Exercise 4

Get started with Hadoop

Prior Knowledge
Unix Command Line Shell
Simple Python

Learning Objectives
Understand how to start and stop HDFS, and transfer files into and out of the Hadoop filesystem.
Understand how to create a Python mapper/reducer and execute this on a single-node setup of Hadoop.
Stop and start YARN.

Software Requirements
(see separate document for installation of these)

- Apache Hadoop 2.7.1
- Python 2.7.x
- Nano text editor or other text editor

Part A: Hadoop File System (HDFS)

1. Make sure you are running the Ubuntu VM, and start a fresh terminal window.

2. We need to clean up the Hadoop filesystem and re-format.
   First, make sure the hadoop fs is stopped:

   ```
   stop-dfs.sh
   ```

3. Now let's empty the HDFS storage directory.

   ```
   cd /usr/local/hadoop_store/hdfs
   pwd
   ```
   check that the output is /usr/local/hadoop_store/hdfs
   ```
   rm -rf *
   ```

4. Now let's format the HDFS filesystem:
   ```
   hadoop namenode -format
   ```

5. You should see a lot of output ending something similar to this:

```
15/10/22 09:15:20 INFO namenode.FSNamesystem: Retry cache on namenode is
enabled
15/10/22 09:15:20 INFO namenode.FSNamesystem: Retry cache will use 0.03
of total heap and retry cache entry expiry time is 600000 millis
15/10/22 09:15:20 INFO util.GSet: Computing capacity for map
NameNodeRetryCache
15/10/22 09:15:20 INFO util.GSet: VM type       = 64-bit
15/10/22 09:15:20 INFO util.GSet: 0.029999999329447746% max memory 889
MB = 273.1 KB
15/10/22 09:15:20 INFO util.GSet: capacity      = 2^15 = 32768 entries
15/10/22 09:15:20 INFO namenode.FSImage: Allocated new BlockPoolId: BP-
420615264-127.0.1.1-1445501720083
15/10/22 09:15:20 INFO common.Storage: Storage directory
/usr/local/hadoop_store/hdfs/namenode has been successfully formatted.
15/10/22 09:15:20 INFO namenode.NNStorageRetentionManager: Going to
retain 1 images with txid >= 0
15/10/22 09:15:20 INFO util.ExitUtil: Exiting with status 0
15/10/22 09:15:20 INFO namenode.NameNode: SHUTDOWN_MSG:
/************************************************************
SHUTDOWN_MSG: Shutting down NameNode at oxclo/127.0.1.1
************************************************************/
```

6. Now let's start the Hadoop filesystem. Type:

```
start-dfs.sh
```

You should see output like:

```
15/10/22 09:18:52 WARN util.NativeCodeLoader: Unable to load native-
hadoop library for your platform... using builtin-java classes where
applicable
Starting namenodes on [localhost]
localhost: starting namenode, logging to
/usr/local/hadoop/logs/hadoop-hduser-namenode-oxclo.out
localhost: starting datanode, logging to
/usr/local/hadoop/logs/hadoop-hduser-datanode-oxclo.out
Starting secondary namenodes [0.0.0.0]
0.0.0.0: starting secondarynamenode, logging to
/usr/local/hadoop/logs/hadoop-hduser-secondarynamenode-oxclo.out
15/10/22 09:19:08 WARN util.NativeCodeLoader: Unable to load native-
hadoop library for your platform... using builtin-java classes where
applicable
```

7. Now let's make a directory:

hadoop fs -mkdir -p /user/oxclo/wind

8. And check it worked:

```
hadoop fs -ls -R /
```

You should see:

```
15/10/22 09:24:48 WARN util.NativeCodeLoader: Unable to load native-hadoop
library for your platform... using builtin-java classes where applicable
drwxr-xr-x   - oxclo supergroup          0 2015-11-11 16:36 /user
drwxr-xr-x   - oxclo supergroup          0 2015-11-11 16:36 /user/oxclo
drwxr-xr-x   - oxclo supergroup          0 2015-11-11 16:36 /user/oxclo/wind
```

