BIG DATA INFRASTRUCTURE & CLOUD COMPUTING

Evaluation Practical Work

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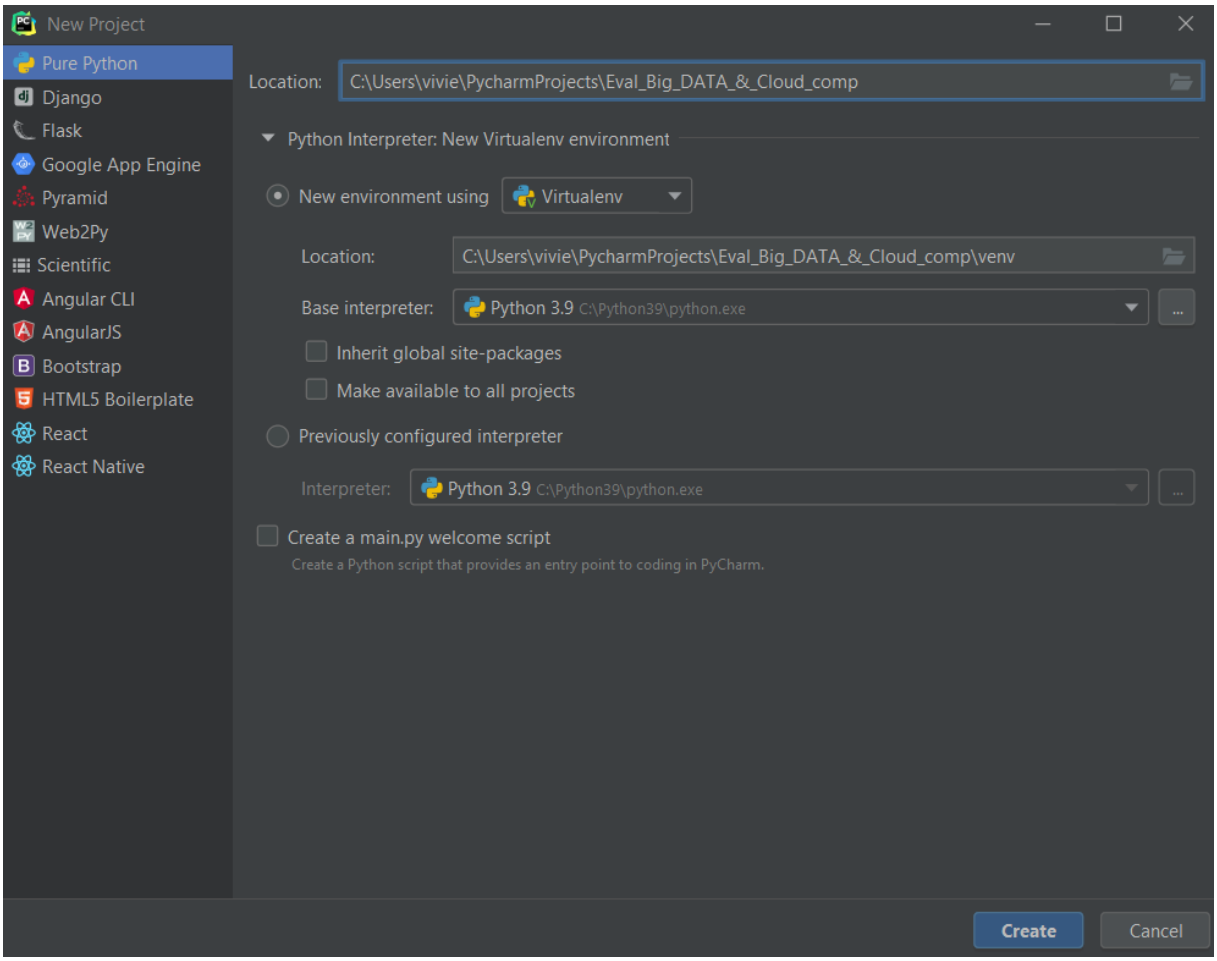
1. **Create a virtual environment in PyCharm and set it up to use Python 3.8 (or another version 3.x already installed on your computer, no need to install 3.8 if you don't have it yet).**

We create an environment named Eval_Big_Data_&_Cloud_comp using Virtualenv and Python 3.8 as shown in the picture below.



2. **Write a script in Python shakespeare_words.py which generates a list of the words contained in the complete works of Shakespeare and output it to a file. Name this file shakespeare_data.txt.**

```python
import re
a_file = open("t8.shakespeare_sentence.txt", "r")

# remove every return to the line
string_without_line_breaks = ""
for line in a_file:
  stripped_line = line.rstrip()
  string_without_line_breaks += stripped_line

# remove the header ( everything between the quotes << and >> )
out = re.sub(r'<<.+?>>', '', string_without_line_breaks)

# remove the number
from string import digits

remove_digits = str.maketrans('', '', digits)
res = out.translate(remove_digits)
```

```python

# split into words with return to line while removing punctuation
wordList = re.sub("[^\w]", " ",  res).split()

# Save the different word in a file
f = open("shakespeare_data.txt", "w+")
for item in wordList:
  f.write("%s\n" % item)

# Close files
f.close()
a_file.close()
```

