Northeastern University

H1B Petitions Data Analysis

Final Project

INFO7275 Advanced Database Mgt Sys (Fall 2017)

Ujjval Hemant Thakkar

NUID: 001232511

13/12/2017

Contents

Problem Statement

The H-1B is an employment-based, non-immigrant visa category for temporary foreign workers in the United States. For a foreign national to apply for H1-B visa, an US employer must offer a job and petition for H-1B visa with the US immigration department. This is the most common visa status applied for and held by international students once they complete college/ higher education (Masters, PhD) and work in a full-time position.

We will be performing the following analysis on this H1B visa petition applications between the years 2011-2016 using **Hadoop MapReduce Jobs**:

- Number of Full time and Part time petitions (***Normal MR Job***)
- Number of petitions based on Location (***Counting with counters Summarization***)
- Predictive yearly analysis of successful certification of the petitions (***Numerical Summarization, Standard Deviation, MR Chaining***)
- Top 10 employers to file the most petitions (***Top N Filtering Pattern, Partitioner***)
- Most Data Engineer jobs for each year for each Location (**Top N Filtering Pattern, Partitioner**)
- Categorizing petitions filed for a "CEO" for each year (***Binning Data Organization Pattern***)
- Successful Petitions based on the Wages (**Inverted Index Pattern**)

The following analysis is performed using **HIVE**:

- Most Data Scientist positions by Industry (HIVE)
- Top 10 Most petitions filed by Employers by Year (HIVE)
- Counting number of petitions based on Location (HIVE)
- Categorizing petitions filed for a "CEO" for each year (HIVE)
- Counting of Number of Full time and Part time petitions (HIVE)

The following analysis is performed using **PIG**:

- Top Data Engineer Locations for each year (PIG)
- Top10 Industry by most Data Scientist positions (PIG)

Dataset

Link: https://www.kaggle.com/nsharan/h-1b-visa/data

The columns in the dataset include:

The **CASE_STATUS** field denotes the status of the application after LCA processing. Certified applications are filed with USCIS for H-1B approval. **CASE_STATUS: CERTIFIED** does not mean the applicant got his/her H-1B visa approved, it just means that he/she is eligible to file an H-1B.

i) **CASE_STATUS:** Status associated with the last significant event or decision. Valid values include "Certified," "Certified-Withdrawn," Denied," and "Withdrawn".
ii) **EMPLOYER_NAME:** Name of employer submitting labor condition application.
iii) **SOC_NAME:** Occupational name associated with the SOC_CODE. SOC_CODE is the occupational code associated with the job being requested for temporary labor condition, as classified by the Standard Occupational Classification (SOC) System.
iv) **JOB_TITLE:** Title of the job
v) **FULL_TIME_POSITION:** Y = Full Time Position; N = Part Time Position
vi) **PREVAILING_WAGE:** Prevailing Wage for the job being requested for temporary labor condition. The wage is listed at annual scale in USD. The prevailing wage for a job position is defined as the average wage paid to similarly employed workers in the requested occupation in the area of intended employment. The prevailing wage is based on the employer's minimum requirements for the position.
vii) **YEAR:** Year in which the H-1B visa petition was filed
viii) **WORKSITE:** City and State information of the foreign worker's intended area of employment
ix) **lon:** longitude of the Worksite
x) **lat:** latitude of the Worksite

Raw dataset description:
https://www.foreignlaborcert.doleta.gov/docs/Performance_Data/Disclosure/FY15-FY16/H-1B_FY16_Record_Layout.pdf

H-1B process: http://www.immi-usa.com/h1b-application-process-step-by-step-guide/

Analysis Description

Command used to copy the dataset from Local to HDFS:

hadoop fs -copyFromLocal /home/ujjvalthakkar/Desktop/InputFiles/H1BData/h1b_kaggle.csv /user/ujjvalthakkar/ProjectFiles/DataSet

HDFS Dataset Location: */user/ujjvalthakkar/ProjectFiles/DataSet/h1b_kaggle.csv*

1. Number of Full-time and Part-time petitions (Normal MR Job)

We are analyzing the number of petitions that are filed for Part-time and the Full-time positions.

1. In the ***H1BSucessFailureMapper,*** we read every petition from the dataset and filter the petitions based on the value of the FULL_TIME_POSITION column. If the value is 'Y' it is a Full Time Position, if the value is 'N' is it a Part Time Position.
2. We set the text key to be FULL TIME or PART TIME and IntWritable value as the count 1.
3. In the ***H1BSucessFailureReducer,*** we read all the values for individual keys and count a total sum, which gives us the number of Part-time and Full-time positions

Command to Execute Jar:

hadoop jar /home/ujjvalthakkar/eclipse-workspace/ADBMS_PROJECT/target/mapreduce_wordcount-0.0.1-SNAPSHOT.jar com.neu.h1BAnalysis.H1BFullTimeCount /user/ujjvalthakkar/ProjectFiles/DataSet/h1b_kaggle.csv /home/ujjvalthakkar/Desktop/ProjectOutputFiles

2. Counting number of petitions based on Location (Counting with counters Summarization)

We are analyzing the number of petitions based on locations. This would help us understand where in the United States is the need for most number of H1B employees. Since we are using the counting with counters summarization pattern, there is no reducer and this is a map only job.

1. In the ***CountPetitionsPerLocationMapper***, we maintain an array of states **statesArray** and two context counter groups ***STATE_COUNTER_GROUP*** and ***UNKNOWN_COUNTER***.
2. After extracting the location of the petition from the WORKSITE column, we fetch the respective state's counter from the context and increment it.
3. In the driver, upon completion of the mapper, we can fetch the counter and print the number of applications from each state.

```
public static class CountPetitionsPerLocationMapper extends Mapper<LongWritable, Text, NullWritable, NullWritable> {

    public static final String STATE_COUNTER_GROUP = "State";
    public static final String UNKNOWN_COUNTER = "Unknown";

    String[] statesArray = new String[] { "CALIFORNIA", "ALABAMA", "ARKANSAS", "ARIZONA", "ALASKA", "COLORADO",
            "CONNECTICUT", "DELAWARE", "FLORIDA", "GEORGIA", "HAWAII", "IDAHO", "ILLINOIS", "INDIANA", "IOWA",
            "KANSAS", "KENTUCKY", "LOUISIANA", "MAINE", "MARYLAND", "MASSACHUSETTS", "MICHIGAN", "MINNESOTA",
            "MISSISSIPPI", "MISSOURI", "MONTANA", "NEBRASKA", "NEVADA", "NEW HAMPSHIRE", "NEW JERSEY", "NEW MEXICO",
            "NEW YORK", "NORTH CAROLINA", "NORTH DAKOTA", "OHIO", "OKLAHOMA", "OREGON", "PENNSYLVANIA",
            "RHODE ISLAND", "SOUTH CAROLINA", "SOUTH DAKOTA", "TENNESSEE", "TEXAS", "UTAH", "VERMONT", "VIRGINIA",
            "WASHINGTON", "WEST VIRGINIA", "WISCONSIN", "WYOMING" };
    HashSet<String> states = new HashSet<String>(Arrays.asList(statesArray));

    @Override
    public void map(LongWritable key, Text line, Context context) throws IOException, InterruptedException {

        String[] values = line.toString().split(",(?=([^\"]*\"[^\"]*\")*[^\"]*$)");
        if (values == null) {
            return;
        }

        String state = values[8].substring(values[8].indexOf(',') + 2, values[8].length() - 1);

        if (state != null && !state.isEmpty() && !state.equalsIgnoreCase("WORKSITE")) {
            boolean unknown = true;
```

Command to Execute Jar:

hadoop jar /home/ujjvalthakkar/eclipse-workspace/ADBMS_PROJECT/target/mapreduce_wordcount-0.0.1-SNAPSHOT.jar com.neu.h1BAnalysis.H1BPetitionCountPerLocation /user/ujjvalthakkar/ProjectFiles/DataSet/h1b_kaggle.csv /home/ujjvalthakkar/Desktop/ProjectOutputFiles

3. Predictive yearly analysis of successful certification of the petitions (Numerical Summarization, Mean, Standard Deviation, MR Chaining)

We analyze the dataset to find out the mean, standard deviation of the number of successful petitions for every year and try to predict the possible number of successful petitions for the upcoming year. Once, the standard deviation is found, we can then add/subtract that value to the last year's success count and predict the possible number of successful petitions.

We chain the MR jobs here. We find out the number of successful predictions for each year using the first job and then use these values to find the mean, standard deviation of the successful counts to predict the further success in the second job.

1. In the ***H1BPetitionSucessMapper,*** we filter the petitions based on the **CASE_STATUS** to be **CERTIFIED** or **CERTIFIED-WITHDRAWN** and then extract the year of that petition as the key and the value is set as the count 1.
2. In the ***H1BPetitionSucessReducer***, we find the sum of the successful petitions for each year and write the output via the context writer.
3. In the second job, we use the ***H1BPetitionSucessPredictiveMapper*** to pass the input values to the reducer
4. In the ***H1BPetitionSucessPredictiveReducer***, we find the mean, standard deviation and then predict the upcoming success as described above.

Command to Execute Jar:

hadoop jar /home/ujjvalthakkar/eclipse-workspace/ADBMS_PROJECT/target/mapreduce_wordcount-0.0.1-SNAPSHOT.jar com.neu.h1BAnalysis.H1BSucessfullPetitionPrediction /user/ujjvalthakkar/ProjectFiles/DataSet/h1b_kaggle.csv /home/ujjvalthakkar/Desktop/ProjectOutputFiles

4. Top 10 employers to file the most petitions (Top N Filtering Pattern, Partitioner)

We analyze the dataset using the Top N Filtering pattern to find out the top 10 employers to file the most petitions during the period of 2011-2016 and this helps us to know about the employers who hire most foreign nationals.