9. Now let's copy some datafiles from the local filesystem into the HDFS:

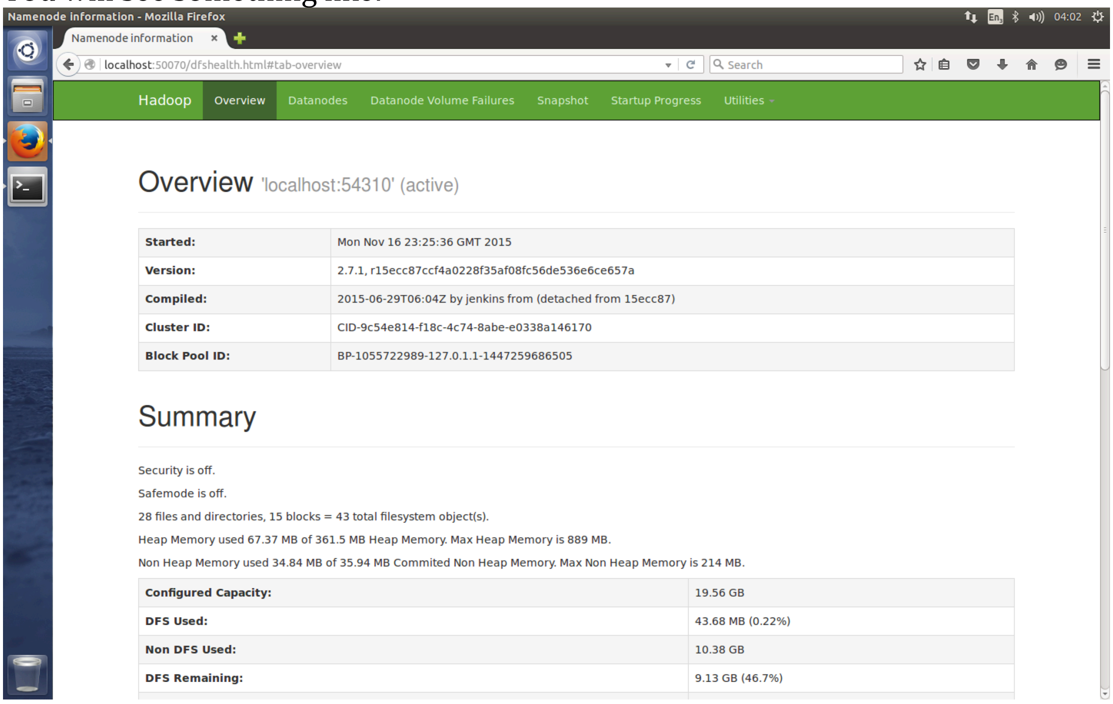
   hadoop fs -put datafiles/wind/2015/* /user/oxclo/wind
   If you repeat the command to list the files on the hadoop filesystem:

   ```
   hadoop fs -ls -R /
   ```

   you should see the new files in place:

```
15/10/22 09:45:07 WARN util.NativeCodeLoader: Unable to load native-hadoop library for
your platform... using builtin-java classes where applicable
drwxr-xr-x   - oxclo supergroup          0 2015-11-11 16:36 /user
drwxr-xr-x   - oxclo supergroup          0 2015-11-11 16:36 /user/oxclo
drwxr-xr-x   - oxclo supergroup          0 2015-11-11 16:37 /user/oxclo/wind
-rw-r--r--   1 oxclo supergroup    2716705 2015-11-11 16:37 /user/oxclo/wind/SF04.csv
-rw-r--r--   1 oxclo supergroup    7896961 2015-11-11 16:37 /user/oxclo/wind/SF15.csv
-rw-r--r--   1 oxclo supergroup    7250586 2015-11-11 16:37 /user/oxclo/wind/SF17.csv
-rw-r--r--   1 oxclo supergroup    5538010 2015-11-11 16:37 /user/oxclo/wind/SF18.csv
-rw-r--r--   1 oxclo supergroup    5818496 2015-11-11 16:37 /user/oxclo/wind/SF36.csv
-rw-r--r--   1 oxclo supergroup    4952077 2015-11-11 16:37 /user/oxclo/wind/SF37.csv
```

10. You can browse the HDFS Web UI by going to http://localhost:50070
    You will see something like:



1\.

   Take a look at the various tabs.