3. Install PySpark using the command line:

```
C:\Users\vivie\PycharmProjects\Eval_Big_DATA_&_Cloud_comp\venv>pip install pyspark
Collecting pyspark
  Using cached pyspark-3.0.1.tar.gz (204.2 MB)
Collecting py4j==0.10.9
  Using cached py4j-0.10.9-py2.py3-none-any.whl (198 kB)
Building wheels for collected packages: pyspark
  Building wheel for pyspark (setup.py) ... done
  Created wheel for pyspark: filename=pyspark-3.0.1-py2.py3-none-any.whl size=204612242 sha256=1a864ff99c9b8630932
  Stored in directory: c:\users\vivie\appdata\local\pip\cache\wheels\ea\21\84\970b03913d0d6a96ef51c34c878add0de9e4
Successfully built pyspark
Installing collected packages: py4j, pyspark
Successfully installed py4j-0.10.9 pyspark-3.0.1

C:\Users\vivie\PycharmProjects\Eval_Big_DATA_&_Cloud_comp\venv>
```

4. **Test the installation by running the PySpark shell:**

```
C:\Users\vivie\PycharmProjects\Eval_Big_DATA_&_Cloud_comp\venv>pyspark
Python 3.8.5 (default, Sep  3 2020, 21:29:08) [MSC v.1916 64 bit (AMD64)] :: Anaconda, Inc. on win32
Type "help", "copyright", "credits" or "license" for more information.
21/02/04 18:38:35 WARN NativeCodeLoader: Unable to load native-hadoop library for your platform... using builtin-java classes where applicable
Using Spark's default log4j profile: org/apache/spark/log4j-defaults.properties
Setting default log level to "WARN".
To adjust logging level use sc.setLogLevel(newLevel). For SparkR, use setLogLevel(newLevel).
Welcome to
      ____              __
     / __/__  ___ _____/ /__
    _\ \/ _ \/ _ `/ __/  '_/
   /__ / .__/\_,_/_/ /_/\_\   version 3.0.1
      /_/

Using Python version 3.8.5 (default, Sep  3 2020 21:29:08)
SparkSession available as 'spark'.
>>> 21/02/04 18:38:48 WARN ProcfsMetricsGetter: Exception when trying to compute pagesize, as a result reporting of ProcessTree metrics is stopped
```

5. **Load your shakespeare_data.txt file in the shell and count the number of words in the file.**

```
data = spark.read.csv('shakespeare_data.txt')
>>> data.count()
909236
>>>
```

6. **Exit the shell:**

```
909236
>>> exit()

C:\Users\vivie\PycharmProjects\Eval_Big_DATA_&_Cloud_comp\venv>SUCCESS: The process with PID 12492 (child process of PID 16560) has been terminated.
SUCCESS: The process with PID 16560 (child process of PID 22780) has been terminated.
SUCCESS: The process with PID 22780 (child process of PID 2592) has been terminated.
```

7. **Create a word_count.py file and do the same thing like with the shell (reading the text file and displaying the number of words). For that, you need to create an instance of spark in your script using a SparkSession:**

The Script:

```
1  from pyspark.sql import SparkSession
2
3  spark = SparkSession.builder.appName('WordCountApp').getOrCreate()
4
5  data = spark.read.csv("shakespeare_data.txt")
6
7
8  print("################COUNT THE NUMBER OF WORDS ##################")
9  print(data.count())
10
```

When running the Script we have the following result:

```
C:\Users\vivie\PycharmProjects\Eval_Big_DATA_&_Cloud_comp\venv>python word_count.py
21/02/04 18:50:51 WARN NativeCodeLoader: Unable to load native-hadoop library for your platform... using builtin-java classes where applicable
Using Spark's default log4j profile: org/apache/spark/log4j-defaults.properties
Setting default log level to "WARN".
To adjust logging level use sc.setLogLevel(newLevel). For SparkR, use setLogLevel(newLevel).
################################################## COUNT THE NUMBER OF WORDS ################################
909236

C:\Users\vivie\PycharmProjects\Eval_Big_DATA_&_Cloud_comp\venv>SUCCESS: The process with PID 23004 (child process of PID 5004) has been terminated.
SUCCESS: The process with PID 5004 (child process of PID 22784) has been terminated.
SUCCESS: The process with PID 22784 (child process of PID 20232) has been terminated.
```

8. Then add spark code to your script in order to show:

- The first three values in the text file

- The 10 longest words, showing their length

- The 10 words having the highest number of occurrences, with their number of occurrences.

Here is the script:

```python
from pyspark.sql import SparkSession
# Create an instance of Spark
spark = SparkSession.builder.appName('WordCountApp').getOrCreate()
# Load the data
data = spark.read.csv("shakespeare_data.txt")

# rename the column
data = data.withColumnRenamed('_c0','words')
print("############################NUMBER OF WORDS ##################################")
print(data.count())

# Create an in-memory DataFrame to query
data.createOrReplaceTempView("text")

print("############################FIRST THREE ##################################")
# First Three values in the words file
first_three = spark.sql("SELECT * FROM text limit 3")
first_three.show()

print("############################TEN LONGEST ##################################")
# 10 longest text, showing their length
ten_longest = spark.sql("SELECT words, LENGTH(words) AS length_words "
                        "FROM text "
                        "GROUP BY words "
                        "ORDER BY LENGTH(words) DESC "
                        "LIMIT 10")
ten_longest.show()
```

```
28  print("############################ TEN HIGHEST OCCURENCES ################################")
29
30  # 10 text having highest number of occurrences, with the number of occurences
31  ten_highest_occ = spark.sql("SELECT words, COUNT(words) AS occurences_words"
32                              " FROM text"
33                              " GROUP BY words "
34                              "ORDER BY COUNT(words) DESC "
35                              "LIMIT 10")
36  ten_highest_occ.show()
37
38
```

