ECE4721J - Lab 2 Report

Methods and Tools for Big Data

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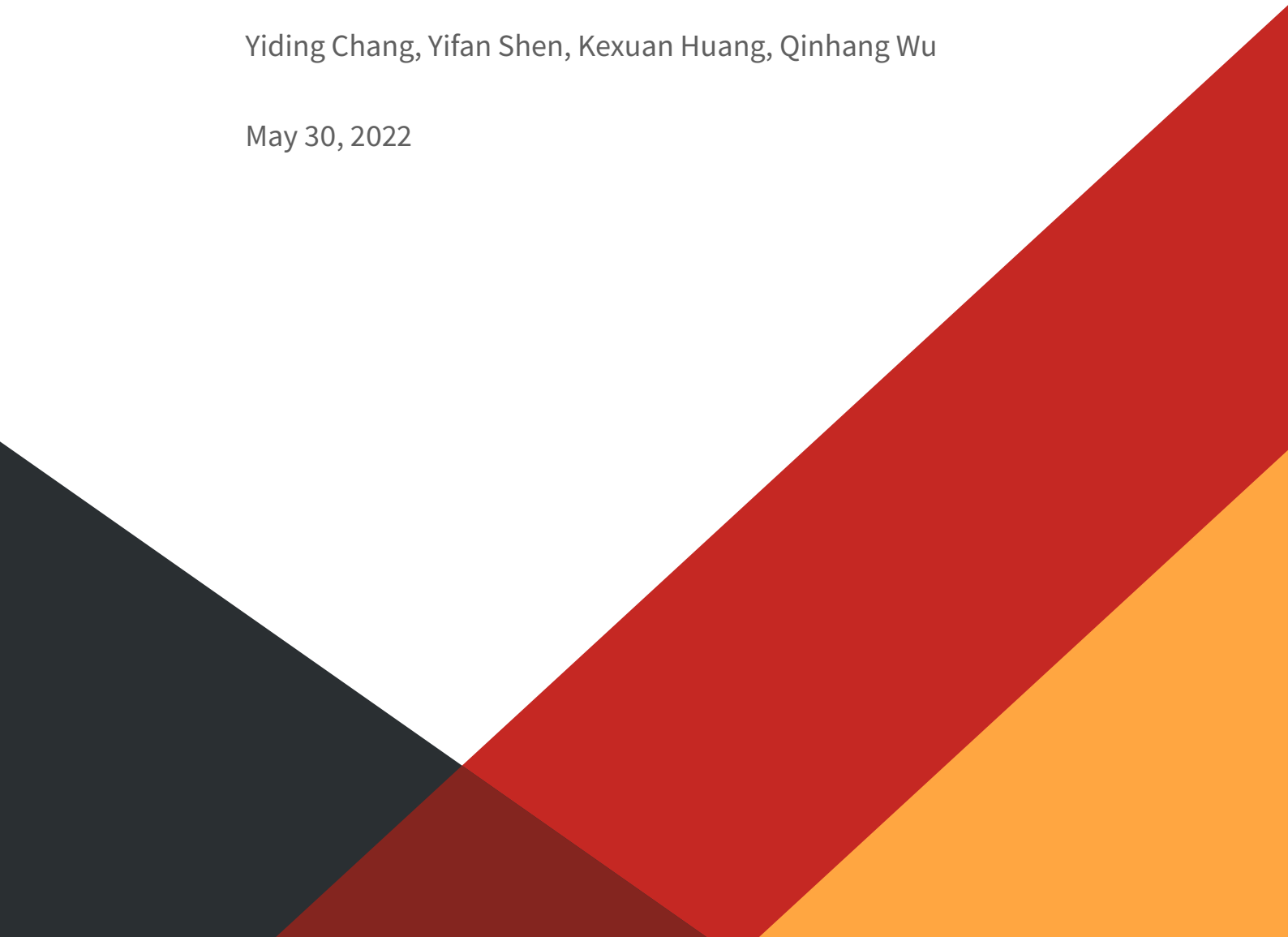
May 30, 2022