11. Congratulations you have successfully completed part A.

Part B. Creating a mapper and reducer, and running map reduce

12. We have a lot of environmental and wind data from San Francisco, which we can analyse for various information.

13. First, let's look at the format of the input data.
    Type

```
hadoop fs -cat /user/oxclo/wind/SF37.csv | head
```

You should see:

```
15/10/22 10:33:52 WARN util.NativeCodeLoader: Unable to load native-hadoop library for
your platform... using builtin-java classes where applicable
Station_ID,Station_Name,Location_Label,Interval_Minutes,Interval_End_Time,Wind_Velocity_
Mtr_Sec,Wind_Direction_Variance_Deg,Wind_Direction_Deg,Ambient_Temperature_Deg_C,Global_
Horizontal_Irradiance
SF37,"Chinatown Medical Center","Chinatown Medical Center",5,2015-01-5?
06:15,3.59,0,263.1,8.61,0
SF37,"Chinatown Medical Center","Chinatown Medical Center",5,2015-01-5?
06:20,3.342,0,268.3,8.58,0
SF37,"Chinatown Medical Center","Chinatown Medical Center",5,2015-01-5?
06:25,3.175,0,271.3,8.45,0
SF37,"Chinatown Medical Center","Chinatown Medical Center",5,2015-01-5?
06:30,2.586,0,279.7,8.45,0
SF37,"Chinatown Medical Center","Chinatown Medical Center",5,2015-01-5?
06:35,3.137,0,273.8,8.44,0
SF37,"Chinatown Medical Center","Chinatown Medical Center",5,2015-01-5?
06:40,2.781,0,277.9,8.54,0
SF37,"Chinatown Medical Center","Chinatown Medical Center",5,2015-01-5?
06:45,3.177,0,269.9,8.66,0
SF37,"Chinatown Medical Center","Chinatown Medical Center",5,2015-01-5?
06:50,2.802,0,277.5,8.72,0
SF37,"Chinatown Medical Center","Chinatown Medical Center",5,2015-01-5?
06:55,3.135,0,273.1,8.65,0
cat: Unable to write to output stream.
```

14. There is a header line and then a set of data, all in comma separated value (CSV) format.

15. Let's start by calculating maximum wind velocity for each district over the given period (the current year).

16. To do this, we can simply extract the Station_ID and the Wind_Velocity_Mtr_sec from each line using the mapper, and then we can summarize this information in the Reducer.

17. There is a skeleton mapper written for you at the URL: http://freo.me/oxclo-mapper

18. Create a directory for your code:
    mkdir ~/wind-analysis
    cd ~/wind-analysis

19. Edit this mapper to output the right key/value pairs.
    a. You can use any Unix text editor. If you know how, then nano is a good terminal based editor. Otherwise I would suggest using gedit, which is called "Text Editor" in the Ubuntu windowing system.

    b. The usual way of passing the key/value pairs from the mapper to the reducer is to use Tab delimited lines. A quick and easy way of printing those out in Python is to create an array of results and then use the join function to link them up with tabs:

    ```
    result = [ k, v ]
    print ('\t'.join(result))
    ```

    c. Don't forget that Python is tab/space sensitive!

20. Before we run this using Hadoop, we can simply test our script using the command-line.

a. We first need to make the mapper.py executable:
chmod +x ./wind-mapper.py

b. We will use the local copy of one of the files

c. Type:
```
cat ~/datafiles/wind/2015/SF37.csv | ./wind-mapper.py
```

d. You should see many data lines like this printed:
```
    SF37          7.079
```

21. Now we need to create a reducer:

    a. The first task is to find the maximum wind speed recorded for each station.

    b. Once again start with the skeleton that is provided in: http://freo.me/oxclo-reducer

    c. Create a file locally and edit it to work. Call it wind-reducer.py
    Don't forget to chmod +x ./wind-reducer.py

    d. I recommend using a python dictionary (https://docs.python.org/2/tutorial/datastructures.html#dictionaries).

    to collect the maximum value by station id.

    e. Hint: you need to convert the number to a string before printing it with the join function, you can do this by using str(max)

22. Check that your code works locally before we try it with Hadoop
```
cat ~/datafiles/wind/2015/SF37.csv \
| ./wind-mapper.py | ./wind-reducer.py
```

23. You should see:
```
SF37 7.079
```
printed out.

24. Now we are ready to run this as a map-reduce job using Hadoop. Firstly, this will run different files on (potentially) different systems and processes. Secondly, it will access the data from HDFS instead of the local file system.