9. Run your script locally and observe the results.

After running we have the following result:

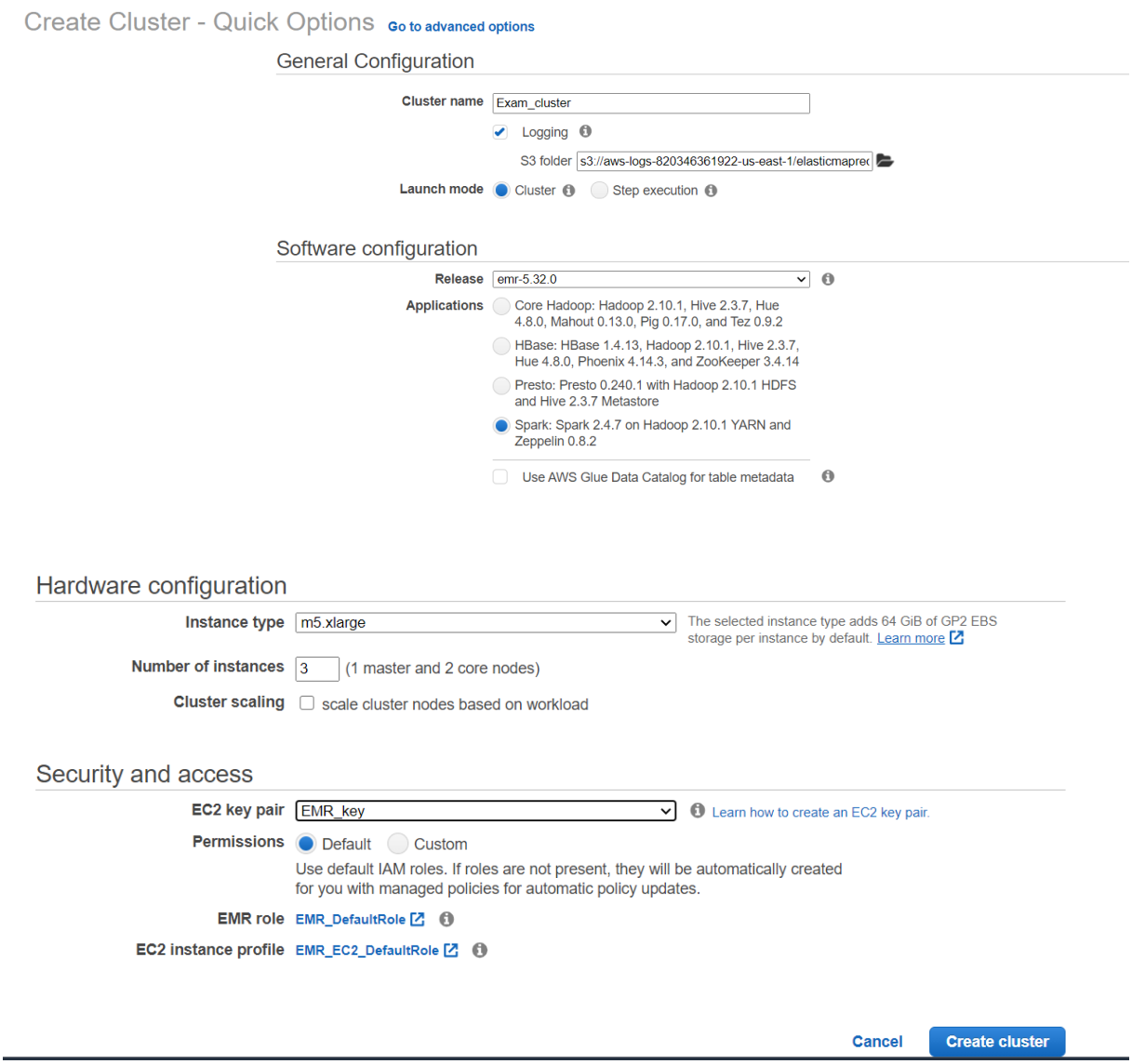
```
C:\Users\vivie\PycharmProjects\Eval_Big_DATA_&_Cloud_comp\venv>python word_count.py
21/02/04 18:58:09 WARN NativeCodeLoader: Unable to load native-hadoop library for your platform...
Using Spark's default log4j profile: org/apache/spark/log4j-defaults.properties
Setting default log level to "WARN".
To adjust logging level use sc.setLogLevel(newLevel). For SparkR, use setLogLevel(newLevel).
############################NUMBER OF WORDS ##################################
909236
############################FIRST THREE ##################################
+---------+
|    words|
+---------+
|     From|
|  fairest|
|creatures|
+---------+
```

```
##############################TEN LONGEST ###################################
+--------------------+------------+
|               words|length_words|
+--------------------+------------+
|honorificabilitud...|          27|
|AntipholusesBALTH...|          21|
|ExeuntKING_HENRY_...|          21|
|possiblesatisfaction|          20|
|GloucestershireEnter|          20|
| ShakespeareDRAMATIS|          19|
| schoolmasterAEMILIA|          19|
| ShakespeareDramatis|          19|
| BALTHAZARANTIPHOLUS|          19|
| OFEPHESUSANTIPHOLUS|          19|
+--------------------+------------+
```

```
############################ TEN HIGHEST OCCURENCES ###################################
+-----+---------------+
|words|occurences_words|
+-----+---------------+
|  the|          23241|
|    I|          22225|
|  and|          18609|
|   to|          16329|
|   of|          15684|
|    a|          12779|
|  you|          12160|
|   my|          10838|
|   in|          10002|
|    d|           8954|
+-----+---------------+
```