1. In the ***H1BApplnsPerEmployeePerYearMapper***, we filter the employee name and the year of the application and pass it to the reducer along with the count 1.

```
public static class H1BApplnsPerEmployeePerYearReducer extends Reducer<Text, LongWritable, NullWritable, Text> {
    private TreeMap<LongWritable, Text> topEmployers = new TreeMap<LongWritable, Text>();
    long sum = 0;

    public void reduce(Text key, Iterable<LongWritable> values, Context context)
            throws IOException, InterruptedException {
        sum = 0;
        for (LongWritable val : values) {
            sum += val.get();
        }
        topEmployers.put(new LongWritable(sum), new Text(key + "," + sum));
        if (topEmployers.size() > 10)
            topEmployers.remove(topEmployers.firstKey());

    }

    protected void cleanup(Context context) throws IOException, InterruptedException {
        for (Text t : topEmployers.descendingMap().values())
```

2. We use the ***CustomPartioner***, to partition the petitions according to the year.
3. In the ***H1BApplnsPerEmployeePerYearReducer***, we find the sum of the number of petitions for the current employer and use an in-memory list TreeMap to store the sum, the name of the employer. We keeps a check on the size of the in memory list, if it happens to be greater than 10, we remove the first key.
4. On cleanup, we then write the output of the in-memory list via the context writer.
5. Output are 7 part files containing the top 10 employers for each year, one for each year from 2011-2016.

Command to Execute Jar:

hadoop jar /home/ujjvalthakkar/eclipse-workspace/ADBMS_PROJECT/target/mapreduce_wordcount-0.0.1-SNAPSHOT.jar com.neu.h1BAnalysis.H1BTop10ApplnsPerEmployeePerYear /user/ujjvalthakkar/ProjectFiles/DataSet/h1b_kaggle.csv /home/ujjvalthakkar/Desktop/ProjectOutputFiles

5. Most Data Engineer jobs for each year for each Location (Top N Filtering Pattern, Partitioner)

We analyze the dataset using the Top N Filtering pattern to find out the top 10 locations filing petitions for a Data Engineer every year. This analysis would help the Data Engineers to target these locations to find a job sponsoring the H1B visa for them.

1. In the ***H1BApplnsPerEmployeePerYearMapper***, we filter the location and Year of the data engineer petitions and pass it to the reducer along with the count 1.
2. We use the ***CustomPartioner***, to partition the petitions according to the year.
3. In the **H1BApplnsPerEmployeePerYearReducer**, we find the sum of the number of petitions and use an in-memory list TreeMap to store the sum, the location. We keep a check on the size of the in-memory list, if it happens to be greater than 10, we remove the first key.
4. On cleanup, we then write the output of the in-memory list via the context writer.
5. Output are 7 part files containing the top 10 locations for each year containing the maximum number of Data engineer petitions, one for each year from 2011-2016.

Command to Execute Jar:

hadoop jar /home/ujjvalthakkar/eclipse-workspace/ADBMS_PROJECT/target/mapreduce_wordcount-0.0.1-SNAPSHOT.jar com.neu.h1BAnalysis.H1BTop10DataEngineerPerYear /user/ujjvalthakkar/ProjectFiles/DataSet/h1b_kaggle.csv /home/ujjvalthakkar/Desktop/ProjectOutputFiles

6. Categorizing petitions filed for a "CEO" for each year (Binning Data Organization Pattern)

We analyze the dataset using the Binning Organization pattern to categorize the petitions filed for a CEO of the company. This analysis helps us to find out the growing entrepreneur sector and the growing changes in the existing organizations. Since we use this pattern, this is a map only job and does not contain a reducer.

1. In the ***H1BCEOPetitionsPerYearMapper***, we filter out the petitions filed for a CEO using the JOB_TITLE column and then organize the data into multiple bins depending on the year of the petition.
2. We use MultipleOutputs for this organization.

Command to Execute Jar:

hadoop jar /home/ujjvalthakkar/eclipse-workspace/ADBMS_PROJECT/target/mapreduce_wordcount-0.0.1-SNAPSHOT.jar com.neu.h1BAnalysis.H1BCEOPetitionsPerYear

```
        job.setMapOutputKeyClass(Text.class);
        job.setMapOutputValueClass(IntWritable.class);

        MultipleOutputs.addNamedOutput(job, "bins", TextOutputFormat.class, Text.class, NullWritable.class);
        MultipleOutputs.setCountersEnabled(job, true);

        FileInputFormat.addInputPath(job, input);
        FileOutputFormat.setOutputPath(job, outputDir);

        // Delete output if exists
        FileSystem hdfs = FileSystem.get(conf);
        if (hdfs.exists(outputDir))
            hdfs.delete(outputDir, true);

        int code = job.waitForCompletion(true) ? 0 : 1;

        System.exit(code);

    }

    public static class H1BCEOPetitionsPerYearMapper extends Mapper<Object, Text, Text, NullWritable> {

        private MultipleOutputs<Text, NullWritable> mos = null;

        protected void setup(Context context) {
            mos = new MultipleOutputs<Text, NullWritable>(context);
        }

        public void map(Object key, Text value, Context context) throws IOException, InterruptedException {

            String[] values = value.toString().split(",(?=([^\"]*\"[^\"]*\")*[^\"]*$)");
            if (values == null) {
                return;
            }

            if (!values[7].equalsIgnoreCase("YEAR")) {
                if (values[4].substring(1, values[4].length()-1).equalsIgnoreCase("CEO") || values[4].substring(1, values[4].length()-1).equalsIgnoreCase("CHIEF EXECUTIVE OFFICER") ||v
                    if (values[7].equalsIgnoreCase("2011")) {
                        mos.write("bins", value, NullWritable.get(), "Year-2011");
                    } else if (values[7].equalsIgnoreCase("2012")) {
                        mos.write("bins", value, NullWritable.get(), "Year-2012");
                    } else if (values[7].equalsIgnoreCase("2013")) {
                        mos.write("bins", value, NullWritable.get(), "Year-2013");
                    } else if (values[7].equalsIgnoreCase("2014")) {
```

/user/ujjvalthakkar/ProjectFiles/DataSet/h1b_kaggle.csv

/home/ujjvalthakkar/Desktop/ProjectOutputFiles

7. Successful Petitions based on the Wages (Inverted Index Pattern)

We analyze the dataset using the Inverted Index Summarization pattern to find out the number of successful and unsuccessful petitions filed for different wage ranges of employee and can be useful for understanding how likely would the visa petition be certified for a particular wage range.

1. In the ***H1BWageRangeSummarizationMapper***, we filter the successful and unsuccessful petitions and compare their wage ranges and summarize them into different wage groups.
2. In the ***H1BWageRangeSummarizationReducer***, we calculate the count for each wage group and write the output using the context writer.

Command to Execute Jar:

hadoop jar /home/ujjvalthakkar/eclipse-workspace/ADBMS_PROJECT/target/mapreduce_wordcount-0.0.1-SNAPSHOT.jar com.neu.h1BAnalysis. H1BWageRangeSummarization /user/ujjvalthakkar/ProjectFiles/DataSet/h1b_kaggle.csv /home/ujjvalthakkar/Desktop/ProjectOutputFiles

```
                    || case_status.equalsIgnoreCase("\"CERTIFIED-WITHDRAWN\"")) {
                double employeeWage = Double.parseDouble(values[6]);
                // jobtitle_outValue.set(job_title);
                if (employeeWage >= 0 && employeeWage <= 30000) {
                    wageRange.set("0-30000 Success Range");
                } else if (employeeWage > 30000 && employeeWage <= 60000) {
                    wageRange.set("30000-60000 Success Range");
                } else if (employeeWage > 60000 && employeeWage <= 70000) {
                    wageRange.set("60000-70000 Success Range");
                } else if (employeeWage > 70000 && employeeWage <= 80000) {
                    wageRange.set("70000-80000 Success Range");
                } else if (employeeWage > 80000 && employeeWage <= 90000) {
                    wageRange.set("80000-90000 Success Range");
                } else if (employeeWage > 90000 && employeeWage <= 100000) {
                    wageRange.set("90000-100000 Success Range");
                } else if (employeeWage > 100000) {
                    wageRange.set("100000- Above Success Range");
                }

            } else {
                if (!values[6].equals("NA")) {
                    double employeeWage = Double.parseDouble(values[6]);
                    // jobtitle_outValue.set(job_title);
                    if (employeeWage >= 0 && employeeWage <= 30000) {
                        wageRange.set("0-30000 Failure Range");
                    } else if (employeeWage > 30000 && employeeWage <= 60000) {
                        wageRange.set("30000-60000 Failure Range");
                    } else if (employeeWage > 60000 && employeeWage <= 70000) {
                        wageRange.set("60000-70000 Failure Range");
                    } else if (employeeWage > 70000 && employeeWage <= 80000) {
                        wageRange.set("70000-80000 Failure Range");
                    } else if (employeeWage > 80000 && employeeWage <= 90000) {
                        wageRange.set("80000-90000 Failure Range");
                    } else if (employeeWage > 90000 && employeeWage <= 100000) {
                        wageRange.set("90000-100000 Failure Range");
                    } else if (employeeWage > 100000) {
                        wageRange.set("100000- Above Failure Range");
                    }
                }
            }
            context.write(wageRange, ONE);
        }
    }
}

public static class H1BWageRangeSummarizationReducer extends Reducer<Text, IntWritable, Text, IntWritable> {
```

