  old
sbin
```

If you look in `bin` you will see `spark-shell`, `pyspark`, and other tools for running and managing Spark.

In your shell profile (often `.bash_profile`), you may see the following lines that indicate that the Spark commands are in your shell execution path.

```
export SPARK=/usr/lib/spark
export SPARK_HOME=$SPARK
export PATH=$SPARK/bin:$PATH
```

You can confirm that your shell can find them by running the Unix/Linux `that` command.

```
$ which spark-shell
$ which pyspark
$ which spark-sql
```

If your shell cannot find any of those programs, you will likely need to check your installation. If it can find the commands, it will return the location of the programs.

We will be using two different datasets in this lab. One is a weblog dataset; the other is a dataset with historic crime data from 2001 for the Chicago area. If you have time to play around with the dataset, it is interesting to explore types of crimes, density of crimes, and so forth. For this lab you can use any substantial data file as a replacement for `"Crimes_-_2001_to_present.csv"`, but you need to modify the commands accordingly. You can download the `"Crimes_-_2001_to_present.csv"` file from GitHub. Because it is a large file, we had to compress and split the file when we uploaded it to GitHub. Therefore, you will need to merge the parts and uncompress the result.

The instructors may have the files more easily accessible for you if you have problems with the procedure below.

Retrieve the files from this directory on GitHub: https://github.com/UC-Berkeley-I-School/w205-labs-exercises/tree/master/data/Crimes_-_2001_to_present_data

You can retrieve them by cloning the exercise repository, if you have already done so, us a `git pull` to update. A clone would look like the following.

```
git clone https://github.com/UC-Berkeley-I-School/w205-labs-exercises.git
```

The files are in the `data/Crimes_-_2001_to_present_data` directory.

Once you have the files (there should be seven of them, all starting with the letter *x*), run the following commands (make sure you do not have other files starting with *x* in the directory). The first one will concatenate the split files into one file. The original file was a compressed CSV file, so we name it appropriately. Next we uncompress it to get the original CSV file.

```
$ cat x* > Crimes_-_2001_to_present.csv.gz
$ gunzip Crimes_-_2001_to_present.csv.gz
```

The result should be that you have the Crime data CSV file in your directory. You also still have the original split files. If you run `ls` it should look something like this:

```
$ ls
Crimes_-_2001_to_present.csv  xac            xaf
xaa                 xad                xag
```

```
xab                    xae
```

You can check the correctness of the resulting files by checking the file size or the number of rows in the file. The size may vary on different computers, but the number of lines should remain the same.

```
$ du -s Crimes_-_2001_to_present.csv
     2688712   Crimes_-_2001_to_present.csv
$ wc -l Crimes_-_2001_to_present.csv
     5862796 Crimes_-_2001_to_present.csv
```

You could remove the split files using `rm`, but it is better to use the `–i` option so that you do not accidentally remove other files in the directory that you want to save.

```
$ rm -i x*
```

At this point you should be able to see the Crime data file in your directory.

```
$ ls
     Crimes_-_2001_to_present.csv
```

Now you are good to go. In addition, you can also try some useful Linux/Unix commands such as `du`, `wc`, and `cat`.

What You Should Have Learned

You should have learned the basic installation of Spark. You have also verified that the Spark programs can be found by your interactive Linux (Unix) shell.

Step 1. Start `pyspark`

First we will start a Spark shell so that we can access Spark and interactively process Spark commands. We will be using `pyspark`, which is a Python-based shell for Spark.

Assuming you have the Spark bin directory in your `PATH` environment variable, you can start `pyspark` by issuing the following command:

```
$pyspark
```

Otherwise go to the `/bin` directory in the installation (`$SPARK_HOME`) folder and type the following:

```
$./pyspark
```

In the `pyspark` shell you can use Python instructions and create RDDs. You can also apply operations on RDDs. Create a Python variable with some value using the following command (this is plain old Python):

```
>>> x = [1,2,3,4,5,6,7,8,9];
>>> print x
[1, 2, 3, 4, 5, 6, 7, 8, 9]
>>> len(x)
9
```

A Spark context is the "object" you use to refer to the Spark cluster. Type `sc` to verify you have one already in your Python shell:

```
>>> sc
<pyspark.context.SparkContext object at 0x1063b3410>
```

So far you have used only Python statements and checked that you have a Spark context. You can use the Spark context to create a Spark RDD from Python data using the command `parallelize`.