10. Create an Amazon EMR cluster (keep default parameters).

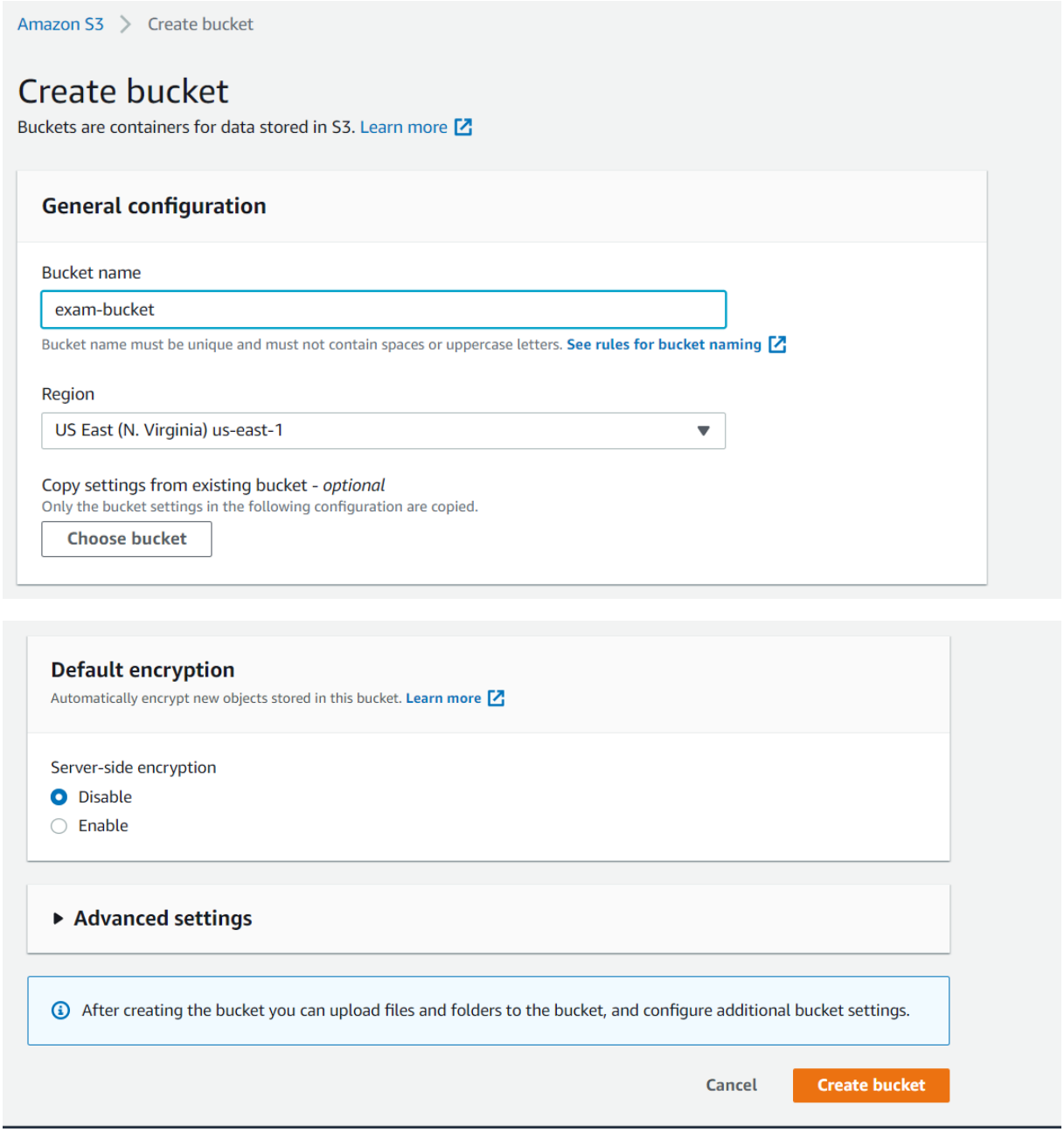
This is the screenshot page of the creation :