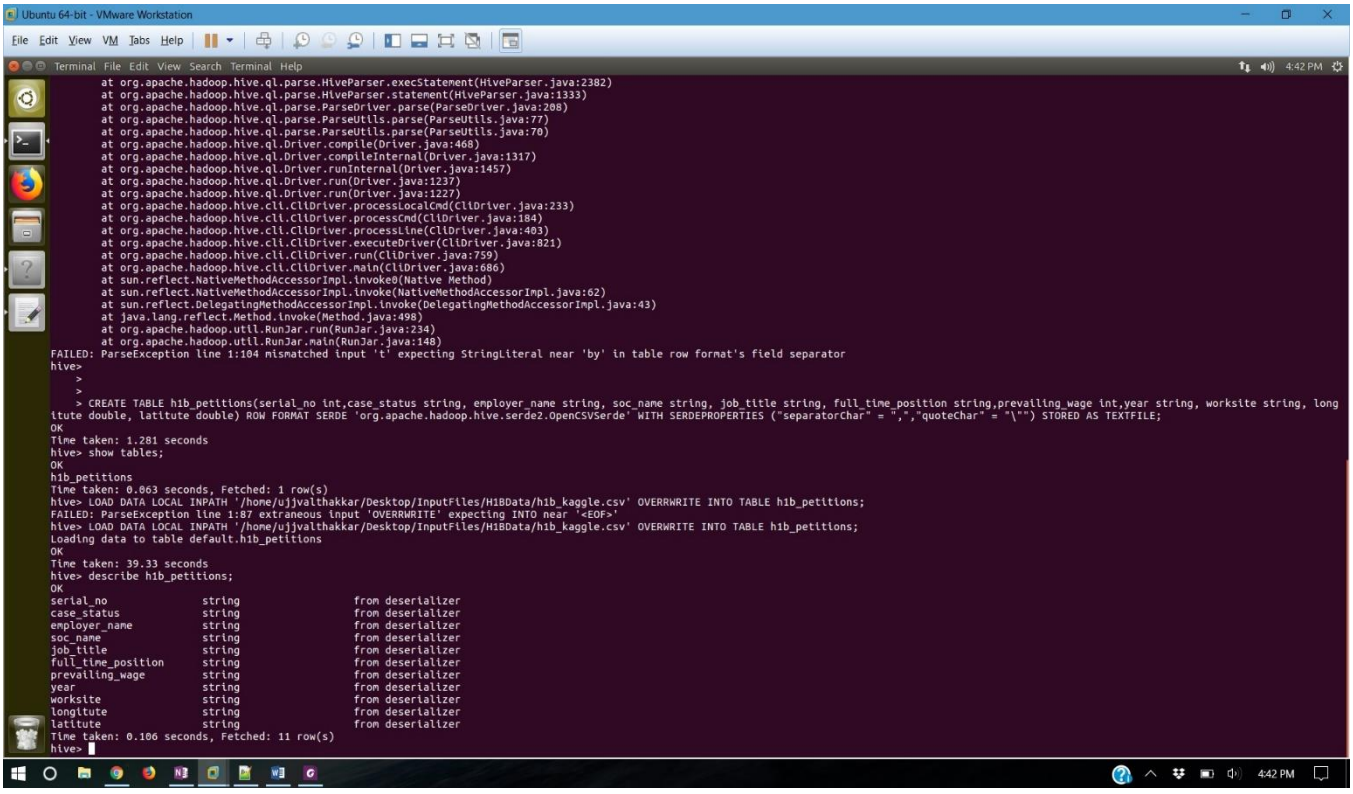
HIVE ANALYSIS

Table Creation

CREATE TABLE h1b_petitions(serial_no int,case_status string, employer_name string, soc_name string, job_title string, full_time_position string,prevailing_wage int,year string, worksite string, longitute double, latitute double) ROW FORMAT SERDE 'org.apache.hadoop.hive.serde2.OpenCSVSerde' WITH SERDEPROPERTIES ("separatorChar" = ","."quoteChar" = "\"") STORED AS TEXTFILE;

Loading the data into the table

LOAD DATA LOCAL INPATH '/home/ujjvalthakkar/Desktop/InputFiles/H1BData/h1b_kaggle.csv' OVERWRITE INTO TABLE h1b_petitions;



8. Most Data Scientist positions by Industry (HIVE)

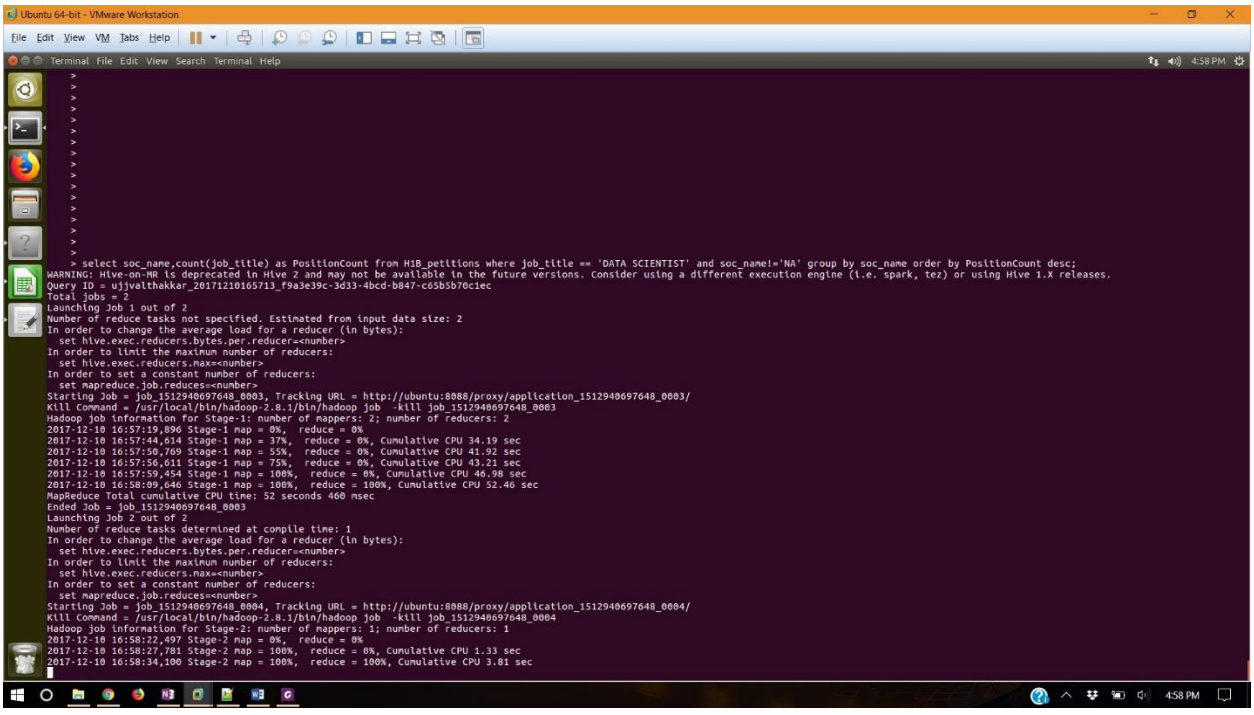
Hive Query:

SELECT SOC_NAME, COUNT(JOB_TITLE) AS POSITIONCOUNT FROM H1B_FINAL WHERE JOB_TITLE == 'DATA SCIENTIST' GROUP BY SOC_NAME ORDER BY POSITIONCOUNT DESC;

Output:

SOC_NAME POSITIONCOUNT
STATISTICIANS 415
COMPUTER AND INFORMATION RESEARCH SCIENTISTS 333
OPERATIONS RESEARCH ANALYSTS 253
Computer and Information Research Scientists 134
COMPUTER OCCUPATIONS, ALL OTHER 121
MATHEMATICIANS 108
Statisticians 104
SOFTWARE DEVELOPERS, APPLICATIONS 79
COMPUTER SYSTEMS ANALYSTS 66
Operations Research Analysts 64
Software Developers, Applications 38
SOFTWARE DEVELOPERS, SYSTEMS SOFTWARE 37
Computer Occupations, All Other 23
Computer Systems Analysts 21
Software Developers, Systems Software 12
FINANCIAL SPECIALISTS, ALL OTHER 11
Mathematicians 10
Database Administrators 8
MATHEMATICAL TECHNICIANS 7
MARKET RESEARCH ANALYSTS AND MARKETING SPECIALISTS 7
DATABASE ADMINISTRATORS 6
BIOLOGICAL SCIENTISTS, ALL OTHER 6
COMPUTER PROGRAMMERS 5
ECONOMISTS 5
COMPUTER NETWORK ARCHITECTS 3
COMPUTER AND INFORMATION SYSTEMS MANAGERS 3
INDUSTRIAL-ORGANIZATIONAL PSYCHOLOGISTS 3
ENGINEERS, ALL OTHER 2
STATISTICAL ASSISTANTS 2
SALES ENGINEERS 2
Computer Programmers 2
Economists 2
ELECTRICAL ENGINEERS 2
Management Analysts 2
SURVEY RESEARCHERS 2
Biological Scientists, All Other 2
Survey Researchers 1

SOFTWARE DEVELOPERS, APPLICATIONS, R&D 1
Materials Scientists 1
Market Research Analysts and Marketing Specialists 1
MATERIALS SCIENTISTS 1
Engineers, All Other 1
Computer Software Engineers, Applications 1
COMPUTER SYSTEMS ANALYST 1
COMPUTER & INFORMATION RESEARCH SCIENTISTS 1
CLINICAL DATA MANAGERS 1
CIVIL ENGINEERS 1
ACTUARIES 1
MEDICAL SCIENTISTS, EXCEPT EPIDEMIOLOGISTS 1
MATERIALS ENGINEERS 1
MANAGEMENT ANALYSTS 1
Life Scientists, All Other 1
Financial Analysts 1
Electrical Engineers 1
Credit Analysts 1
Computer and Information Scientists, Research 1
*COMPUTER OCCUPATIONS, ALL OTHER*1*
COMPUTER & INFORMATION RESEARCH SCIENTIST 1
BUSINESS INTELLIGENCE ANALYSTS 1



