CSC 555 Mining Big Data

Assignment 2 (due Sunday, 4/28)

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Suggested reading: *Mining of Massive Datasets*: Chapter 2.

Hadoop: The Definitive Guide: Chapter 17 (Hive).

1) Describe how you would implement a MapReduce job consisting of Map and Reduce description. You can describe it in your own words or as pseudo-code. Keep in mind that map task reads the input file and produces (key, value) pairs. Reduce task takes a list of (key, value) pairs for each key and combines all values for each key.
   Remember that Map operates on individual blocks and Reduce on individual keys with a set of values. Thus, for Mapper you need to state what your code does given a block of data and for Reduce you need to state what your reducer does <u>for each key</u>. You don't have to explain how to parse the file and extract numbers/names.

   a) For a Student table (ID, Name, Advisor, Year, Month), convert

   ```
   SELECT Year, Month, COUNT(*)
   FROM Student
   GROUP BY Year, Month;
   ```

   For each block of data, the mapper will produce key value pairs consisting of Year and Month as the key and ID, Name and Advisor as the value. The reducer will perform a count of all of the occurrences of each key. Because the ID, Name and Advisor value itself is not actually needed to determine the result, the mapper could assign a value of 1 for each key and the reducer would simply sum all of the records for each key.

   b) For Employee(EID, First, Last, Phone, Age) and Agent(AID, First, Last, Address), find everyone with the same name using MapReduce:

   ```
   SELECT a.First, a.Last, EID, AID, Phone
   FROM Employee as e, Agent as a
   WHERE e.Last = a.Last AND e.First = a.First;
   ```

   Blocks will come from either table Employee or table Agent. The mapper will produce keys containing First and Last from each block. The values will depend upon which table the block came from. For Employee, the values will be EID, Phone, and a table identifier (could be the name or some assigned id). From Agent, the values will be AID and a table identifier.

   The reducer will combine values where the keys from Employee match the keys from Agent.

   c) Same tables:

   ```
   SELECT Age, COUNT(DISTINCT a.First)
   FROM Employee, Agent
   WHERE EID = AID
   GROUP BY Age;
   ```

Blocks will come from either table Employee or table Agent. The mapper will produce keys containing either EID or AID from each block, depending upon which table the block is from. The values will depend upon which table the block came from. For Employee, the values will be Age and a table identifier (could be the name or some assigned id). From Agent, the values will be First and a table identifier.

There reducer will have multiple steps. First the reducer will combine values from Employee with values from Agent where the keys match, in this case EID and AID. Next the reducer will remove duplicate values of First and Age, meaning, for a given Age, a specific First value should only occur once. Finally, the reducer will count each of the remaining records for each age value.

Note, the record matching and deduplication could also be performed by using a combiner prior to sending to the reducer.

2) Suppose you are tasked with analysis of the company's web server logs. The log dump contains a large amount of information with up to 10 different attributes (columns). You regularly run a Hadoop job to perform analysis pertaining to 3 specific attributes – TimeOfAccess, OriginOfAccess and FileName.

a) Name two possible ways to speed up log analysis of your Hadoop job

1. Tuning the Number of Mapper or Reducer Tasks
2. Writing a Combiner to reduce the load of the reduce task

b) If a Mapper task fails while processing a block of data – what is the location (i.e., which node) where MapReduce framework will prefer to restart it?

The Master node, aka Name node, is responsible for detecting failures and will restart all of the Map tasks assigned to that Mapper.

c) If the job is executed with 5 Reducers

i) How many files does the output generate?

Five

ii) Suggest one possible hash function that may be used to assign keys to reducers.

From the TimeOfAccess attribute, apply the following function to the minutes value.

Minutes MOD 5

Assuming that the possible minutes values have a relatively equal rate of occurrence, this hash function will evenly distribute keys to the 5 reducers.

d) True or False?

i) A message that was encrypted with a public key can be decrypted with a corresponding private key

True

ii) A message that was encrypted with a private key can be decrypted with a corresponding public key

Technically true, you may do this as a means of signing the message for authenticity. However, you would not do this in practice to secure a message.

iii) A message that was encrypted with a public key can only be read by its intended recipient, the holder of the private key

True

3) Consider a Hadoop job that processes an input data file of size equal to 42 disk blocks (42 different blocks, you can assume that HDFS replication factor is set to 1). The mapper in this job requires 1 minute to read and fully process a single block of data. For the purposes of this assignment, you can assume that the reduce part of this job takes zero time.

a) Approximately how long will it take to process the file if you only had one Hadoop worker node? You can assume that that only one mapper is created on every node.