```
>>> distData = sc.parallelize(x);
>>> print distData;
ParallelCollectionRDD[0] at parallelize at
PythonRDD.scala:391
```

The Spark context `parallelize` action is used to take local programming collections and create RDDs from them. In this case, we created a RDD from a Python array.

The resulting value of the `distData` variable is an RDD representation. Try running `len(distData)`; what happens, and why? To count elements in an RDD you need to use RDD actions. You can find a list of available actions in the programming guide. To count the elements, you use the `count()` action. Try the following:

```
>>> nx=distData.count()
>>> print nx
9
```

As you probably noticed, the default level of logging can be distracting. To reduce the volume of logging information, go to the `$SPARK_HOME/conf` directory. Sometimes this directory is stored in another location. If you are using one of our AMIs, look in the `/usr/lib/spark/conf/` directory. Create a `log4j.properties` file. If you do not already have one, you can get one by copying the `log4j.properties.template` file. To set the logging level to warnings (`WARN`), change `INFO` to `WARN` in the property `log4j.rootCategory=WARN` console.

```
# Set everything to be logged to the console
log4j.rootCategory=WARN, console
log4j.appender.console=org.apache.log4j.ConsoleAppender
log4j.appender.console.target=System.err
log4j.appender.console.layout=org.apache.log4j.PatternLayou
t
```

Restart `pyspark`, and rerun the commands above. You should see much less output in the Spark shell.

What You Should Have Learned

You should understand how to start `pyspark`. You also learned that `pyspark` is a shell with access to the Python language and to the underlying Spark cluster capabilities. We also showed you how to make `pyspark` less verbose by reducing the amount of logging displayed. If you have problems, you may consider increasing logging again to understand what is going on in your execution.

Step 2. Load a File and Count the Rows

Spark is commonly used to process large sets of data, and naturally we often read these data files from disk. The action `textFile` is an operation on Spark contexts that creates a RDD from a file that resides in HDFS or the local file system. Make sure you cloned the data file `Crimes_-_2001_to_present.csv` in the lab directory (assuming you are using the directory "`/data/mylab`"). Now create an RDD from that file using the following action:

```
crimedata =sc.textFile("file:///data/mylab/Crimes_-
_2001_to_present.csv")
```

If you run the AIM, you can copy the data to HDFS and have `pyspark` get the file from there.

Print the number of lines in this RDD using the following command:

```
>>> print crimedata.count()
5862796
>>>
```

As you can see there are almost 6 million records, so it took a few seconds to count them.

You can get the first element of the RDD with the `first` operation:

```
>>> crimedata.first()
```

You can get the *n* first elements with the operation `take(n)`:

```
>>> crimedata.take(10)
```

As you see the data include the header information. Removing the header from the RDD is not straightforward because the RDD is immutable by design. One way to remove the header is to create a new RDD and to filter out the first row. An example of one of the many ways to do this follows:

```
>>> noHeaderCrimedata =
crimedata.zipWithIndex().filter(lambda (row,index): index >
0).keys()
```

It is a quite a processing-heavy way of doing it, but as we mentioned, RDDs are immutable. You cannot just go in and remove a record. This is an inherent characteristic of Spark, which allows it to do certain things more efficiently.

Print the first line to verify that the header is gone, and count the lines to ensure the number seems correct.

```
>>> noHeaderCrimedata.first()
>>> noHeaderCrimedata.count()
```

Here is a more Python-like way of doing the same task that may be easier to understand. We first define a Python function in our Python Spark shell using the following line:

```
 >>> def remove_header(itr_index, itr): return
iter(list(itr)[1:]) if itr_index == 0 else itr
```

We then execute a `mapPartitionWithIndex` operation, passing that function as an argument.

```
     >>> noHeaderCrimeData2 =
crimedata.mapPartitionsWithIndex(remove_header)
```

Print the first line and the count to make sure they are correct.

What You Should Have Learned

You should understand how to create an RDD from a file and how apply operations on the RDD. You used examples such as `first` and `count`. We also illustrated that RDDs are immutable and that even to remove one row (the header) you need to create a new RDD.

Step 3. Filter Records and Structures

One obvious operation for Spark is to filter the data. Let's filter out all crimes that seem to be related to `NARCOTICS`.

We can do this using the filter operation and a lambda function that checks for the word "`NARCOTICS`" in each row. We will return only rows that included that word.

```
     narcoticsCrimes = noHeaderCrimedata.filter(lambda x:
"NARCOTICS" in x)
     >>> narcoticsCrimes.count()
     663712
```

It appears that 663,712 crimes are related to narcotics. Use `take(n)` to check that the data seems good. For example:

```
     >>> narcoticsCrimes.take(20)
```

The RDD we have is just long strings. The fact that fields are comma separated does not mean anything to the Spark RDD. If we want to perform more advanced computations and manipulations, we need to parse the rows and create the appropriate structure for our data. The following operation splits each record as an array using the Python operation `split`. It then creates a new RDD where each row is an array of strings as opposed to one long string.

