Tutorial:
Introduction to Spark MapReduce

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1. Overview

Welcome

Welcome to the MapReduce tutorial. This tutorial covers the critical skills needed to develop a Spark MapReduce application. It starts with an already deployed Spark environment where students will execute a series of hands-on labs.

Objectives

Upon completing this tutorial, students will be able to:

- Perform basic operations on HDFS

- Develop a simple MapReduce application (Word Count)
- Run MapReduce applications and examine the output
- Make modifications in MapReduce applications

Structure

This guide is designed as a set of step-by-step instructions for hands-on exercises. It teaches you how to operate the MapReduce service in a functional test environment through a series of examples. Exercises should be completed in the order described in the following steps.

1. Download some input datasets
2. Prepare a HDFS and upload dataset on it
3. Develop a simple **"Word Count"** application
4. Run the application on Spark and examine the output
5. Modify the **"Word Count"** application to discard common words
6. Rebuilt, and rerun the modified application
7. Do it yourself modification

2. Requirements

This tutorial is designed to work on the **Hortonworks Sandbox 2.3.2** virtual machine. You need to have a working HortonWorks Sandbox machine either locally or on the Amazon Web Services.

Also, all assignments are designed based on **JDK 7** (included in the virtual machine).

Please refer to “Tutorial: Run HortonWorks Sandbox 2.3 Locally” or “Tutorial: Run HortonWorks Sandbox 2.3 on AWS” for more information.

3. Setup Virtual Machine

Step 1: Start the virtual machine; then connect to it through the SSH.

Step 2: After successfully logging in, you should see a prompt similar to the following:

```
[root@sandbox ~]#
```

Step 3: Create a new folder for this tutorial:

```
# mkdir mapreduce-tutorial
```

Step 4: Change the current folder:

```
# cd mapreduce-tutorial
```

4. Prepare the HDFS

MapReduce needs all the input and output files to be located on HDFS. In this section, we will first download some text file as the input dataset. Then we create necessary folders on HDFS. Lastly, we copy the dataset to the HDFS.
For the input dataset some masterpieces by William Shakespeare (Hamlet, Macbeth, Othello, and Romeo & Juliet) will be downloaded directly from the Gutenberg Project.

Step 1: Create a folder for the input datasets:

```
# mkdir dataset
```

Step 2: Download the following Shakespeare books:

```
# wget -c http://www.gutenberg.lib.md.us/2/2/6/2264/2264.txt -P dataset
# wget -c http://www.gutenberg.lib.md.us/2/2/6/2265/2265.txt -P dataset
# wget -c http://www.gutenberg.lib.md.us/2/2/6/2266/2266.txt -P dataset
# wget -c http://www.gutenberg.lib.md.us/2/2/6/2267/2267.txt -P dataset
```

Step 3: Create some folders on HDFS:

```
# hadoop fs -mkdir -p /tutorial/input
```

Step 4: Upload the Dataset to HDFS

```
# hadoop fs -put ./dataset/* /tutorial/input
```

5. Hello World (Word Count)

The Word Count application is the canonical example in MapReduce. It is a straightforward application of MapReduce, and MapReduce can handle word count extremely efficiently. In this particular example, we will be doing a word count within Shakespeare's books.

If you are new to Python programming language, take a look at:

https://pythonspot.com

Step 1: Create a new Python source code file using the following command:

```
# nano wordcount.py
```

Step 2: Type (or copy/paste) the Python code of **"Appendix A"** in the editor, and then quit **nano** and save the file.

Step 2 (Alternative): Quit **nano**. Download the source from the github:

```
# wget -c https://github.com/xldrx/mapreduce_examples/raw/master/
tutorial/first_example/wordcount.py
```

To learn more about developing MapReduce applications in Python, visit:

http://spark.apache.org/docs/latest/quick-start.html

Step 3: Run the application using the following command and wait for it to be done:

```
# spark-submit ./wordcount.py /tutorial/input/ /tutorial/output
```

Step 4: The output of the application will be on the HDFS. To see the output, you may use the following command:

```
# hadoop fs -cat /tutorial/output/*
```

Step 5 (Optional): The output files can be downloaded from HDFS using the following command:

```
# hadoop fs -get /tutorial/output/* .
```

Step 6 (Optional: Just in case of runtime errors: If you encounter any errors (possibly due to typos), you need to first edit the source file and fix the problems. Additionally, the output folder on HDFS should be cleaned before a new run using following command:

```
# hadoop fs -rm -r -f /tutorial/output
```

Finally, run the code again.

6. Make Modifications

Let's make some changes to the Word Count application. As you might have already noticed, words are not correctly tokenized. This happens because the default function for splitting strings in Python only uses a limited number of splitter characters. Furthermore, there are a few common English words that are not that interesting enough to be included in the output.
In this section, we will fix these two problems.