42 minutes

b) 20 Hadoop worker nodes?

3 minutes

c) 50 Hadoop worker nodes?

1 minute

d) 75 Hadoop worker nodes?

1 minute

e) Now suppose you were told that the replication factor has been changed to 3? That is, each block is stored in triplicate, but file size is still 45 blocks. Which of the answers (if any) in a)-c) above will have to change?

The write time of the reduce tasks will increase.

You can ignore the network transfer costs and other potential overheads as well as the possibility of node failure. If you feel some information is missing please be sure to state your assumptions.

4) In this section we are going to use Hive to run a few queries over the Hadoop framework. These instructions assume that you are starting from a working Hadoop installation. It should be sufficient to start your instance and the Hadoop framework on it.

   Hive commands are listed in **Calibri bold font**

   a) Download and install Hive:

      cd
      (this command is there to make sure you start from home directory, on the same level as where hadoop is located)
      wget http://rasinsrv07.cstcis.cti.depaul.edu/CSC555/apache-hive-2.0.1-bin.tar.gz
      gunzip apache-hive-2.0.1-bin.tar.gz
      tar xvf apache-hive-2.0.1-bin.tar

      set the environment variables (can be automated by adding these lines in ~/.bashrc). If you don't, you will have to set these variables every time you use Hive.
      export HIVE_HOME=/home/ec2-user/apache-hive-2.0.1-bin
      export PATH=$HIVE_HOME/bin:$PATH

      $HADOOP_HOME/bin/hadoop fs -mkdir /tmp
      $HADOOP_HOME/bin/hadoop fs -mkdir /user/hive/warehouse
      (if you get an error here, it means that /user/hive does not exist yet. Fix that by running **$HADOOP_HOME/bin/hadoop fs -mkdir -p /user/hive/warehouse instead)**

      $HADOOP_HOME/bin/hadoop fs -chmod g+w /tmp
      $HADOOP_HOME/bin/hadoop fs -chmod g+w /user/hive/warehouse

      We are going to use Vehicle data (originally from http://www.fueleconomy.gov/feg/download.shtml)

      You can get the already unzipped, comma-separated file from here:
      wget http://rasinsrv07.cstcis.cti.depaul.edu/CSC555/vehicles.csv

      You can take a look at the data file by either
      nano vehicles.csv or
      more vehicles.csv (you can press space to scroll and q or Ctrl-C to break out)

      Note that the first row in the data is the list of column names. What follows after commands that start Hive, is the table that you will create in Hive loading the first 5 columns. Hive is not particularly sensitive about invalid or partial data, hence if we only define the first 5 columns, it will simply load the first 5 columns and ignore the rest. You can see the description of all the columns here (atvtype was added later) http://www.fueleconomy.gov/feg/ws/index.shtml#vehicle

Create the ec2-user directory on the HDFS side (absolute path commands should work anywhere and not just in Hadoop directory as bin/hadoop does). Here, we are creating the user "home" directory on the HDFS side.

```
hadoop fs -mkdir /user/ec2-user/
```

Run hive (from the hive directory because of the first command below):

```
cd $HIVE_HOME
$HIVE_HOME/bin/schematool -initSchema -dbType derby
```

(NOTE: This command initializes the database metastore. If you need to restart/reformat or see errors related to meta store, run **rm -rf metastore_db/** and then repeat the above initSchema command)

```
bin/hive
```

You can now create a table by pasting this into the Hive terminal:

```
CREATE TABLE VehicleData (
barrels08 FLOAT, barrelsA08 FLOAT,
charge120 FLOAT, charge240 FLOAT,
city08 FLOAT)
ROW FORMAT DELIMITED FIELDS
TERMINATED BY ',' STORED AS TEXTFILE;
```

You can load the data (from the local file system, not HDFS) using:

```
LOAD DATA LOCAL INPATH '/home/ec2-user/vehicles.csv'
OVERWRITE INTO TABLE VehicleData;
```

(NOTE: If you downloaded vehicles.csv file into the hive directory, you have to change file name to /home/ec2-user/apache-hive-2.0.1-bin/vehicles.csv instead)