```
     >>> narcoticsCrimeRecords = narcoticsCrimes.map(lambda r :
r.split(","))
```

You can see the first array record using

```
>>> narcoticsCrimeRecords.first()
```

You can verify that you still have the same number of rows using

```
>>> narcoticsCrimeRecords.count()
```

What You Should Have Learned

You should understand that RDDs are immutable. You can filter RDDs, but doing so creates a new RDD. You should also understand that RDDs do not understand anything about the structure of the records (except for key value structures, which we discuss in the next section). But you can store any Python structure that seems useful in an RDD.

Step 4. Key Values

An important structure in Spark is called a key value pair. In Python these are represented as Python tuples. A tuple is an immutable sequence of elements of various types.

You can create a new RDD consisting of tuples using the following operation:

```
>>> narcoticsCrimeTuples = narcoticsCrimes.map(lambda x:
(x.split(",")[0], x))
```

You can check that the number of tuples is the same as the number of records in the data.

```
>>> narcoticsCrimeTuples.count()
```

This operation takes the first element and makes it a key, and the rest of the row becomes the value part of the tuple. You can examine the tuple using the following operation:

```
>>> narcoticsCrimeTuples.first()
```

And you can check it out using these RDD and Python functions.
Get the first tuple:

```
>>> firstTuple=narcoticsCrimeTuples.first()
```

How many elements do you have in the tuple?

```
>>> len(firstTuple)
```

What is the key of the first tuple?

```
>>> firstTuple[0]
```

What is the value of the first tuple?

```
>>> firstTuple[1]
```

There is one little problem with the tuple. Can you spot it? How should we change the map and lambda functions above to address that?

You can perform many operations once you have a key value tuple. You can join, reduce, map, and so on. You can read about the operations in the *RDD Spark Programming Guide*. One operation you can do is to sort by key:

```
>>> sorted=narcoticsCrimeTuples.sortByKey()
```

If you print the first element in the sorted RDD and the original RDD, you will see they are different.

```
>>> sorted.first()
```

```
>>> narcoticsCrimeTuples.first()
```

SUBMISSION 1: Submit the first 10 rows of the unsorted and the sorted RDD to show that you successfully created both. Also explain the issue with the tuple and how to possibly correct it in the map/lambda function that was used to create the tuples.

What You Should Have Learned

Now you should understand the concept of key value tuples and how you can create them. You have also tried one operation on RDDs using the key value structure.

Step 5. Start Spark SQL

***Important**: You can skip this step if you run on an AMI that does not have appropriate support for Spark SQL. If you have a later version of Spark with Hadoop installed on your computer, you should be able to run this. You can also try the steps to install a complete Spark/Hadoop per instructions on the troubleshooting section. Proceed to Step 7 to learn about Spark SQL API.*

Spark SQL can be used directly from `pyspark` or a `scala` shell. But there is also a Spark SQL CLI called the Beeline client. If you use `pyspark` or use Spark SQL programmatically, you need create a special Spark SQL context. With the Spark SQL CLI, the context is already there for you and you can use SQL commands.

You start Beeline with the following command:

```
$spark-sql
```

Once started you can run some commands to ensure that it works. Show tables, create a table, and drop the table by running the next commands:

```
spark-sql> show tables;

spark-sql> create table dummy (somedata varchar(500));
OK
Time taken: 0.369 seconds

spark-sql> show tables;
dummy     false
Time taken: 0.053 seconds, Fetched 1 row(s)

spark-sql> drop table dummy;

spark-sql> show tables;
```

What You Should Have Learned

You should understand the difference between using the Spark SQL CLI and using Spark SQL programmatically. You are able to start Spark SQL CLI and issue some basic commands to see that it works.

Step 6. Spark SQL Table Loaded With Data From a CSV file

***Important**: You can skip this step if you run on an AMI that does not have appropriate support for Spark SQL. If you have a later version of Spark with Hadoop installed on your computer, you should be able to run this. You can also try the steps to install a complete Spark/Hadoop per instructions on the troubleshooting section. Proceed to Step 7 to learn about Spark SQL API.*

You can create a Spark SQL table. The following `create` statement creates a table that has a schema that corresponds to the `web_session_log` data. Run the following `create` statement directly on the `spark-sql` shell prompt:

```
create table Web_Session_Log
(DATETIME varchar(500),
USERID varchar(500),
SESSIONID varchar(500),
PRODUCTID varchar(500),
REFERERURL varchar(500))
row format delimited fields terminated by '\t'
stored as textfile;
```

You can load files from the local files system or from HDFS. Let's load weblog data available on GitHub.

Run the `describe` command to see that it was created correctly. If it was not, you may need to drop it and try again correcting any mistakes.