1. Input File Generation

We first randomly 1000 students with `generate.py`. Then we use `grading.sh` and `grading.awk` to randomly assign student ID and grades for these 1000 students, with each student randomly appear a number of times depending on the input data size. The input files we used are as follows,

Number of students	File Size
1000	29 KB
10000	287 KB
100000	2.8 MB
1000000	28.7 MB
10000000	286.9 MB
100000000	2.87 GB

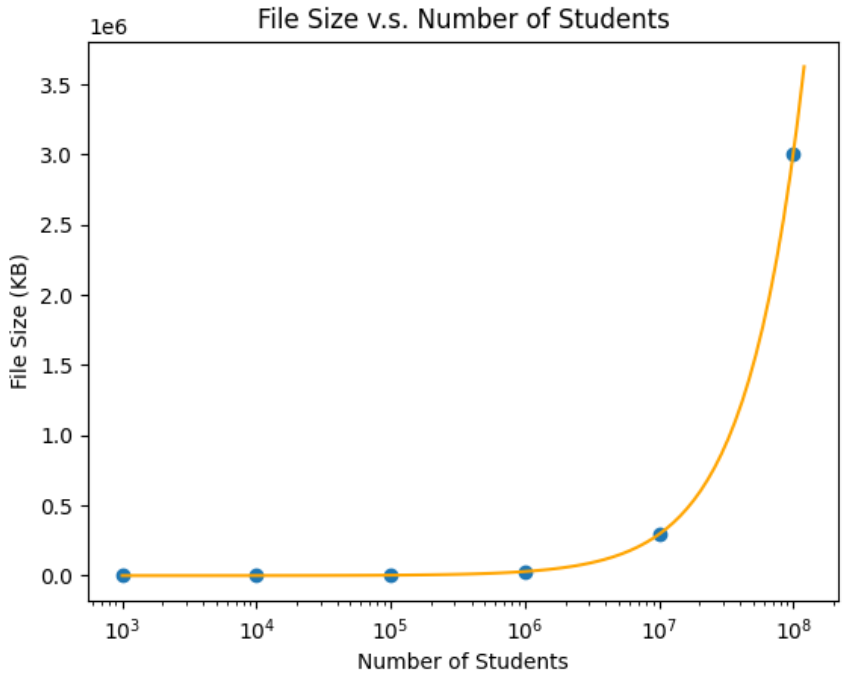


Figure 1: File Generation

2. Performance on a single computer

The CPU of the computer used in this session is 2.3 GHz Dual-Core Intel Core i5 and the RAM is 8 GB.

The command used is listed in the last section of this report. A sample output is attached as well.

The speed (total time in the unit of seconds) versus the size of the file is as follows,

Number of students	File Size	Total Time (s)
1000	29 KB	4.088
10000	287 KB	4.826
100000	2.8 MB	5.189
1000000	28.7 MB	8.904
10000000	286.9 MB	55.917
100000000	2.87 GB	534