Verify that your table had successfully loaded by running

```
SELECT COUNT(*) FROM VehicleData;
```

(Copy the query output and report how many rows you got as an answer.)

```
hive> SELECT COUNT(*) FROM VehicleData;
WARNING: Hive-on-MR is deprecated in Hive 2 and may not be available
in the future versions. Consider using a different execution engine
(i.e. spark, tez) or using Hive 1.X releases.
Query ID = ec2-user_20190429235252_c0d00542-eee1-4160-a670-
748f8d4e1787
```

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```
Total jobs = 1
Launching Job 1 out of 1
Number of reduce tasks determined at compile time: 1
In order to change the average load for a reducer (in bytes):
  set hive.exec.reducers.bytes.per.reducer=<number>
In order to limit the maximum number of reducers:
  set hive.exec.reducers.max=<number>
In order to set a constant number of reducers:
  set mapreduce.job.reduces=<number>
Starting Job = job_1556581144464_0001, Tracking URL = http://ip-172-
31-29-137.us-east-
2.compute.internal:8088/proxy/application_1556581144464_0001/
Kill Command = /home/ec2-user/hadoop-2.6.4/bin/hadoop job  -kill
job_1556581144464_0001
Hadoop job information for Stage-1: number of mappers: 1; number of
reducers: 1
2019-04-29 23:53:05,467 Stage-1 map = 0%,  reduce = 0%
2019-04-29 23:53:13,289 Stage-1 map = 100%,  reduce = 0%, Cumulative
CPU 1.21 sec
2019-04-29 23:53:22,059 Stage-1 map = 100%,  reduce = 100%, Cumulative
CPU 2.44 sec
MapReduce Total cumulative CPU time: 2 seconds 440 msec
Ended Job = job_1556581144464_0001
MapReduce Jobs Launched:
Stage-Stage-1: Map: 1  Reduce: 1   Cumulative CPU: 2.44 sec   HDFS
Read: 11775010 HDFS Write: 6 SUCCESS
Total MapReduce CPU Time Spent: 2 seconds 440 msec
OK
34175
Time taken: 30.672 seconds, Fetched: 1 row(s)
```

Run a couple of HiveQL queries to verify that everything is working properly:

SELECT MIN(barrels08), AVG(barrels08), MAX(barrels08) FROM VehicleData;
(copy the output from that query)

```
hive> SELECT MIN(barrels08), AVG(barrels08), MAX(barrels08) FROM
VehicleData;
WARNING: Hive-on-MR is deprecated in Hive 2 and may not be available
in the future versions. Consider using a different execution engine
(i.e. spark, tez) or using Hive 1.X releases.
Query ID = ec2-user_20190429235812_47318e48-fac7-4b48-8bb0-
031f48fa1424
Total jobs = 1
Launching Job 1 out of 1
Number of reduce tasks determined at compile time: 1
In order to change the average load for a reducer (in bytes):
  set hive.exec.reducers.bytes.per.reducer=<number>
In order to limit the maximum number of reducers:
  set hive.exec.reducers.max=<number>
```

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```
In order to set a constant number of reducers:
  set mapreduce.job.reduces=<number>
Starting Job = job_1556581144464_0002, Tracking URL = http://ip-172-
31-29-137.us-east-
2.compute.internal:8088/proxy/application_1556581144464_0002/
Kill Command = /home/ec2-user/hadoop-2.6.4/bin/hadoop job  -kill
job_1556581144464_0002
Hadoop job information for Stage-1: number of mappers: 1; number of
reducers: 1
2019-04-29 23:58:20,537 Stage-1 map = 0%,  reduce = 0%
2019-04-29 23:58:28,046 Stage-1 map = 100%,  reduce = 0%, Cumulative
CPU 1.79 sec
2019-04-29 23:58:35,534 Stage-1 map = 100%,  reduce = 100%, Cumulative
CPU 3.0 sec
MapReduce Total cumulative CPU time: 3 seconds 0 msec
Ended Job = job_1556581144464_0002
MapReduce Jobs Launched:
Stage-Stage-1: Map: 1  Reduce: 1   Cumulative CPU: 3.0 sec   HDFS
Read: 11777415 HDFS Write: 37 SUCCESS
Total MapReduce CPU Time Spent: 3 seconds 0 msec
OK
0.059892 17.820177449476272   47.06831
Time taken: 24.201 seconds, Fetched: 1 row(s)
```