Step 1: Edit the source code:

```
# nano wordcount.py
```

Step 2: Edit the file to match with following code:

```
sc = SparkContext(appName="PythonWordCount")
    common_words = ["the", "a", "an", "and", "of", "to", "in", "am",
"is", "are", "at", "not"]
    lines = sc.textFile(sys.argv[1], 1)
    counts = lines.flatMap(lambda x: re.split(r"[ \t,;\.\?!-:@\[\]\(\){}
_\*/]+", x)) \
                  .filter(lambda x: x.lower() not in common_words and
len(x) > 0) \
                  .map(lambda x: (x, 1)) \
                  .reduceByKey(add)
```

Step 2 (Alternative): Quit **nano**. Download the following source from the github:

```
# wget https://github.com/xldrx/mapreduce_examples/raw/master/tutorial/
second_example/wordcount.py
```

Step 3: Clear the output folder:

```
# hadoop fs -rm -r /tutorial/output
```

Step 4: Run the application:

```
# spark-submit ./wordcount.py /tutorial/input/ /tutorial/output/
```

Step 5: Check the results:

```
# hadoop fs -cat /tutorial/output/*
```

7. Do it your self

One other problem with the current output is that it is too long. In this section we will develop a new application which only shows the top 10 most commonly used words.

Step 1: Create a new Python source code file using the following command:

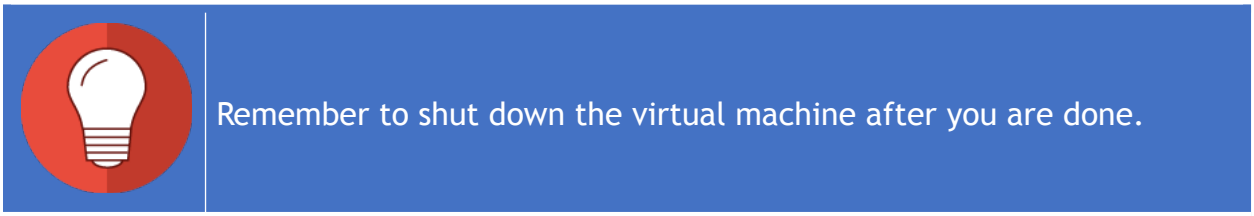
```
# nano topwords.python
```

Step 3: Type (or copy/paste) the Python code of **"Appendix C"** in the editor, and then quit **nano** and save the file.

Step 3 (Alternative): Quit **nano**. Download the following source from the github:

```
# wget https://github.com/xldrx/mapreduce_examples/raw/master/tutorial/
third_example/topwords.py
```

Step 4: Try to run this application yourself.



8. Questions to Think About

1. Why data should be on HDFS?
2. Why should the “output” folder be removed each time?

Appendix A: Word Count v1 Source Code

```
import sys
from operator import add

from pyspark import SparkContext


if __name__ == "__main__":
    if len(sys.argv) != 3:
        print("Usage: wordcount <input> <output>")
        exit(-1)
    sc = SparkContext(appName="PythonWordCount")
    lines = sc.textFile(sys.argv[1], 1)
    counts = lines.flatMap(lambda x: x.split(' ')) \
                  .map(lambda x: (x, 1)) \
                  .reduceByKey(add)
    counts.saveAsTextFile(sys.argv[2])
    sc.stop()
```

Appendix B: Word Count v2 Source Code

```
import sys
from operator import add

from pyspark import SparkContext
import re

if __name__ == "__main__":
    if len(sys.argv) != 3:
        print("Usage: wordcount <input> <output>")
        exit(-1)
    sc = SparkContext(appName="PythonWordCount")
    common_words = ["the", "a", "an", "and", "of", "to", "in",
"am", "is", "are", "at", "not"]
    lines = sc.textFile(sys.argv[1], 1)
    counts = lines.flatMap(lambda x: re.split(r"[ \t,;\.\?!-:@\
[\]\(\){}_\*/]+", x)) \
                  .filter(lambda x: x.lower() not in
common_words and len(x) > 0) \
                  .map(lambda x: (x, 1)) \
                  .reduceByKey(add)

    counts.saveAsTextFile(sys.argv[2])
    sc.stop()
```

Appendix C: Top Words Source Code

```
#! /usr/bin/env python -u
# coding=utf-8

__author__ = 'xl'

import sys
from operator import add

from pyspark import SparkContext
import re

if __name__ == "__main__":
    if len(sys.argv) != 3:
        print("Usage: wordcount <input> <output>")
        exit(-1)
    sc = SparkContext(appName="PythonWordCount")
    common_words = ["the", "a", "an", "and", "of", "to", "in",
"am", "is", "are", "at", "not"]
    lines = sc.textFile(sys.argv[1], 1)
    counts = lines.flatMap(lambda x: re.split(r"[ \t,;\.\?!-:@\
[\]\(\){}_\*/]+", x)) \
                  .filter(lambda x: x.lower() not in
common_words and len(x) > 0) \
                  .map(lambda x: (x, 1)) \
                  .reduceByKey(add) \
                  .map(lambda x: (x[1],x[0])) \
                  .sortByKey(ascending=False) \
                  .take(10)
    counts = sc.parallelize(counts) \
                  .map(lambda x: (x[1],x[0]))
    counts.saveAsTextFile(sys.argv[2])
    output = counts.collect()

    for (word, count) in output:
        print("%s: %i" % (word, count))


    sc.stop()
```