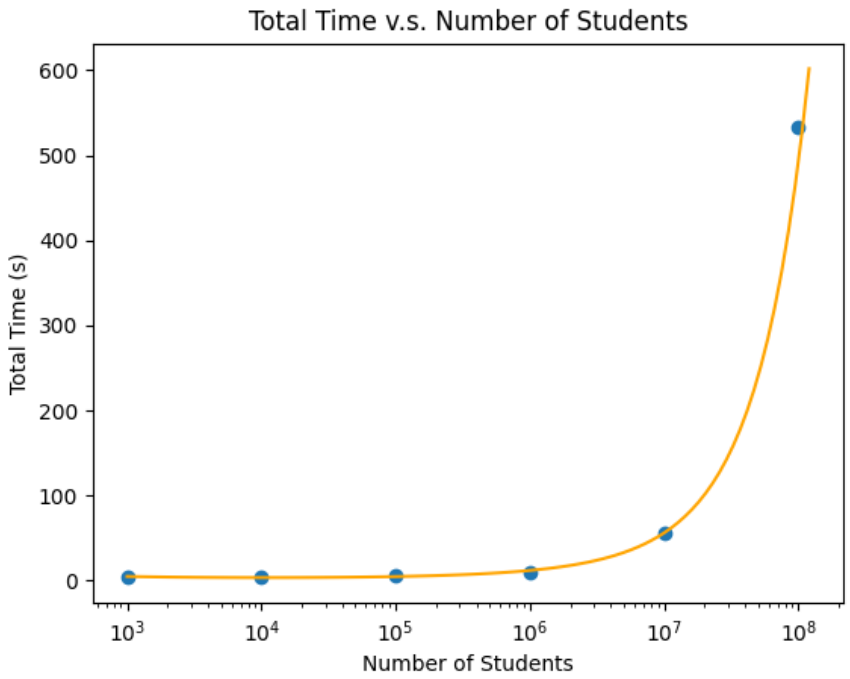


Figure 2: Single Performance

3. Performance on the group cluster

4. Hadoop MapReduce

The Apache Hadoop is a framework supporting the distributed processing of large data sets across clusters of computers, which takes advantage of the MapReduce programming model that processes and generates big data sets with distributed algorithm on a cluster. MapReduce mainly consists of:

- Mapper: takes splitted input from the disk as <`key`,`value`> pairs, processes them, and produces another intermediate <`key`,`value`> pairs as output.
- Reducer: takes <`key`,`value`> pairs with the same key, aggregates the values, and produces new useful <`key`,`value`> pairs as output.

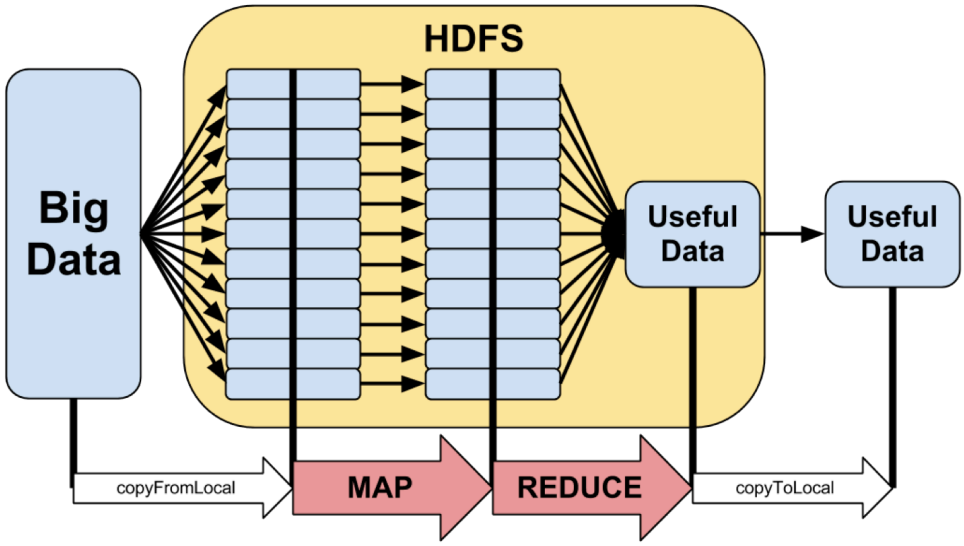


Figure 3: Hadoop MapReduce

a. Generate Raw Data

- Run: `python generate.py`
- Python module: `names`, `random`
- Input: None
- Ouput: 3 text files in `data/`
  - `firstnames.txt`
  - `lastnames.txt`

- id.txt

Code for `generate.py`

```python
import os
import random
import names

DATA_NUMBER = 1000
ENTRY_NUMBER = 10000

BASE_DIR = "data/"

id = set()
firstnames = set()
lastnames = set()


def generate_raw():

    for _ in range(DATA_NUMBER):
        id.add(random.randint(1000000000, 9999999999))

    for _ in range(DATA_NUMBER):
        firstnames.add(names.get_first_name())

    for _ in range(DATA_NUMBER):
        lastnames.add(names.get_last_name())

    if (not os.path.exists(BASE_DIR)):
        os.makedirs(BASE_DIR)

    with open(os.path.join(BASE_DIR, 'id.txt'), 'w') as f:
        for i in id:
            f.write(str(i) + '\n')

    with open(os.path.join(BASE_DIR, 'firstnames.txt'), 'w') as f:
        for i in firstnames:
            f.write(i + '\n')

    with open(os.path.join(BASE_DIR, 'lastnames.txt'), 'w') as f:
        for i in lastnames:
            f.write(i + '\n')


def generate_csv():
    first = list(firstnames)
    last = list(lastnames)
    ID = list(id)
```

```
46      with open("grades.csv", 'w') as f:
47          for i in range(ENTRY_NUMBER):
48              rand = random.randint(0, min(len(first), len(last), len(ID)
                    )-1)
49              grade = random.randint(0, 100)
50              f.write("{} {},{},{}\n".format(
51                  first[rand], last[rand], ID[rand], grade))
52
53
54  if "__main__" == __name__:
55      generate_raw()
56      generate_csv()
```