```
spark-sql> describe web_session_log;
datetime  varchar(500)   NULL
userid    varchar(500)   NULL
sessionid varchar(500)   NULL
productid varchar(500)   NULL
refererurl     varchar(500)   NULL
Time taken: 0.083 seconds, Fetched 5 row(s)
```

Assuming you have the weblog data in the directory where you are running the `spark-sql` shell, you can load the file from the file system into the table using the command below. If the file is located somewhere else, you need to modify the path to the file.

```
spark-sql> LOAD DATA LOCAL INPATH "./weblog_lab.csv" INTO
TABLE web_session_log;
```

Once the data are loaded you can count the number of rows using the following `select` statement:

```
spark-sql> select count(*) from web_session_log;
```

You can check that this count seems reasonable by comparing it with the number of rows in the original file. You can get the number of files using the Unix/Linux command `wc`.

```
$ wc -l weblog_lab.csv
```

Using Spark SQL you can use a number of SQL commands to query your data. Let's select all rows in the weblog that are related to eBay.

```
spark-sql> select * from web_session_log where refererurl =
"http://www.ebay.com" ;
```

And now let's count the number of rows that are related to eBay.

```
spark-sql> select count(*) from web_session_log where
refererurl = "http://www.ebay.com" ;
```

What You Should Have Learned

In this section you should have learned how to create a table in the Spark SQL CLI and how to load data into the empty table. You also practiced some simple SQL commands on the loaded dataset.

Step 7. Accessing Spark SQL in Python Code

Spark SQL can be used from a program or directly from a shell such as `pyspark`. Using a shell requires that you create the appropriate Spark context and programmatically define schemas and such. A table is ultimately represented as a Spark DataFrame. Next we will go through step by step what you need to import, how you read the data, how you create an object that represents the schema, and, finally, how you combine the schema definition and the data to create a table DataFrame.

We also show some simple queries using SQL in the resulting SQL DataFrame.

First make sure to import all necessary file types to your Python environment. You can try the following example interactively in a `pyspark` shell. Make sure you run it in the directory where you store the data file or adapt the path in the example accordingly.

```
$ pyspark

>>> from pyspark.sql import SQLContext
>>> from pyspark.sql.types import *
```

Create the Spark SQL Context.

```
>>> sqlContext = SQLContext(sc)
```

Read the weblog data into an RDD. You may need to adjust the path to the data based on where you stored them.

```
>>> lines = sc.textFile('file:///data/labs/w205-labs-exercises/data/weblog_lab.csv ')
```

Create a map of the data so that they can be structured into a table.

```
>>> parts = lines.map(lambda l: l.split('\t'))
```

```
>>> Web_Session_Log = parts.map(lambda p: (p[0], p[1],p[2], p[3],p[4]))
```

Create string with the name of the columns of your table.

```
>>> schemaString = 'DATETIME USERID SESSIONID PRODUCTID REFERERURL'
```

Create a data structure of StructFields that can be used to create a table.

```
>>> fields = [StructField(field_name, StringType(), True) for field_name in schemaString.split()]
```

Combine the fields into a schema object.

```
>>> schema = StructType(fields)
```

Create a table based on a DataFrame using the data that was read and the structure representing the schema.

```
>>> schemaWebData = sqlContext.createDataFrame(Web_Session_Log, schema)
```

Register the object as a table with a table name.

```
>>> schemaWebData.registerTempTable('Web_Session_Log')
```

Query the table.

```
>>> results = sqlContext.sql('SELECT count(*) FROM Web_Session_Log')
```

Use the DataFrame operation `show` to print the content of the result of the query.

```
>>> results.show()
```

The following query can be used to query the number of rows related to eBay:

```
select count(*) from web_session_log where REFERERURL'=
"http://www.ebay.com" ;
```

Note: The case sensitivity is sometime different, depending on where you run the command. Keep that in mind if you see certain errors.

Enhance the script to execute the above query, and answer Submission 2.

SUBMISSION 2: Submit the number of rows returned by the select on eBay entries.

It should print that the result has one cell with some value.

SUBMISSION 3: Submit the number returned in the DataFrame of the `result.show()` command above.

Another query, with a screen shot.

```
>>> results = sqlContext.sql('SELECT * FROM
Web_Session_Log')
>>> results.show()
```

See below for screenshot of what you should see.