9. Top 10 Most petitions filed by Employers by Year (HIVE)

Hive Query:

SELECT EMPLOYER_NAME,YEAR,COUNT(EMPLOYER_NAME) AS PETITIONCOUNT FROM H1B_PETITIONS GROUP BY EMPLOYER_NAME,YEAR ORDER BY PETITIONCOUNT DESC LIMIT 10;

Output:

EMPLOYER_NAME	YEAR	PETITIONCOUNT
INFOSYS LIMITED	2015	33245
INFOSYS LIMITED	2013	32223
INFOSYS LIMITED	2016	25352
INFOSYS LIMITED	2014	23759
CAPGEMINI AMERICA INC	2016	16725
TATA CONSULTANCY SERVICES LIMITED	2015	16553
INFOSYS LIMITED	2012	15818
TATA CONSULTANCY SERVICES LIMITED	2014	14098
TATA CONSULTANCY SERVICES LIMITED	2016	13134
WIPRO LIMITED	2015	12201

10. Counting number of petitions based on Location (HIVE)

Hive Query:

SELECT count(SUBSTR(WORKSITE,(INSTR(WORKSITE,",")+2),length(WORKSITE))), SUBSTR(WORKSITE,(INSTR(WORKSITE,",")+2),length(WORKSITE)) FROM H1B_PETITIONS GROUP BY (SUBSTR(WORKSITE,(INSTR(WORKSITE,",")+2),length(WORKSITE)));

Output:

42054 ARIZONA
14762 ARKANSAS
559941 CALIFORNIA
103168 GEORGIA
30516 INDIANA
16743 IOWA
12702 KENTUCKY
3918 MAINE
56257 MARYLAND
116466 MASSACHUSETTS
82964 MICHIGAN
48686 MINNESOTA
986 MONTANA
214076 NEW JERSEY
79672 NORTH CAROLINA
10597 OKLAHOMA

23790 OREGON
109960 PENNSYLVANIA
1452 PUERTO RICO
12932 SOUTH CAROLINA
27673 TENNESSEE
13107 UTAH
102801 WASHINGTON
3079 WEST VIRGINIA
896 WYOMING
10253 ALABAMA
1396 ALASKA
32038 COLORADO
50253 CONNECTICUT
18138 DELAWARE
22708 DISTRICT OF COLUMBIA
105773 FLORIDA
3752 HAWAII
4191 IDAHO
160814 ILLINOIS
13782 KANSAS
11669 LOUISIANA
4270 MISSISSIPPI
34813 MISSOURI
3604 NA
9256 NEBRASKA
7448 NEVADA
9929 NEW HAMPSHIRE
5541 NEW MEXICO
291411 NEW YORK
2927 NORTH DAKOTA
76575 OHIO
1 ORKSITE
11715 RHODE ISLAND
1902 SOUTH DAKOTA
294454 TEXAS
1941 VERMONT
90028 VIRGINIA
32672 WISCONSIN

11. Categorizing petitions filed for a "CEO" for each year (HIVE)

Hive Query:

SELECT Year,Count(year) from H1B_PETITIONS WHERE job_title="CEO" OR job_title="CHEIF EXECUTIVE OFFICER" or job_title="CHIEF EXECUTIVE OFFICER" group by year;

Output:

2011 167
2013 191
2015 247
2012 275
2014 212
2016 209

12. Counting of Number of Full time and Part time petitions (HIVE)

Hive Query:

SELECT COUNT(*) FROM H1B_PETITIONS WHERE FULL_TIME_POSITION="Y" OR FULL_TIME_POSITION="Y";

Output:

2576104

13. Top 10 Locations with most DATA ENGINEER petitions

Hive Query:

SELECT SPLIT(WORKSITE,'[,]')[1] AS STATE, COUNT(SPLIT(WORKSITE,'[,]')[1]) AS JOB_COUNT FROM H1B_PETITIONS WHERE JOB_TITLE LIKE='DATA ENGINEER' GROUP BY SPLIT(WORKSITE,'[,]')[1] ORDER BY JOB_COUNT DESC LIMIT 10;

Output:

CALIFORNIA 323
NEW YORK 88
WASHINGTON 24
MASSACHUSETTS 24
ILLINOIS 20
MICHIGAN 16
TEXAS 15
VIRGINIA 11
NEW JERSEY 9
FLORIDA 8

PIG ANALYSIS

Loading the data

REGISTER /home/ujjvalthakkar/Jars/piggybank-0.11.0.jar;

DEFINE CSV_Storage org.apache.pig.piggybank.storage.CSVExcelStorage();

***h1b_petitions** = load '/home/ujjvalthakkar/Desktop/InputFiles/H1BData/h1b_kaggle.csv' using CSV_Storage() as (serial_no: int,case_status: chararray, employer_name: chararray, soc_name: chararray, job_title: chararray, fulltime_position: chararray,prevailing_wage: int,year: chararray, worksite: chararray, longitude: double, latitute: double);*

14. Top Data Engineer Locations for each year (PIG)

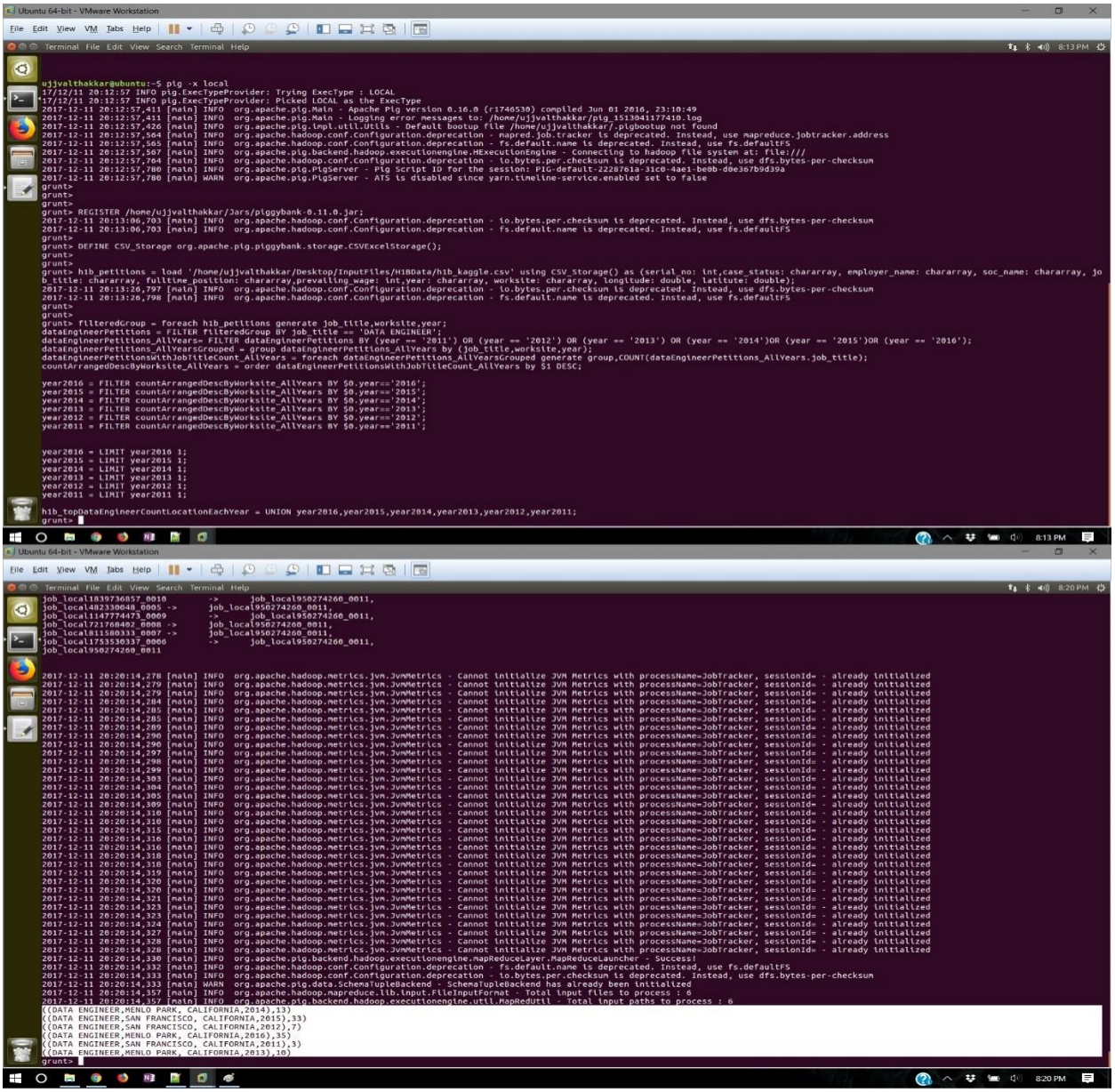
Script:

```
filteredGroup = foreach h1b_petitions generate job_title,worksite,year;
dataEngineerPetitions = FILTER filteredGroup BY job_title == 'DATA ENGINEER';
dataEngineerPetitions_AllYears= FILTER dataEngineerPetitions BY (year == '2011') OR (year == '2012')
OR (year == '2013') OR (year == '2014')OR (year == '2015')OR (year == '2016');
dataEngineerPetitions_AllYearsGrouped = group dataEngineerPetitions_AllYears by
(job_title,worksite,year);
dataEngineerPetitionsWithJobTitleCount_AllYears = foreach dataEngineerPetitions_AllYearsGrouped
generate group,COUNT(dataEngineerPetitions_AllYears.job_title);
countArrangedDescByWorksite_AllYears = order dataEngineerPetitionsWithJobTitleCount_AllYears
by $1 DESC;

year2016 = FILTER countArrangedDescByWorksite_AllYears BY $0.year=='2016';
year2015 = FILTER countArrangedDescByWorksite_AllYears BY $0.year=='2015';
year2014 = FILTER countArrangedDescByWorksite_AllYears BY $0.year=='2014';
year2013 = FILTER countArrangedDescByWorksite_AllYears BY $0.year=='2013';
year2012 = FILTER countArrangedDescByWorksite_AllYears BY $0.year=='2012';
year2011 = FILTER countArrangedDescByWorksite_AllYears BY $0.year=='2011';

year2016 = LIMIT year2016 1;
year2015 = LIMIT year2015 1;
year2014 = LIMIT year2014 1;
year2013 = LIMIT year2013 1;
year2012 = LIMIT year2012 1;
```

```
year2011 = LIMIT year2011 1;
h1b_topDataEngineerCountLocationEachYear = UNION
year2016,year2015,year2014,year2013,year2012,year2011;
dump h1b_topDataEngineerCountLocationEachYear;
```