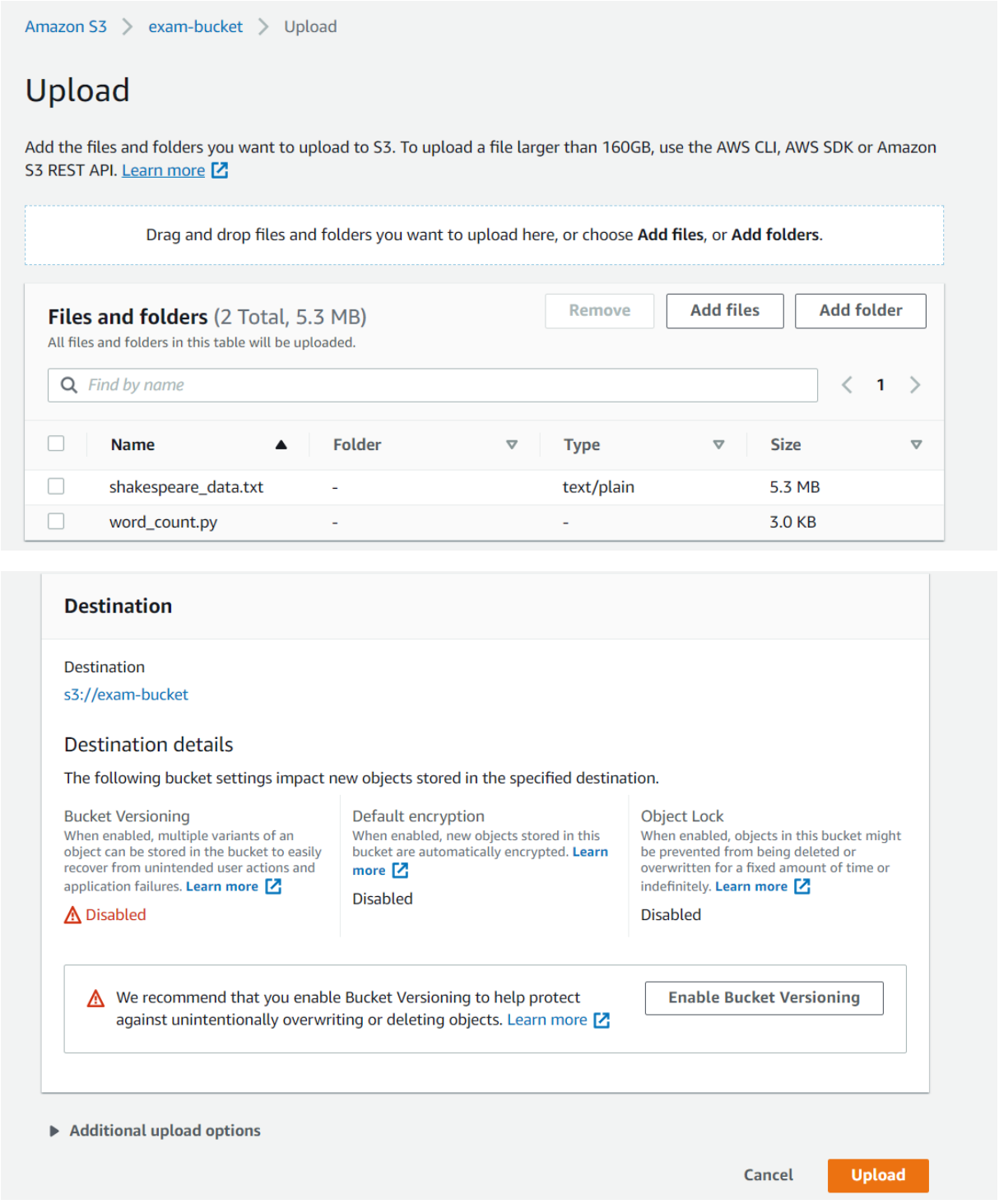
After the creation complete we have this result:

11. Create a S3 bucket and upload your data to the bucket.

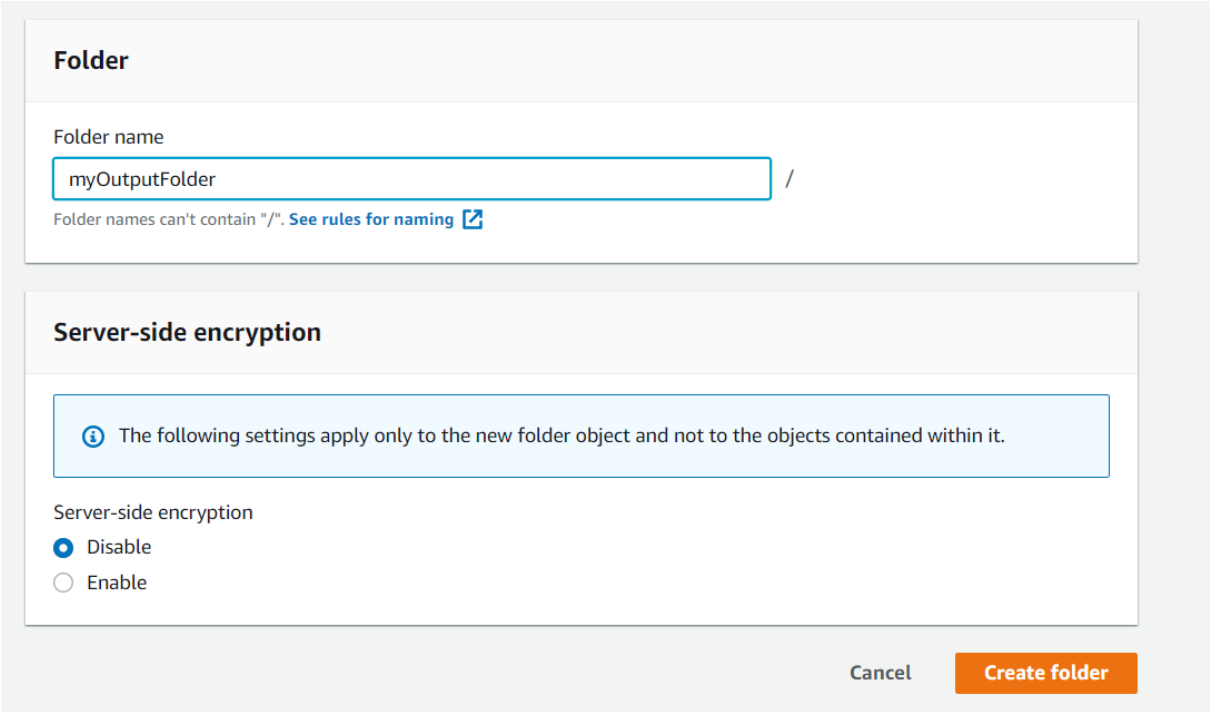
- The creation



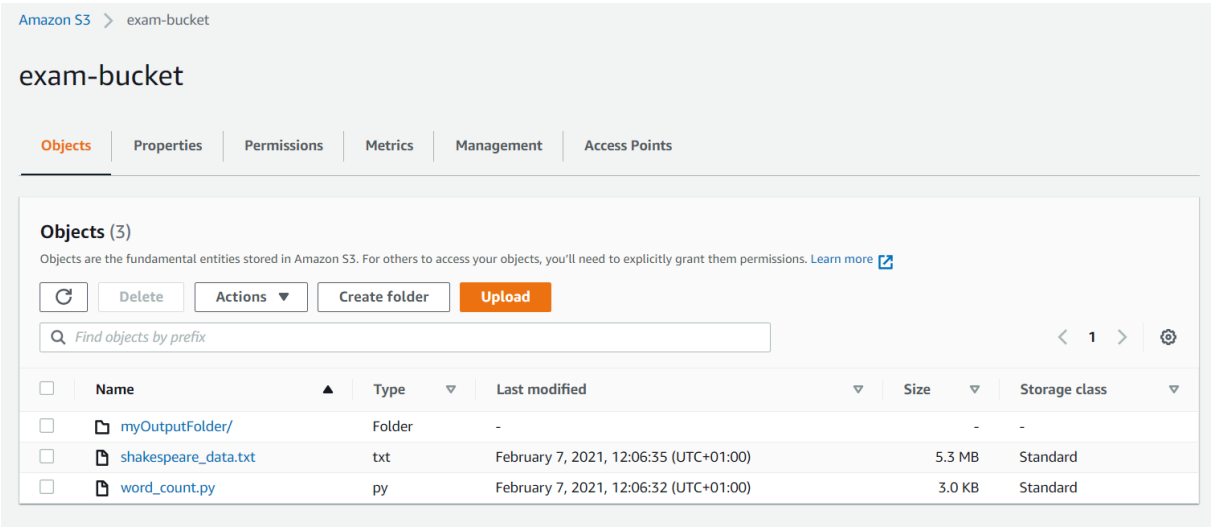
- The upload :



- Creation of a folder where we will save the result

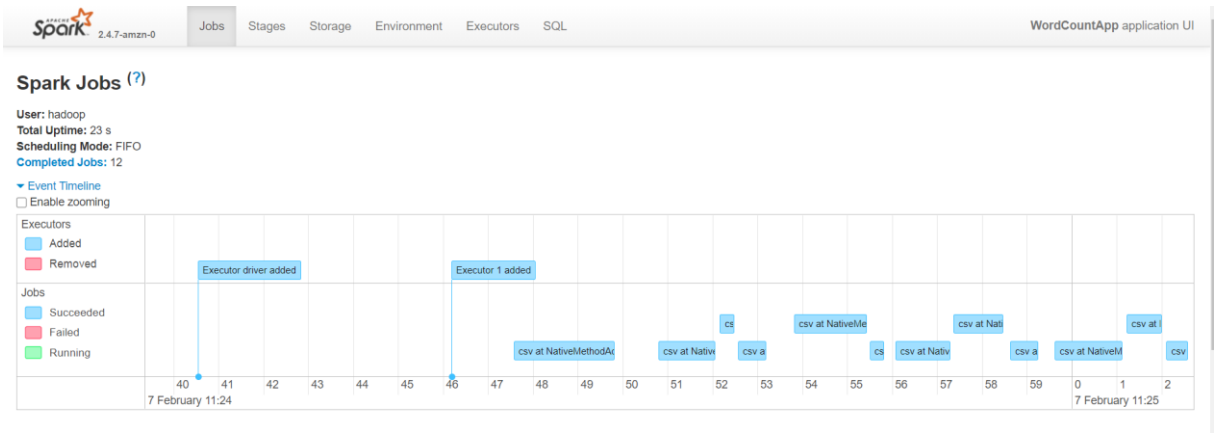


- So this is our bucket ready :



12. Open the Spark History Server user interface.

13. Run your script on the cluster using the graphical user interface. Observe the jobs being run in the Spark History Server.