```
>>> results = sqlContext.sql('SELECT * FROM Web_Session_Log')
>>> results.show()
+-------------------+--------------------+--------------------+-----------------+--------------------+
|           DATETIME|              USERID|           SESSIONID|        PRODUCTID|          REFERERURL|
+-------------------+--------------------+--------------------+-----------------+--------------------+
|               date|              userid|           sessionid|        productid|          refererurl|
|2008-01-31 15:54:25|__RequestVerifica...|;+.ASPXAUTH=C31HD...|/product/YJ29IOCVQ|  http://www.abc.com|
|2005-12-08 02:36:30|__RequestVerifica...|;+.ASPXAUTH=H7HTS...|/product/MVI9HHP8A| http://www.ebay.com|
|2015-06-07 23:27:58|__RequestVerifica...|;+.ASPXAUTH=58SZL...| /search/P5XKO3AC9|  http://www.abc.com|
|2009-03-12 03:16:27|__RequestVerifica...|;+.ASPXAUTH=VBWZJ...|/product/A13025WBT|http://www.shophe...|
|2014-07-23 08:36:03|__RequestVerifica...|;+.ASPXAUTH=VXBLE...| /search/5PI9XD6LZ|http://www.facebo...|
|2002-12-30 08:42:09|__RequestVerifica...|;+.ASPXAUTH=YABJB...|/product/WS80XJFW2|  http://www.xyz.com|
|2004-11-03 20:29:10|__RequestVerifica...|;+.ASPXAUTH=2F90N...|/product/OJ201IBUN|http://www.homesh...|
|2012-01-26 12:39:57|__RequestVerifica...|;+.ASPXAUTH=SEWRR...|/product/OA3QGXF1U|  http://www.xyz.com|
|2008-04-30 02:01:34|__RequestVerifica...|;+.ASPXAUTH=6OB10...| /search/K1IRBE1DU|  http://www.abc.com|
|2003-08-23 09:44:43|__RequestVerifica...|;+.ASPXAUTH=1NRGS...|/product/ANGEKDMKM|http://www.shophe...|
|2008-04-09 01:24:24|__RequestVerifica...|;+.ASPXAUTH=2Y8NA...|/product/LC94NBS9A|http://www.facebo...|
|2000-08-07 06:45:19|__RequestVerifica...|;+.ASPXAUTH=KS9LL...| /search/HDKWJ5ORV|http://www.facebo...|