Output:

```
((DATA ENGINEER,MENLO PARK, CALIFORNIA,2014),13)
((DATA ENGINEER,SAN FRANCISCO, CALIFORNIA,2015),33)
((DATA ENGINEER,SAN FRANCISCO, CALIFORNIA,2012),7)
((DATA ENGINEER,MENLO PARK, CALIFORNIA,2016),35)
((DATA ENGINEER,SAN FRANCISCO, CALIFORNIA,2011),3)
((DATA ENGINEER,MENLO PARK, CALIFORNIA,2013),10)
```



15. Top10 Industry by most Data Scientist positions (PIG)

Script:

```
filteredDataScientist  = filter h1b_petitions by job_title == 'DATA SCIENTIST';
filteredDataScientist1 = foreach filteredDataScientist generate soc_name,job_title;
groupedByIndustry = group filteredDataScientist1 by soc_name;
groupedByIndustryWithCount = foreach groupedByIndustry generate
group,COUNT(filteredDataScientist1.job_title) as totalCount;
orderedGroupedByIndustryWithCount = order groupedByIndustryWithCount by totalCount desc;
top10OrderedGroupedByIndustryWithCount = LIMIT orderedGroupedByIndustryWithCount 10;
dump top10OrderedGroupedByIndustryWithCount;
```

Output:

```
(STATISTICIANS,415)
(COMPUTER AND INFORMATION RESEARCH SCIENTISTS,333)
(OPERATIONS RESEARCH ANALYSTS,253)
(Computer and Information Research Scientists,134)
(COMPUTER OCCUPATIONS, ALL OTHER,121)
(MATHEMATICIANS,108)
(Statisticians,104)
(SOFTWARE DEVELOPERS, APPLICATIONS,79)
(COMPUTER SYSTEMS ANALYSTS,66)
(Operations Research Analysts,64)
```