b. Generate `grades.csv`

- run: `./grading.sh`

c. Mapper

- run: `./mapper.sh < grades.csv`
- Usage: Reads `stdin` with name, studentID and grades separated by newline. Returns the tab-separated pair: `studentID<TAB>grade`
- Input: `stdin` (e.g `Michael Huang,0123456789,100`)
- Output: `stdout` (e.g `0123456789<TAB>10`)
- Test: Use input redirection to read from file `grades.csv`

Code for `mapper.sh`

```
1  #!/bin/bash
2  # Reads STDIN with name, studentID and grades separated by newline
3  # Returns the tab-separated pair: studentID<TAB>grade
4  # Output:
5  #    STDOUT: 0123456789<TAB>100
6
7  awk -F "," '{printf "%s\t%s\n", $2, $3}'
```

d. Reducer

- run: `./reducer.sh < data/reducer.in`
- Usage: Reads pairs from the standard input. Each tab-separated pair is composed of a studentID and a list of grades. Returns the max grade for each student on the standard output.

- Input: `stdin` (e.g. `0123456789<TAB>86 100 92`)
- Output: A single number as the max grade (e.g. `100`)
- Test: Use input redirection to read from file `data/reducer.in`

Code for `reducer.py`

```python
#!/usr/bin/python
#coding:utf-8

import sys

def reduce():

    roster = {}

    # build roster
    line = sys.stdin.readline()
    while line:
        entry = line.split()
        ID = entry[0]
        grade = int(entry[1])
        roster.setdefault(ID, []).append(grade)
        line = sys.stdin.readline()

    # find max grade
    for ID in sorted(roster.keys()):
        print("{} {}".format(ID, max(roster[ID])))


if "__main__" == __name__:
    reduce()
```

e. Hadoop Pseudo distribution

Run the following command for Streaming and Mapreduce,

```
time hadoop jar share/hadoop/tools/lib/hadoop-streaming-3.3.2.jar -
   input input/lab2/grades.csv -output output -mapper mapper.sh -
   reducer reducer.sh -file ~/Downloads/lab2/mapper.sh  -file ~/
   Downloads/lab2/reducer.sh
```

HDFS

```
hdfs dfs -ls <dir_in_hdfs>
```

```
hdfs dfs -mkdir <dir_in_hdfs>
hdfs dfs -put <file_in_your_system> <dir_in_hdfs>
hdfs dfs -get <file_in_hdfs>
hdfs dfs -rm -r -f output/ # you need to empty the output directory everytime you want to rerun the code, you will see a message if rm is successful
```

You can check via Utilities->Browse file system in `localhost:9870` to check the directory and files on the hdfs.

Streaming

In your hadoop home directory, run streaming with package: `share/hadoop/tools/lib/hadoop-streaming-3.3.2.jar` via the following command after you have created `dir_in_hdfs` for `inputdir` and `outputdir`.

```
hadoop jar share/hadoop/tools/lib/hadoop-streaming-3.3.2.jar -input inputdir -output outputdir -mapper mapper.sh -reducer reducer.sh -file localdirectorymapper.sh  -file localdirectoryreducer.sh
```

Notes:

- `reducer.sh` and `mapper.sh` can be local file, while inputfile is in the HDFS
- Error handling
  - `WARN org.apache.hadoop.streaming.PipeMapRed: java.io.IOException`
    - Check if `#!/usr/bin/env python` is included if you are using Python
    - Check if exception handling is correct in the shell scripts