SELECT (barrels08/city08) FROM VehicleData;
(you do not need to report the output from that query, but report "Time taken")

```
Time taken: 0.129 seconds, Fetched: 34175 row(s)
```

Next, we are going to output three of the columns into a separate file (as a way to transform data for further manipulation that you may be interested in)

INSERT OVERWRITE DIRECTORY 'ThreeColExtract'
SELECT barrels08, city08, charge120
FROM VehicleData;

You can now exit Hive by running **exit;**

And verify that the new output file has been created (the file will be called 000000_0)
The file would be created in HDFS in user home directory (/user/ec2-user/ThreeColExtract)

Report the size of the newly created file and include the screenshot.

Size = 627,873 bytes

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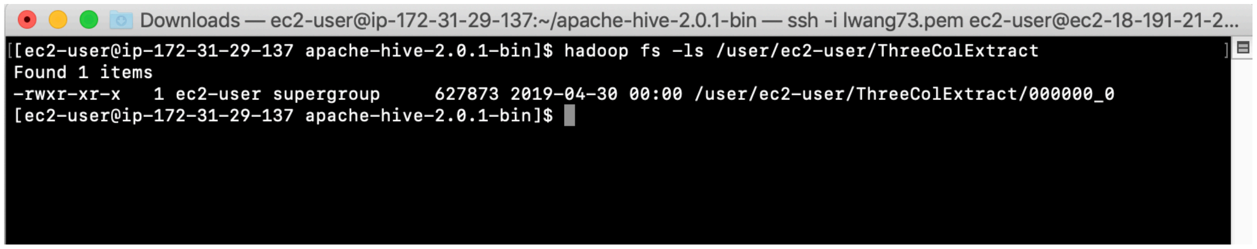


Downloads — ec2-user@ip-172-31-29-137:~/apache-hive-2.0.1-bin — ssh -i lwang73.pem ec2-user@ec2-18-191-21-2...

```
[[ec2-user@ip-172-31-29-137 apache-hive-2.0.1-bin]$ hadoop fs -ls /user/ec2-user/ThreeColExtract
 Found 1 items
 -rwxr-xr-x   1 ec2-user supergroup     627873 2019-04-30 00:00 /user/ec2-user/ThreeColExtract/000000_0
 [ec2-user@ip-172-31-29-137 apache-hive-2.0.1-bin]$
```

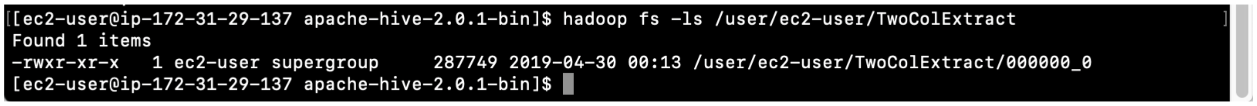
Next, you should go back to the Hive terminal, create a new table that is going to load 8 columns instead of 5 in our example (i.e. create and load a new table that defines 8 columns by including columns city08U,cityA08,cityA08U) and use Hive to generate a new output file containing only the city08U and cityA08U columns from the vehicles.csv file. Report the size of that output file as well.

CREATE TABLE VehicleData2 (
barrels08 FLOAT, barrelsA08 FLOAT,
charge120 FLOAT, charge240 FLOAT,
city08 FLOAT, city08U FLOAT,
cityA08 FLOAT, cityA08U FLOAT)
ROW FORMAT DELIMITED FIELDS
TERMINATED BY ',' STORED AS TEXTFILE;

LOAD DATA LOCAL INPATH '/home/ec2-user/vehicles.csv'
OVERWRITE INTO TABLE VehicleData2;

INSERT OVERWRITE DIRECTORY 'TwoColExtract'
SELECT city08U, cityA08U
FROM VehicleData2;

Size = 287,749 bytes



```
[[ec2-user@ip-172-31-29-137 apache-hive-2.0.1-bin]$ hadoop fs -ls /user/ec2-user/TwoColExtract
 Found 1 items
 -rwxr-xr-x   1 ec2-user supergroup     287749 2019-04-30 00:13 /user/ec2-user/TwoColExtract/000000_0
 [ec2-user@ip-172-31-29-137 apache-hive-2.0.1-bin]$
```

<u>Submit a single document containing your written answers. Be sure that this document contains your name and "CSC 555 Assignment 2" at the top.</u>