Visualization and Charts

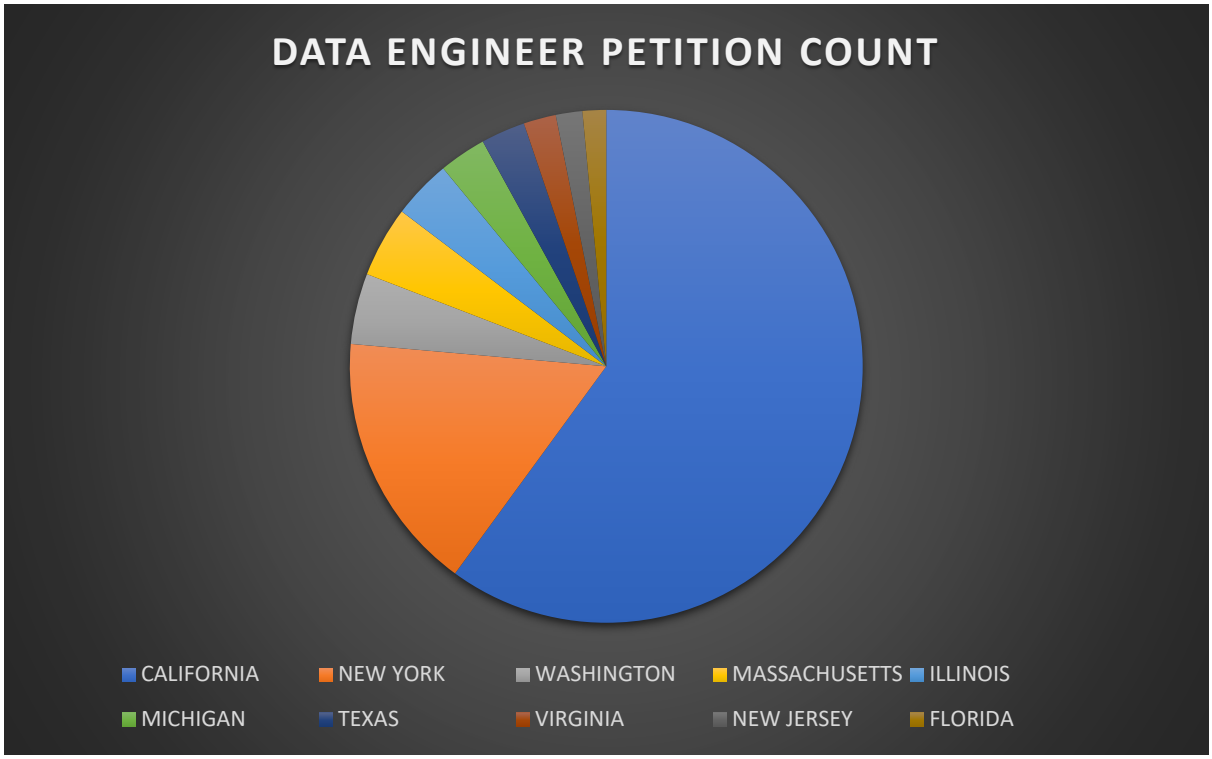


Figure: Top 10 Locations with most DATA ENGINEER petitions

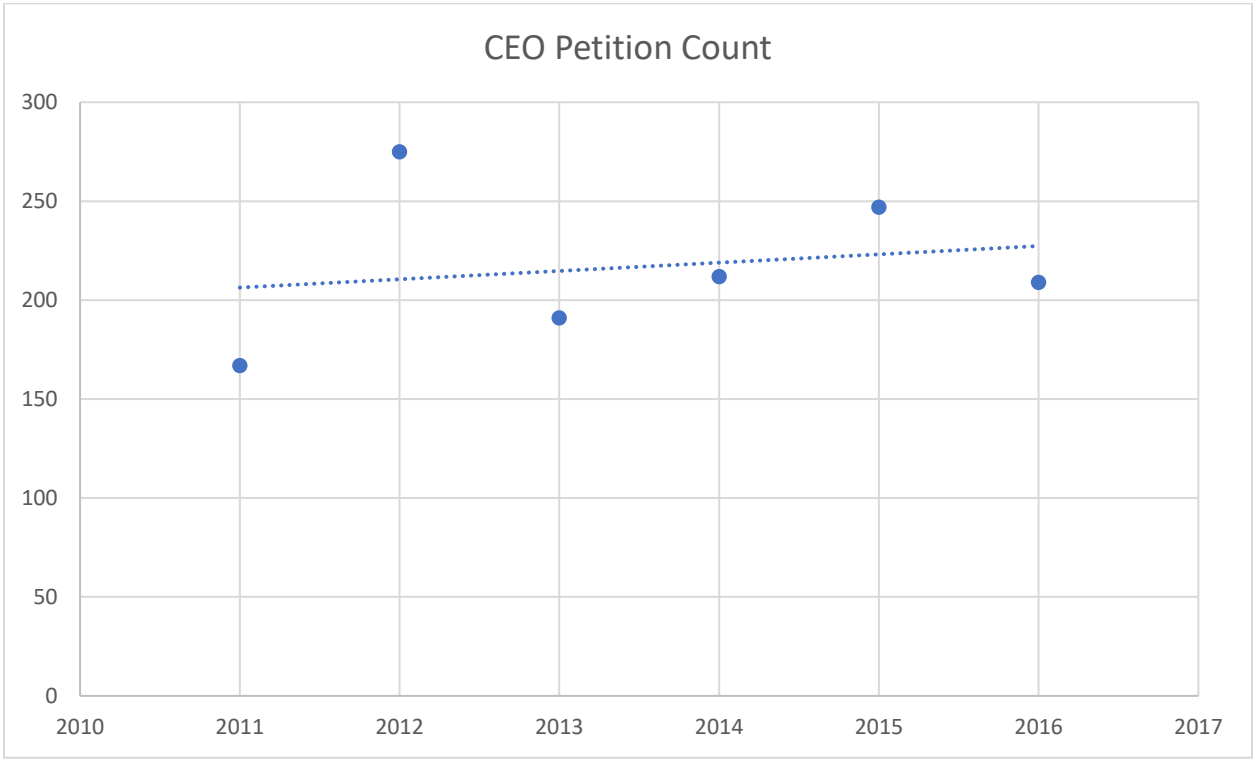


Figure: Categorizing petitions filed for a "CEO" for each year

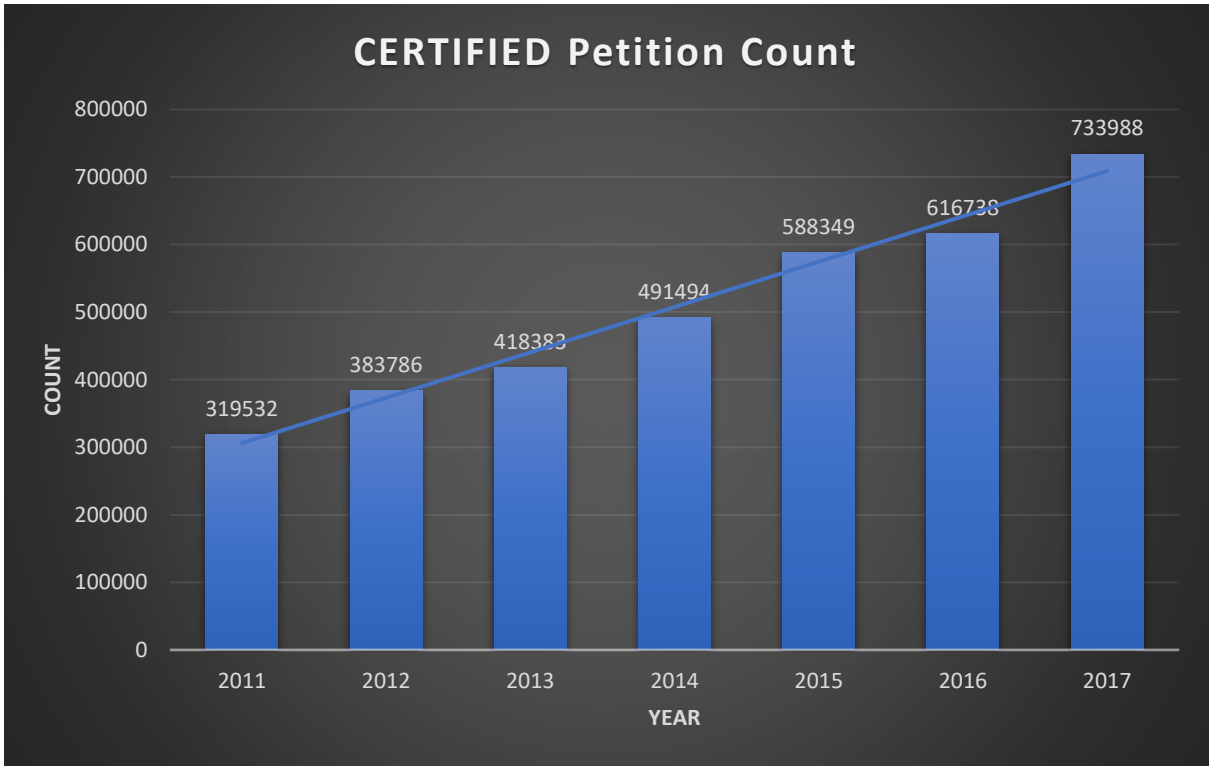


Figure: Predictive yearly analysis of successful certification of the petitions

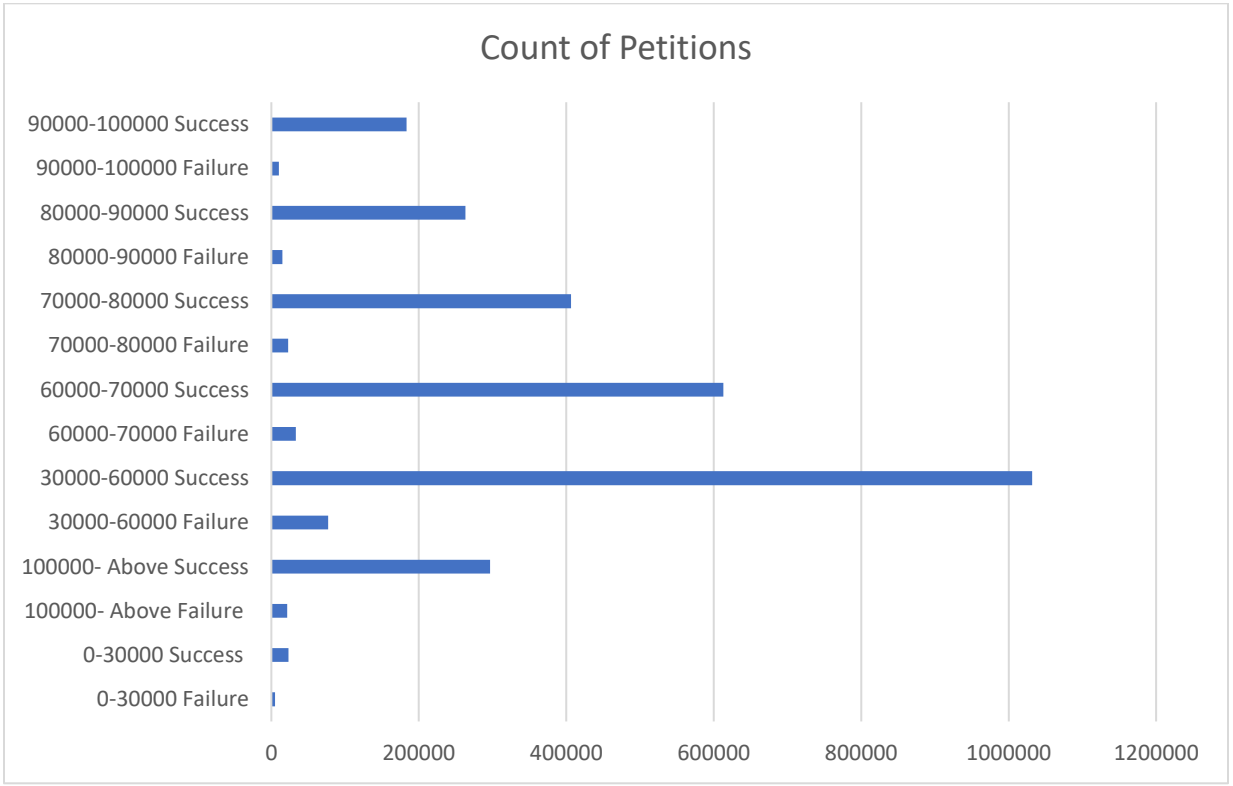


Figure: Successful and Unsuccessful petitions based on the Wage Ranges

I also used the http://app.rawgraphs.io/ to visualize some of the outputs.

Sample HTML Code for generating the SVG:

```
<!DOCTYPE html>
<html>
<head>
<title>Top10 Industry by most Data Scientist positions </title>
</head>
<body>
<svg width="1200" height="1200" xmlns="http://www.w3.org/2000/svg">
  <g transform="translate(10,10)">
    <g>
      <circle class="node node--root" transform="translate(590,590)" r="590" style="fill-
opacity: 0; stroke: rgb(221, 221, 221); stroke-opacity: 1;"></circle>
      <circle class="node node--leaf"
transform="translate(558.5075487516589,525.8620301548337)" r="199.2135082291827"
style="fill: rgb(191, 105, 105); fill-opacity: 1; stroke: rgb(221, 221, 221); stroke-opacity:
0;"></circle>
      <circle class="node node--leaf"
transform="translate(877.8062200190669,525.8620301548337)" r="120.08516303822536"
style="fill: rgb(191, 156, 105); fill-opacity: 1; stroke: rgb(221, 221, 221); stroke-opacity:
0;"></circle>
      <circle class="node node--leaf"
transform="translate(779.6998382420991,341.57504414686366)" r="88.68877057722851"
style="fill: rgb(174, 191, 105); fill-opacity: 1; stroke: rgb(221, 221, 221); stroke-opacity:
0;"></circle>
      <circle class="node node--leaf"
transform="translate(613.5963985101138,204.9713912860051)" r="126.37147834322454"
style="fill: rgb(122, 191, 105); fill-opacity: 1; stroke: rgb(221, 221, 221); stroke-opacity:
0;"></circle>
      <circle class="node node--leaf"
transform="translate(382.1229406783518,267.70006532706446)" r="113.45105651858101"
style="fill: rgb(105, 191, 139); fill-opacity: 1; stroke: rgb(221, 221, 221); stroke-opacity:
0;"></circle>
      <circle class="node node--leaf"
transform="translate(188.52064995961575,479.6931531363379)" r="173.64285886530925"
style="fill: rgb(105, 191, 191); fill-opacity: 1; stroke: rgb(221, 221, 221); stroke-opacity:
0;"></circle>
      <circle class="node node--leaf"
transform="translate(330.11835277287696,698.9175997964467)" r="87.33466402780026"
style="fill: rgb(105, 139, 191); fill-opacity: 1; stroke: rgb(221, 221, 221); stroke-opacity:
0;"></circle>
```