25. Before we can run the map-reduce job, we need to start up YARN, the job scheduler.
    a. Type:
    ```
    start-yarn.sh
    ```
    b. You should see:

    ```
    starting yarn daemons
    ```

```
starting resourcemanager, logging to
/usr/local/hadoop/logs/yarn-hduser-resourcemanager-oxclo.out
localhost: starting nodemanager, logging to
/usr/local/hadoop/logs/yarn-hduser-nodemanager-oxclo.out
```

26. Now we can initiate the job. To run the python job, we utilize a generic capability of Hadoop to run code that uses standard input/output. Of course we've written those Python programs to do exactly that. This capability is called Hadoop Streaming

    a. Type (on one line)

       yarn jar /usr/local/hadoop/share/hadoop/tools/lib/hadoop-streaming-2.7.1.jar -input /user/oxclo/wind/ -output /user/oxclo/output -mapper ./wind-mapper.py -reducer ./wind-reducer.py

b. You should see a **lot** of log output, ending something similar to:

```
15/10/23 14:35:38 INFO mapred.Task: Task attempt_local1643623661_0001_r_000000_0 is
allowed to commit now
15/10/23 14:35:38 INFO output.FileOutputCommitter: Saved output of task
'attempt_local1643623661_0001_r_000000_0' to
hdfs://localhost:54310/usr/hduser/output/_temporary/0/task_local1643623661_0001_r_0000
00
15/10/23 14:35:38 INFO mapred.LocalJobRunner: Records R/W=235183/1 > reduce
15/10/23 14:35:38 INFO mapred.Task: Task 'attempt_local1643623661_0001_r_000000_0'
done.
15/10/23 14:35:38 INFO mapred.LocalJobRunner: Finishing task:
attempt_local1643623661_0001_r_000000_0
15/10/23 14:35:38 INFO mapred.LocalJobRunner: reduce task executor complete.
15/10/23 14:35:39 INFO mapreduce.Job:  map 100% reduce 100%
15/10/23 14:35:39 INFO mapreduce.Job: Job job_local1643623661_0001 completed
successfully
15/10/23 14:35:39 INFO mapreduce.Job: Counters: 35
        File System Counters
                FILE: Number of bytes read=6670124
                FILE: Number of bytes written=17106042
                FILE: Number of read operations=0
                FILE: Number of large read operations=0
                FILE: Number of write operations=0
                HDFS: Number of bytes read=170316404
                HDFS: Number of bytes written=44
                HDFS: Number of read operations=78
                HDFS: Number of large read operations=0
                HDFS: Number of write operations=9
        Map-Reduce Framework
                Map input records=392695
                Map output records=235183
                Map output bytes=2485256
                Map output materialized bytes=2955658
                Input split bytes=600
                Combine input records=0
                Combine output records=0
                Reduce input groups=5
                Reduce shuffle bytes=2955658
                Reduce input records=235183
                Reduce output records=4
                Spilled Records=470366
                Shuffled Maps =6
                Failed Shuffles=0
                Merged Map outputs=6
                GC time elapsed (ms)=300
                Total committed heap usage (bytes)=3470262272
        Shuffle Errors
                BAD_ID=0
                CONNECTION=0
                IO_ERROR=0
                WRONG_LENGTH=0
                WRONG_MAP=0
                WRONG_REDUCE=0
        File Input Format Counters
                Bytes Read=34172835
        File Output Format Counters
                Bytes Written=44
15/10/23 14:35:39 INFO streaming.StreamJob: Output directory: /usr/hduser/output
```

c. Now you can check if there is any output:

```
hadoop fs –cat /user/oxclo/output/part-00000
```

d. You should see:

```
15/10/23 14:38:44 WARN util.NativeCodeLoader: Unable to load
native-hadoop library for your platform... using builtin-java
classes where applicable
SF04   34.12
SF36   11.05
SF15   7.92
SF17   5.767
SF18   10.57
SF37   7.079
```

27. If you do not see the same output, then check your code and re-run. If you re-run you will need to specify a new output directory (e.g. output-2).

28. Now modify your code to calculate the average wind velocity at each station.

    Hint 1: copy your reducer.py code to reducer-average.py to start with.
    Hint 2: you shouldn't need to change the mapper
    Hint 3: you will need to specify a new output directory

    Run your code using hadoop and compare your answers to these:

```
SF04 2.30098174812
SF36 2.46417253091
SF15 1.82141456775
SF17 0.518350025349
SF18 2.22022343917
SF37 2.2604035055
```

29. Congratulations! You have completed this exercise.

30. If you want to see a sample of code that calculates both the maxes and the averages, it is here: https://github.com/pzfreo/ox-clo/tree/master/code/wind-analysis/complete

31. Extension:
    Determine which direction (N,NE,E,SE,S,SW,W,NW) has had the strongest average winds this year across all stations.