14. Observe the final state in Spark History Server.

Completed Jobs (12)

Job Id	Description	Submitted	Duration	Stages: Succeeded/Total	Tasks (for all stages): Succeeded/Total
11	csv at NativeMethodAccessorImpl.java:0 csv at NativeMethodAccessorImpl.java:0	2021/02/07 11:25:02	0.5 s	2/2 (2 skipped)	27/27 (12 skipped)
10	csv at NativeMethodAccessorImpl.java:0 csv at NativeMethodAccessorImpl.java:0	2021/02/07 11:25:01	0.8 s	1/1 (1 skipped)	10/10 (2 skipped)
9	csv at NativeMethodAccessorImpl.java:0 csv at NativeMethodAccessorImpl.java:0	2021/02/07 11:24:59	1 s	1/1	2/2
8	csv at NativeMethodAccessorImpl.java:0 csv at NativeMethodAccessorImpl.java:0	2021/02/07 11:24:58	0.6 s	2/2 (2 skipped)	27/27 (12 skipped)
7	csv at NativeMethodAccessorImpl.java:0 csv at NativeMethodAccessorImpl.java:0	2021/02/07 11:24:57	1 s	1/1 (1 skipped)	10/10 (2 skipped)
6	csv at NativeMethodAccessorImpl.java:0 csv at NativeMethodAccessorImpl.java:0	2021/02/07 11:24:56	1 s	1/1	2/2
5	csv at NativeMethodAccessorImpl.java:0 csv at NativeMethodAccessorImpl.java:0	2021/02/07 11:24:55	0.3 s	2/2 (1 skipped)	11/11 (2 skipped)
4	csv at NativeMethodAccessorImpl.java:0 csv at NativeMethodAccessorImpl.java:0	2021/02/07 11:24:53	2 s	1/1	2/2
3	csv at NativeMethodAccessorImpl.java:0 csv at NativeMethodAccessorImpl.java:0	2021/02/07 11:24:52	0.6 s	1/1 (2 skipped)	1/1 (12 skipped)
2	csv at NativeMethodAccessorImpl.java:0 csv at NativeMethodAccessorImpl.java:0	2021/02/07 11:24:52	0.3 s	1/1 (1 skipped)	10/10 (2 skipped)
1	csv at NativeMethodAccessorImpl.java:0 csv at NativeMethodAccessorImpl.java:0	2021/02/07 11:24:50	1 s	1/1	2/2
0	csv at NativeMethodAccessorImpl.java:0 csv at NativeMethodAccessorImpl.java:0	2021/02/07 11:24:47	2 s	1/1	1/1

Stages for All Jobs

Completed Stages: 15
Skipped Stages: 10

Completed Stages (15)

Stage Id	Description		Submitted	Duration	Tasks: Succeeded/Total	Input	Output	Shuffle Read	Shuffle Write
24	csv at NativeMethodAccessorImpl.java:0	+details	2021/02/07 11:25:02	0.2 s	1/1		112.0 B	5.9 KB	
23	csv at NativeMethodAccessorImpl.java:0	+details	2021/02/07 11:25:02	0.3 s	26/26			2.6 MB	5.9 KB
20	csv at NativeMethodAccessorImpl.java:0	+details	2021/02/07 11:25:01	0.8 s	10/10			2.2 MB	2.6 MB
18	csv at NativeMethodAccessorImpl.java:0	+details	2021/02/07 11:24:59	1 s	2/2	5.3 MB			2.2 MB
17	csv at NativeMethodAccessorImpl.java:0	+details	2021/02/07 11:24:59	0.2 s	1/1		263.0 B	7.8 KB	
16	csv at NativeMethodAccessorImpl.java:0	+details	2021/02/07 11:24:58	0.4 s	26/26			2.2 MB	7.8 KB
13	csv at NativeMethodAccessorImpl.java:0	+details	2021/02/07 11:24:57	1 s	10/10			2.2 MB	2.2 MB
11	csv at NativeMethodAccessorImpl.java:0	+details	2021/02/07 11:24:56	1 s	2/2	5.3 MB			2.2 MB
10	csv at NativeMethodAccessorImpl.java:0	+details	2021/02/07 11:24:55	0.1 s	1/1		27.0 B		
9	csv at NativeMethodAccessorImpl.java:0	+details	2021/02/07 11:24:55	0.1 s	10/10				892.0 B
7	csv at NativeMethodAccessorImpl.java:0	+details	2021/02/07 11:24:53	2 s	2/2	5.3 MB			2.2 MB
6	csv at NativeMethodAccessorImpl.java:0	+details	2021/02/07 11:24:52	0.5 s	1/1		16.0 B	590.0 B	
3	csv at NativeMethodAccessorImpl.java:0	+details	2021/02/07 11:24:52	0.3 s	10/10			18.0 KB	590.0 B
1	csv at NativeMethodAccessorImpl.java:0	+details	2021/02/07 11:24:50	1 s	2/2	5.3 MB			18.0 KB
0	csv at NativeMethodAccessorImpl.java:0	+details	2021/02/07 11:24:47	2 s	1/1	16.0 KB			

15. Propose and test different optimizations to improve the performances. Show the performance gains attained with each optimization tested.

- First optimiation : adding number of repartition on write and read statement

```
text_df = spark.read.csv(data_source).repartition(10)
first_three.repartition(10).write.option("header",
"true").mode("append").csv(output_uri)
```

```
• count_df.repartition(10).write.option("header",
  "true").mode("append").csv(output_uri)
• ten_longest.repartition(10).write.option("header",
  "true").mode("append").csv(output_uri)

• ten_highest_occ.repartition(10).write.option("header",
  "true").mode("append").csv(output_uri)
```

▾ Completed Stages (18)