<circle class="node node--leaf" transform="translate(476.7963774372216,810.6146493292333)" r="97.03093415625335" style="fill: rgb(122, 105, 191); fill-opacity: 1; stroke: rgb(221, 221, 221); stroke-opacity: 0;"></circle>
<circle class="node node--leaf" transform="translate(788.8123482608656,879.0072909223375)" r="222.3927961348818" style="fill: rgb(174, 105, 191); fill-opacity: 1; stroke: rgb(221, 221, 221); stroke-opacity: 0;"></circle>
<circle class="node node--leaf" transform="translate(1053.7919198829877,676.1355970119864)" r="111.33028902270583" style="fill: rgb(191, 105, 156); fill-opacity: 1; stroke: rgb(221, 221, 221); stroke-opacity: 0;"></circle>
</g>
<g>
<text text-anchor="middle" transform="translate(590,590)" style="font-size: 11px; font-family: Arial, Helvetica;"></text>
<text text-anchor="middle" transform="translate(558.5075487516589,525.8620301548337)" style="font-size: 11px; font-family: Arial, Helvetica;">COMPUTER AND INFORMATION RESEARCH SCIENTISTS</text>
<text text-anchor="middle" transform="translate(877.8062200190669,525.8620301548337)" style="font-size: 11px; font-family: Arial, Helvetica;">COMPUTER OCCUPATIONS</text>
<text text-anchor="middle" transform="translate(779.6998382420991,341.57504414686366)" style="font-size: 11px; font-family: Arial, Helvetica;">COMPUTER SYSTEMS ANALYSTS</text>
<text text-anchor="middle" transform="translate(613.5963985101138,204.9713912860051)" style="font-size: 11px; font-family: Arial, Helvetica;">Computer and Information Research Scientists</text>
<text text-anchor="middle" transform="translate(382.1229406783518,267.70006532706446)" style="font-size: 11px; font-family: Arial, Helvetica;">MATHEMATICIANS</text>
<text text-anchor="middle" transform="translate(188.52064995961575,479.6931531363379)" style="font-size: 11px; font-family: Arial, Helvetica;">OPERATIONS RESEARCH ANALYSTS</text>
<text text-anchor="middle" transform="translate(330.11835277287696,698.9175997964467)" style="font-size: 11px; font-family: Arial, Helvetica;">Operations Research Analysts</text>
<text text-anchor="middle" transform="translate(476.7963774372216,810.6146493292333)" style="font-size: 11px; font-family: Arial, Helvetica;">SOFTWARE DEVELOPERS</text>
<text text-anchor="middle" transform="translate(788.8123482608656,879.0072909223375)" style="font-size: 11px; font-family: Arial, Helvetica;">STATISTICIANS</text>

```
        <text text-anchor="middle"
    transform="translate(1053.7919198829877,676.1355970119864)" style="font-size: 11px;
    font-family: Arial, Helvetica;">Statisticians</text>
        </g>
      </g>
    </svg>
    </body>
    </html>
```

OUTPUT:

Figure: Top10 Industry by most Data Scientist positions

Appendix

1. Code: Number of Full time and Part time petitions (Normal MR Job)

```
public class H1BFullTimeCount {

	public static void main(String[] args) throws IOException, ClassNotFoundException,
InterruptedException {
		// TODO Auto-generated method stub

		// Normal Counting of Number of Full time and Part time Petitions

		Configuration conf = new Configuration();

		if (args.length != 2) {
			System.err.println("Usage: H1BDataAnalysis <input> <out>");
			System.exit(2);
		}

		Path input = new Path(args[0]);
		Path outputDir = new Path(args[1]);

		Job job = new Job(conf, "H1B Data Analysis");
		job.setJarByClass(H1BSucessFailureMapper.class);
		job.setMapperClass(H1BSucessFailureMapper.class);
		job.setReducerClass(H1BSucessFailureReducer.class);
		job.setNumReduceTasks(1);

		job.setMapOutputKeyClass(Text.class);
		job.setMapOutputValueClass(IntWritable.class);
		job.setOutputKeyClass(Text.class);
		job.setOutputValueClass(IntWritable.class);

		FileInputFormat.addInputPath(job, input);
		FileOutputFormat.setOutputPath(job, outputDir);

		// Delete output if exists
		FileSystem hdfs = FileSystem.get(conf);
		if (hdfs.exists(outputDir))
			hdfs.delete(outputDir, true);

		int code = job.waitForCompletion(true) ? 0 : 1;

		System.exit(code);

	}

	public static class H1BSucessFailureMapper extends Mapper<Object, Text, Text, IntWritable> {

		private Text outkey = new Text();
		private IntWritable outvalue = new IntWritable();

		public void map(Object key, Text value, Context context) throws IOException,
InterruptedException {
			//String[] values = value.toString().split(",");
			String[] values = value.toString().split(",(?=([^\"]*\"[^\"]*\")*[^\"]*$)");
```

```
                        if (values == null) {
                                return;
                        }

                        if (!values[1].equals("\"CASE_STATUS\"") ) {

                                if (values[5].equalsIgnoreCase("\"Y\""))
                                        outkey.set("FULL TIME");
                                else if (values[5].equalsIgnoreCase("\"N\""))
                                        outkey.set("PART TIME");
                                outvalue.set(1);
                                context.write(outkey, outvalue);
                        }
                }
        }

        public static class H1BSucessFailureReducer extends Reducer<Text, IntWritable, Text, IntWritable> {

                private IntWritable outvalue = new IntWritable();

                public void reduce(Text key, Iterable<IntWritable> values, Context context)
                                throws IOException, InterruptedException {
                        int sum = 0;
                        // For each input value
                        for (IntWritable t : values) {
                                sum += t.get();
                        }
                        outvalue.set(sum);
                        context.write(key, outvalue);
                }
        }
}
```

2. Code: Number of petitions based on Location (Counting with counters Summarization)

```
public class H1BPetitionCountPerLocation {

	// Counting number of petitions based on Location(Counting with counters)

	public static void main(String[] args) throws IOException, ClassNotFoundException,
InterruptedException {
		// TODO Auto-generated method stub
		Configuration conf = new Configuration();

		if (args.length != 2) {
			System.err.println("Usage: H1BDataAnalysis <input> <out>");
			System.exit(2);
		}

		Path input = new Path(args[0]);
		Path outputDir = new Path(args[1]);

		Job job = new Job(conf, "H1B Data Analysis");
		job.setJarByClass(H1BPetitionCountPerLocation.class);
		job.setMapperClass(CountPetitionsPerLocationMapper.class);
		job.setNumReduceTasks(0);

		FileInputFormat.addInputPath(job, input);
		FileOutputFormat.setOutputPath(job, outputDir);

		// Delete output if exists
		FileSystem hdfs = FileSystem.get(conf);
		if (hdfs.exists(outputDir))
			hdfs.delete(outputDir, true);

		int code = job.waitForCompletion(true) ? 0 : 1;

		if (code == 0) {
			System.out.println("OUTPUT VALUES:\nSTATE\tNUMBER OF PETITIONS");
			for (Counter counter :
job.getCounters().getGroup(CountPetitionsPerLocationMapper.STATE_COUNTER_GROUP)) {
				System.out.println(counter.getDisplayName() + "\t" + counter.getValue());
			}
		}

		FileSystem.get(conf).delete(outputDir, true);

	}

	public static class CountPetitionsPerLocationMapper extends Mapper<LongWritable, Text,
NullWritable, NullWritable> {

		public static final String STATE_COUNTER_GROUP = "State";
		public static final String UNKNOWN_COUNTER = "Unknown";

		String[] statesArray = new String[] { "CALIFORNIA", "ALABAMA", "ARKANSAS", "ARIZONA",
"ALASKA", "COLORADO",
				"CONNECTICUT", "DELAWARE", "FLORIDA", "GEORGIA", "HAWAII", "IDAHO",
"ILLINOIS", "INDIANA", "IOWA",
```

```
                                        "KANSAS", "KENTUCKY", "LOUISIANA", "MAINE", "MARYLAND",
"MASSACHUSETTS", "MICHIGAN", "MINNESOTA",
                                        "MISSISSIPPI", "MISSOURI", "MONTANA", "NEBRASKA", "NEVADA", "NEW
HAMPSHIRE", "NEW JERSEY", "NEW MEXICO",
                                        "NEW YORK", "NORTH CAROLINA", "NORTH DAKOTA", "OHIO",
"OKLAHOMA", "OREGON", "PENNSYLVANIA",
                                        "RHODE ISLAND", "SOUTH CAROLINA", "SOUTH DAKOTA", "TENNESSEE",
"TEXAS", "UTAH", "VERMONT", "VIRGINIA",
                                        "WASHINGTON", "WEST VIRGINIA", "WISCONSIN", "WYOMING" };
                        HashSet<String> states = new HashSet<String>(Arrays.asList(statesArray));

                        @Override
                        public void map(LongWritable key, Text line, Context context) throws IOException,
InterruptedException {

                                String[] values = line.toString().split(",(?=([^\"]*\"[^\"]*\")*[^\"]*$)");
                                if (values == null) {
                                        return;
                                }

                                String state = values[8].substring(values[8].indexOf(',') + 2, values[8].length() - 1);

                                if (state != null && !state.isEmpty() && !state.equalsIgnoreCase("WORKSITE")) {
                                        boolean unknown = true;
                                        if (states.contains(state)) {
                                                context.getCounter(STATE_COUNTER_GROUP, state).increment(1);
                                                unknown = false;
                                        }
                                        if (unknown) {
                                                context.getCounter(UNKNOWN_COUNTER, state).increment(1);
                                        }
                                }
                        }
                }
}
```