|2013-10-09 05:22:31|__RequestVerifica...|;+.ASPXAUTH=UA1WH...| /search/5LPS3BTJI|http://www.facebo...|
|2006-07-31 08:12:44|__RequestVerifica...|;+.ASPXAUTH=GDVM0...| /search/BW80TIDQP|  http://www.xyz.com|
|2014-07-27 13:23:18|__RequestVerifica...|;+.ASPXAUTH=OY5S5...| /search/D5S8HFH9D|http://www.facebo...|
|2001-01-10 18:23:03|__RequestVerifica...|;+.ASPXAUTH=VMOYI...|/product/I8VLXARNQ|  http://www.xyz.com|
|2011-09-24 21:28:13|__RequestVerifica...|;+.ASPXAUTH=SDVEA...| /search/S44PIHRYX|http://www.shophe...|
|2008-09-19 02:52:53|__RequestVerifica...|;+.ASPXAUTH=7NEBV...| /search/CX28DBZYW|http://www.shophe...|
|2006-03-01 20:10:27|__RequestVerifica...|;+.ASPXAUTH=K58W1...|/product/GG8EXER8K|http://www.amazon...|
+-------------------+--------------------+--------------------+-----------------+--------------------+
only showing top 20 rows
```

You can also run the program as a script. Let's assume you create a script `mysql.py`, which you placed in `/tmp` with the data file. The content of `mysql.py` follows. You may need to adjust the location of data file based on where you stored it and if you opted to have it on HDFS.

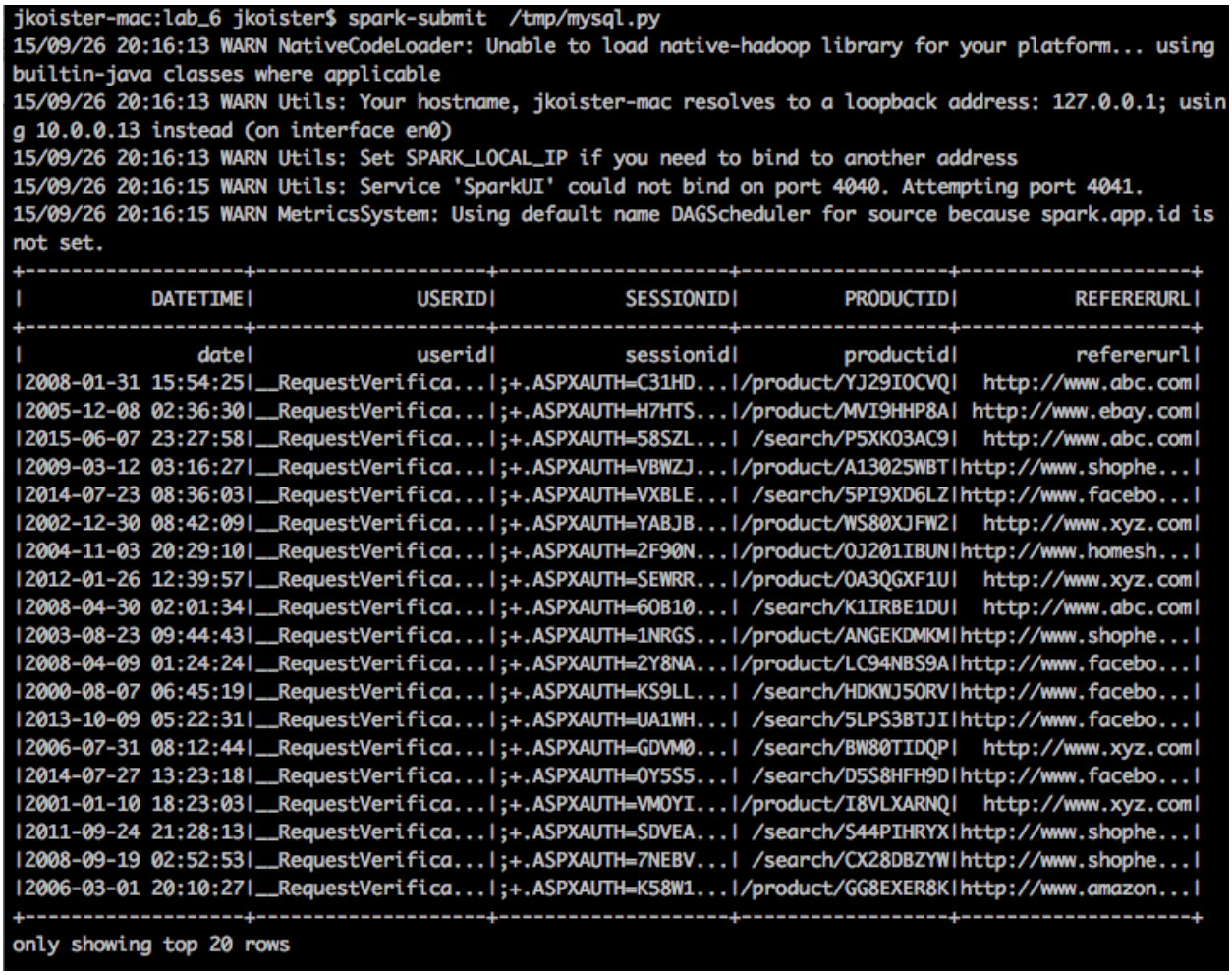
```
    from pyspark import SparkContext
    from pyspark.sql import SQLContext
    from pyspark.sql.types import *
    sc = SparkContext("local", "weblog app")
    sqlContext = SQLContext(sc)
    lines = sc.textFile('file:///data/labs/w205-labs-
exercises/data//weblog_lab.csv')
    parts = lines.map(lambda l: l.split('\t'))
    Web_Session_Log = parts.map(lambda p: (p[0], p[1],p[2],
p[3],p[4]))
    schemaString = 'DATETIME USERID SESSIONID PRODUCTID
REFERERURL'
    fields = [StructField(field_name, StringType(), True) for
field_name in schemaString.split()]
    schema = StructType(fields)
```