Stage Id	Description	Submitted	Duration	Tasks: Succeeded/Total	Input	Output	Shuffle Read	Shuffle Write
38	csv at NativeMethodAccessorImpl.java:0 +details	2021/02/07 11:45:26	0.3 s	10/10		319.0 B	720.0 B	
33	csv at NativeMethodAccessorImpl.java:0 +details	2021/02/07 11:45:26	17 ms	1/1			5.9 KB	720.0 B
32	csv at NativeMethodAccessorImpl.java:0 +details	2021/02/07 11:45:25	0.2 s	26/26			2.6 MB	5.9 KB
29	csv at NativeMethodAccessorImpl.java:0 +details	2021/02/07 11:45:25	0.7 s	10/10			2.2 MB	2.6 MB
27	csv at NativeMethodAccessorImpl.java:0 +details	2021/02/07 11:45:23	1 s	2/2	5.3 MB			2.2 MB
26	csv at NativeMethodAccessorImpl.java:0 +details	2021/02/07 11:45:22	0.6 s	10/10		434.0 B	878.0 B	
21	csv at NativeMethodAccessorImpl.java:0 +details	2021/02/07 11:45:22	27 ms	1/1			7.8 KB	878.0 B
20	csv at NativeMethodAccessorImpl.java:0 +details	2021/02/07 11:45:22	0.4 s	26/26			2.2 MB	7.8 KB
17	csv at NativeMethodAccessorImpl.java:0 +details	2021/02/07 11:45:21	1 s	10/10			2.2 MB	2.2 MB
15	csv at NativeMethodAccessorImpl.java:0 +details	2021/02/07 11:45:19	1 s	2/2	5.3 MB			2.2 MB
14	csv at NativeMethodAccessorImpl.java:0 +details	2021/02/07 11:45:19	0.2 s	1/1		27.0 B		
13	csv at NativeMethodAccessorImpl.java:0 +details	2021/02/07 11:45:19	0.1 s	10/10				892.0 B
11	csv at NativeMethodAccessorImpl.java:0 +details	2021/02/07 11:45:17	2 s	2/2	5.3 MB			2.2 MB
10	csv at NativeMethodAccessorImpl.java:0 +details	2021/02/07 11:45:16	0.6 s	10/10		16.0 B	59.0 B	
6	csv at NativeMethodAccessorImpl.java:0 +details	2021/02/07 11:45:15	37 ms	1/1			590.0 B	59.0 B
3	csv at NativeMethodAccessorImpl.java:0 +details	2021/02/07 11:45:15	0.3 s	10/10			18.0 KB	590.0 B
1	csv at NativeMethodAccessorImpl.java:0 +details	2021/02/07 11:45:14	1 s	2/2	5.3 MB			18.0 KB
0	csv at NativeMethodAccessorImpl.java:0 +details	2021/02/07 11:45:11	2 s	1/1	7.6 KB			

- Second optimization : Partitions — That Determine the parallelism At shuffle level

We change it on our script using the command :

```
spark.conf.set("spark.sql.shuffle.partitions", 500)
```

Stages for All Jobs

Completed Stages: 15
Skipped Stages: 10

▾ Completed Stages (15)

Stage Id	Description	Submitted	Duration	Tasks: Succeeded/Total	Input	Output	Shuffle Read	Shuffle Write
24	csv at NativeMethodAccessorImpl.java:0 +details	2021/02/07 11:39:15	0.2 s	1/1		112.0 B	124.8 KB	
23	csv at NativeMethodAccessorImpl.java:0 +details	2021/02/07 11:39:13	1 s	500/500			2.2 MB	124.8 KB
20	csv at NativeMethodAccessorImpl.java:0 +details	2021/02/07 11:39:13	0.5 s	10/10			2.2 MB	2.2 MB
18	csv at NativeMethodAccessorImpl.java:0 +details	2021/02/07 11:39:11	1 s	2/2	5.3 MB			2.2 MB
17	csv at NativeMethodAccessorImpl.java:0 +details	2021/02/07 11:39:11	0.2 s	1/1		263.0 B	139.9 KB	
16	csv at NativeMethodAccessorImpl.java:0 +details	2021/02/07 11:39:09	2 s	500/500			1899.5 KB	139.9 KB
13	csv at NativeMethodAccessorImpl.java:0 +details	2021/02/07 11:39:07	1.0 s	10/10			2.2 MB	1899.5 KB
11	csv at NativeMethodAccessorImpl.java:0 +details	2021/02/07 11:39:06	1 s	2/2	5.3 MB			2.2 MB
10	csv at NativeMethodAccessorImpl.java:0 +details	2021/02/07 11:39:05	0.2 s	1/1		27.0 B		
9	csv at NativeMethodAccessorImpl.java:0 +details	2021/02/07 11:39:05	0.1 s	10/10				892.0 B
7	csv at NativeMethodAccessorImpl.java:0 +details	2021/02/07 11:39:03	2 s	2/2	5.3 MB			2.2 MB
6	csv at NativeMethodAccessorImpl.java:0 +details	2021/02/07 11:39:02	0.5 s	1/1		16.0 B	590.0 B	
3	csv at NativeMethodAccessorImpl.java:0 +details	2021/02/07 11:39:02	0.3 s	10/10			18.0 KB	590.0 B
1	csv at NativeMethodAccessorImpl.java:0 +details	2021/02/07 11:39:00	1 s	2/2	5.3 MB			18.0 KB
0	csv at NativeMethodAccessorImpl.java:0 +details	2021/02/07 11:38:58	2 s	1/1	7.6 KB			

CONCLUSION:

As we can see the difference is not notable because our app doesn't deal with big data and the script is also short. With a bigger data, those settings would have increase the performance of our spark app.