```
    schemaWebData = sqlContext.createDataFrame(Web_Session_Log,
schema)
    schemaWebData.registerTempTable('web_session_log')
    results = sqlContext.sql('SELECT * FROM web_session_log')
    results.show()
```

You can now run the Python Spark SQL script using the command. You can use `pyspark` to run the command, but the recommended way is to use `spark-submit`.

```
$ spark-submit /tmp/mysql.py
```

The output may look something like the following screenshot.



```
jkoister-mac:lab_6 jkoister$ spark-submit  /tmp/mysql.py
15/09/26 20:16:13 WARN NativeCodeLoader: Unable to load native-hadoop library for your platform... using
builtin-java classes where applicable
15/09/26 20:16:13 WARN Utils: Your hostname, jkoister-mac resolves to a loopback address: 127.0.0.1; usin
g 10.0.0.13 instead (on interface en0)
15/09/26 20:16:13 WARN Utils: Set SPARK_LOCAL_IP if you need to bind to another address
15/09/26 20:16:15 WARN Utils: Service 'SparkUI' could not bind on port 4040. Attempting port 4041.
15/09/26 20:16:15 WARN MetricsSystem: Using default name DAGScheduler for source because spark.app.id is
not set.
+-----------------+-----------------+-----------------+----------------+-----------------+
|         DATETIME|           USERID|        SESSIONID|       PRODUCTID|       REFERERURL|
+-----------------+-----------------+-----------------+----------------+-----------------+
|             date|           userid|        sessionid|       productid|       refererurl|
|2008-01-31 15:54:25|__RequestVerifica...|;+.ASPXAUTH=C31HD...|/product/YJ29IOCVQ|  http://www.abc.com|
|2005-12-08 02:36:30|__RequestVerifica...|;+.ASPXAUTH=H7HTS...|/product/MVI9HHP8A| http://www.ebay.com|
|2015-06-07 23:27:58|__RequestVerifica...|;+.ASPXAUTH=58SZL...| /search/P5XKO3AC9|  http://www.abc.com|
|2009-03-12 03:16:27|__RequestVerifica...|;+.ASPXAUTH=VBWZJ...|/product/A13025WBT|http://www.shophe...|
|2014-07-23 08:36:03|__RequestVerifica...|;+.ASPXAUTH=VXBLE...| /search/5PI9XD6LZ|http://www.facebo...|
|2002-12-30 08:42:09|__RequestVerifica...|;+.ASPXAUTH=YABJB...|/product/WS80XJFW2|  http://www.xyz.com|
|2004-11-03 20:29:10|__RequestVerifica...|;+.ASPXAUTH=2F90N...|/product/OJ201IBUN|http://www.homesh...|
|2012-01-26 12:39:57|__RequestVerifica...|;+.ASPXAUTH=SEWRR...|/product/OA3QGXF1U|  http://www.xyz.com|
|2008-04-30 02:01:34|__RequestVerifica...|;+.ASPXAUTH=6OB10...| /search/K1IRBE1DU|  http://www.abc.com|
|2003-08-23 09:44:43|__RequestVerifica...|;+.ASPXAUTH=1NRGS...|/product/ANGEKDMKM|http://www.shophe...|
|2008-04-09 01:24:24|__RequestVerifica...|;+.ASPXAUTH=2Y8NA...|/product/LC94NBS9A|http://www.facebo...|
|2000-08-07 06:45:19|__RequestVerifica...|;+.ASPXAUTH=KS9LL...| /search/HDKWJ5ORV|http://www.facebo...|
|2013-10-09 05:22:31|__RequestVerifica...|;+.ASPXAUTH=UA1WH...| /search/5LPS3BTJI|http://www.facebo...|
|2006-07-31 08:12:44|__RequestVerifica...|;+.ASPXAUTH=GDVM0...| /search/BW80TIDQP|  http://www.xyz.com|
|2014-07-27 13:23:18|__RequestVerifica...|;+.ASPXAUTH=OY5S5...| /search/D5S8HFH9D|http://www.facebo...|
|2001-01-10 18:23:03|__RequestVerifica...|;+.ASPXAUTH=VMOYI...|/product/I8VLXARNQ|  http://www.xyz.com|
|2011-09-24 21:28:13|__RequestVerifica...|;+.ASPXAUTH=SDVEA...| /search/S44PIHRYX|http://www.shophe...|
|2008-09-19 02:52:53|__RequestVerifica...|;+.ASPXAUTH=7NEBV...| /search/CX28DBZYW|http://www.shophe...|
|2006-03-01 20:10:27|__RequestVerifica...|;+.ASPXAUTH=K58W1...|/product/GG8EXER8K|http://www.amazon...|
+-----------------+-----------------+-----------------+----------------+-----------------+
only showing top 20 rows
```

What You Should Have Learned

You should have learned how to create a Python script that uses Spark SQL and how to run the script.

Step 8. Caching Tables and Uncaching Tables

Caching Tables

This process is extremely useful when you are joining a tiny dataset with a huge dataset.

`CACHE TABLE` and `UNCACHE TABLE` statements are available to do this task, making it very easy.

To cache a table:

```
CACHE TABLE logs_last_month;
```

To uncache a table:

```
UNCACHE TABLE logs_last_month;
```

Once a table is cached, you can use in your Spark queries.

Submissions, summary

There are three items that need to be submitted from this lab to be approved.

In Step 3:

SUBMISSION 1: Submit the first 10 rows of the unsorted and the sorted RDD to show that you successfully created both. Also explain the issue with the tuple and how to possibly correct it in the map/lambda function that was used to create the tuples.

In Step 5:

SUBMISSION 2: Submit the number of rows returned by the `select` on eBay entries.

In Step 6:

SUBMISSION 3: Submit the number returned in the DataFrame of the `result.show()` command.

Troubleshooting

Connection problem on laptop or Macbook

If you get an exception similar to "`ERROR SparkContext: Error initializing SparkContext. java.net.UnknownHostException:…`", ensure you have the brand and model of your computer added to the `/etc/hosts` file. For example add the line "`127.0.0.1 <myhost>`", where <myhost> is the name of your computer.

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Hadoop connection problem on EC2 instance

If you get an error that looks something like this on the AMI:

```
     py4j.protocol.Py4JJavaError: An error occurred while
calling o34.collect.
     : java.net.ConnectException: Call From ip-10-61-206-
219.ec2.internal/10.61.206.219 to localhost:8020 failed on
connection exception: java.net.ConnectException: Connection
refused; For more details see:
http://wiki.apache.org/hadoop/ConnectionRefused
```

your Hadoop instance is likely not running. With the "`ucb_w205_complete - ami-71cdb014`," use the `start-hadoop.sh` and `stop-hadoop.sh` scripts to start and stop the Hadoop service.

AMI

If you are using the AMI, you need to attach an EBS volume.
Follow these instructions for how to create a volume and attach it to you instance:
http://docs.aws.amazon.com/AWSEC2/latest/UserGuide/ebs-attaching-volume.html

When you create a volume you give it a name. I used `/dev/sdh` (`h` for hadoop) so that I remember it. When you check volumes on you EC2 instance, you will see different name. In the example below my `sdh` got named `xvdh`. I recognized it by the `h` and the size.

```
[root@ip-10-61-206-219 ~]# lsblk
NAME MAJ:MIN RM SIZE RO TYPE MOUNTPOINT
xvda1 202:1  0  10G 0 disk /
xvdb 202:16  0  4G 0 disk
xvdh 202:112 0 100G 0 disk /data
```

You have an attached volume. Now you need to create a file system on that raw disk volume and then mount the volume on your root file system so that it can be accessed by programs. A file system is like a tree of trees, and mounting essentially means you attach a tree to a branch

of another tree. File systems are also a structure of information on your disk that tracks files, blocks of files, who owns the files, and so forth. That is why you need to create the file system.

This guide explains how to create and mount the file system. The only problem I noticed with the guide was that it left out that you should provide the type of file system to mount. If the example in the guide fails for you, try this:

```
sudo mount -t ext4 /dev/xvdh /data
```

http://docs.aws.amazon.com/AWSEC2/latest/UserGuide/ebs-using-volumes.html

Error at '\t'

Sometimes cutting and pasting changes the representation of characters. Edit the command in spark-sql and make sure you have '' quotes.

Local Spark Installation for spark-sql CLI

You create a new installation of Spark using the below instructions you will be able to run the CLI. The following if for the AMI, but you can do the corresponding steps on you own computer or in another environment.

```
wget http://www.us.apache.org/dist/spark/spark-1.5.0/spark-1.5.0-bin-hadoop2.6.tgzmv spark-1.5.0-bin-hadoop2.6 spark15
export SPARK_HOME=$HOME/spark15
export HADOOP_CONF_DIR=/etc/hadoop/conf
```

I would also propose changing Log tracing to WARN in the conf/log4j file.
If you check which spark-sql you use you should see the following.

```
# which spark-sql
/root/spark15/bin/spark-sql
```

You need to make sure Hadoop is started. Then start spark-sql and you should be able to do step-5 and step-6 of this lab.

In sufficient memory

If you get an ERROR concerning insufficient memory you should probably make sure you get more memory for the node you are running the lab on. This is particularly important so that you can process somewhat realistic data sets for Exercises and Projects. To get through this lab, however, you can reduce the data set. Lets assume you had issues with the Crime data set. This data set has close to 6 million rows. Lets say you can handle 1 million rows in memory on your node. You could then use the following command to split the data set in 1 million row parts.

The `split` command will create a number of splits. The `xaa` files is the first part of the original file. We want to use that as it contains the header information that we look at later in the lab.

```
$ split -l 1000000 Crimes_-_2001_to_present.csv
$ ls
Crimes_-_2001_to_present.csv  xad
xaa                           xae
xab                           xaf
xac
$ mv xaa Crimes_-_2001_to_present_1M-1.csv
```

You can now complete the `pyspark` sections on the lab using this data set. Be aware that some of the counts etc. mentioned in the lab may be incorrect with respect to this smaller data set.