3. Code: Predictive yearly analysis of successful certification of the petitions (Numerical Summarization, Standard Deviation, MR Chaining)

```
public class H1BSucessfullPetitionPrediction {

	// Predictive yearly analysis of successful certication of the petitions(Summarization,Standard
Deviation)

	public static void main(String[] args) throws IOException, ClassNotFoundException,
InterruptedException {
		// TODO Auto-generated method stub
		Configuration conf = new Configuration();

		if (args.length != 2) {
			System.err.println("Usage: H1BDataAnalysis <input> <out>");
			System.exit(2);
		}

		Path input = new Path(args[0]);
		Path outputDir = new Path(args[1]);

		Job job = new Job(conf, "H1B Data Analysis");

		job.setJarByClass(H1BSucessfullPetitionPrediction.class);
		job.setMapperClass(H1BPetitionSucessMapper.class);
		job.setReducerClass(H1BPetitionSucessReducer.class);
		job.setNumReduceTasks(1);

		job.setMapOutputKeyClass(Text.class);
		job.setMapOutputValueClass(IntWritable.class);
		job.setOutputKeyClass(Text.class);
		job.setOutputValueClass(IntWritable.class);

		FileInputFormat.addInputPath(job, input);
		FileOutputFormat.setOutputPath(job, outputDir);

		// Delete output if exists
		FileSystem hdfs = FileSystem.get(conf);
		if (hdfs.exists(outputDir))
			hdfs.delete(outputDir, true);

		int code = job.waitForCompletion(true) ? 0 : 1;

		if (code == 0) {
			Job job1 = new Job(conf, "H1B Data Analysis");

			job1.setJarByClass(H1BSucessfullPetitionPrediction.class);
			job1.setMapperClass(H1BPetitionSucessPredictiveMapper.class);
			job1.setReducerClass(H1BPetitionSucessPredictiveReducer.class);
			job1.setNumReduceTasks(1);

			job1.setMapOutputKeyClass(NullWritable.class);
			job1.setMapOutputValueClass(Text.class);
			job1.setOutputKeyClass(Text.class);
			job1.setOutputValueClass(IntWritable.class);
```

```
                Path finalOutput = new Path("FinalOutput");
                FileInputFormat.addInputPath(job1, outputDir);
                FileOutputFormat.setOutputPath(job1, finalOutput);
                // Delete output if exists
                if (hdfs.exists(finalOutput))
                        hdfs.delete(finalOutput, true);
                code = job1.waitForCompletion(true) ? 0 : 1;
        }
        System.exit(code);
    }

    public static class H1BPetitionSucessMapper extends Mapper<Object, Text, Text, IntWritable> {

        private Text outkey = new Text();
        private IntWritable outvalue = new IntWritable();

        public void map(Object key, Text value, Context context) throws IOException,
InterruptedException {
                // String[] values = value.toString().split(",");
                String[] values = value.toString().split(",(?=([^\"]*\"[^\"]*\")*[^\"]*$)");

                if (values == null) {
                        return;
                }

                if (!values[1].equals("CASE_STATUS")) {
                        String case_status = values[1].trim();
                        String year = values[7].trim();
                        if ((case_status.equalsIgnoreCase("\"CERTIFIED\"")
                                        || case_status.equalsIgnoreCase("\"CERTIFIED-
WITHDRAWN\""))) {
                                outkey.set(year);
                                outvalue.set(1);
                                context.write(outkey, outvalue);
                        }
                }
        }
    }

    public static class H1BPetitionSucessPredictiveMapper extends Mapper<Object, Text, NullWritable,
Text> {

        private Text outkey = new Text();

        public void map(Object key, Text value, Context context) throws IOException,
InterruptedException {
                // String[] values = value.toString().split(",");
                String[] values = value.toString().split("\t");

                if (values == null) {
                        return;
                } else {
                        outkey.set(values[0] + "\t" + values[1]);
                        context.write(NullWritable.get(), outkey);
                }
        }
```

```
	}

	public static class H1BPetitionSucessReducer extends Reducer<Text, IntWritable, Text, IntWritable> {

		private IntWritable outvalue = new IntWritable();

		public void reduce(Text key, Iterable<IntWritable> values, Context context)
				throws IOException, InterruptedException {

			int sum = 0;
			// For each input value
			for (IntWritable t : values) {
				sum += t.get();
			}
			outvalue.set(sum);
			context.write(key, outvalue);
		}
	}

	public static class H1BPetitionSucessPredictiveReducer extends Reducer<NullWritable, Text, Text,
IntWritable> {

		private IntWritable outvalue = new IntWritable();
		private TreeMap<String, Integer> successRange = new TreeMap<String, Integer>();
		private Text result = new Text();

		public void reduce(NullWritable key, Iterable<Text> values, Context context)
				throws IOException, InterruptedException {
			int sum = 0;
			int count = 0;
			successRange.clear();
			// For each input value
			for (Text t : values) {

				String[] value = t.toString().split("\t");
				successRange.put(value[0], Integer.parseInt(value[1]));
				count++;
				sum += Integer.parseInt(value[1]);
			}

			float mean = sum / count;
			float sumOfSquares = 0.0f;
			for (Entry<String, Integer> entry : successRange.entrySet()) {
				sumOfSquares += (entry.getValue() - mean) * (entry.getValue() - mean);
			}
			float stdDev = (float) Math.sqrt(sumOfSquares / (count - 1));
			Entry<String, Integer> lastEntry = successRange.lastEntry();
			String nextYear = String.valueOf(Integer.parseInt(lastEntry.getKey()) + 1);
			float predictedSucessPetitionValue = lastEntry.getValue() + stdDev;
			successRange.put(nextYear, (int) predictedSucessPetitionValue);
			for (Entry<String, Integer> entry : successRange.entrySet()) {
				context.write(new Text(entry.getKey()), new IntWritable(entry.getValue()));
			}
		}
	}
}
```

4. Code: Top 10 employers to file the most petitions (Top N Filtering Pattern, Partitioner)

```
public class H1BTop10ApplnsPerEmployeePerYear {

	public static void main(String[] args) throws IOException, ClassNotFoundException,
InterruptedException {
		// TODO Auto-generated method stub
		// Top 10 employers to file the most petitions(TOP N FILTERING PATTERN)
		Configuration conf = new Configuration();

		if (args.length != 2) {
			System.err.println("Usage: H1BDataAnalysis <input> <output>");
			System.exit(2);
		}

		Path input = new Path(args[0]);
		Path outputDir = new Path(args[1]);

		Job job = new Job(conf, "H1BDataAnalysis Top 10 Employers");
		job.setJarByClass(H1BApplnsPerEmployeePerYearMapper.class);

		job.setMapperClass(H1BApplnsPerEmployeePerYearMapper.class);
		job.setPartitionerClass(CustomPartioner.class);
		job.setReducerClass(H1BApplnsPerEmployeePerYearReducer.class);
		job.setNumReduceTasks(7);

		job.setMapOutputKeyClass(Text.class);
		job.setMapOutputValueClass(LongWritable.class);
		job.setOutputKeyClass(NullWritable.class);
		job.setOutputValueClass(Text.class);

		FileInputFormat.addInputPath(job, input);
		FileOutputFormat.setOutputPath(job, outputDir);

		// Delete output if exists
		FileSystem hdfs = FileSystem.get(conf);
		if (hdfs.exists(outputDir))
			hdfs.delete(outputDir, true);

		int code = job.waitForCompletion(true) ? 0 : 1;

		System.exit(code);

	}

	public static class CustomPartioner extends Partitioner<Text, LongWritable> {

		@Override
		public int getPartition(Text key, LongWritable value, int numReduceTasks) {
			String[] str = key.toString().split("\t");
			if (str[1].equals("2011"))
				return 0;
			if (str[1].equals("2012"))
				return 1;
			if (str[1].equals("2013"))
```

```
                        return 2;
                if (str[1].equals("2014"))
                        return 3;
                if (str[1].equals("2015"))
                        return 4;
                if (str[1].equals("2016"))
                        return 5;
                else
                        return 6;
        }
    }

    public static class H1BApplnsPerEmployeePerYearMapper extends Mapper<LongWritable, Text, Text,
LongWritable> {
        LongWritable one = new LongWritable(1);

        public void map(LongWritable key, Text value, Context context) throws IOException,
InterruptedException {
                if (key.get() > 0)

                {
                        String[] values = value.toString().split(",(?=([^\"]*\"[^\"]*\")*[^\"]*$)");
                        if (!values[1].equals("NA") && values[1] != null && !values[2].equals("NA")
&& values[2] != null
                                        && !values[7].equals("NA") && values[7] != null) {
                                Text answer = new Text(values[2].replaceAll("\"", "") + "\t" +
values[7]);
                                context.write(answer, one);
                        }
                }
        }
    }

    public static class H1BApplnsPerEmployeePerYearReducer extends Reducer<Text, LongWritable,
NullWritable, Text> {
        private TreeMap<LongWritable, Text> topEmployers = new TreeMap<LongWritable, Text>();
        long sum = 0;

        public void reduce(Text key, Iterable<LongWritable> values, Context context)
                        throws IOException, InterruptedException {
                sum = 0;
                for (LongWritable val : values) {
                        sum += val.get();
                }
                topEmployers.put(new LongWritable(sum), new Text(key + "," + sum));
                if (topEmployers.size() > 10)
                        topEmployers.remove(topEmployers.firstKey());

        }

        protected void cleanup(Context context) throws IOException, InterruptedException {
                for (Text t : topEmployers.descendingMap().values())
                        context.write(NullWritable.get(), t);
        }
    }
}
```

5. Code: Most Data Engineer jobs for each year for each Location (Top N Filtering Pattern, Partitioner)

```
public class H1BTop10DataEngineerPerYear {

	public static void main(String[] args) throws IOException, ClassNotFoundException,
InterruptedException {
		// TODO Auto-generated method stub
		// Most Data Engineer jobs for each year for each Location(TOP N FILTERING PATTERN)
		Configuration conf = new Configuration();

		if (args.length != 2) {
			System.err.println("Usage: H1BDataAnalysis <input> <output>");
			System.exit(2);
		}

		Path input = new Path(args[0]);
		Path outputDir = new Path(args[1]);

		Job job = new Job(conf, "H1BDataAnalysis Top 10 Employers");
		job.setJarByClass(H1BApplnsPerEmployeePerYearMapper.class);

		job.setMapperClass(H1BApplnsPerEmployeePerYearMapper.class);
		job.setPartitionerClass(CustomPartioner.class);
		job.setReducerClass(H1BApplnsPerEmployeePerYearReducer.class);
		job.setNumReduceTasks(7);

		job.setMapOutputKeyClass(Text.class);
		job.setMapOutputValueClass(LongWritable.class);
		job.setOutputKeyClass(NullWritable.class);
		job.setOutputValueClass(Text.class);

		FileInputFormat.addInputPath(job, input);
		FileOutputFormat.setOutputPath(job, outputDir);

		// Delete output if exists
		FileSystem hdfs = FileSystem.get(conf);
		if (hdfs.exists(outputDir))
			hdfs.delete(outputDir, true);

		int code = job.waitForCompletion(true) ? 0 : 1;

		System.exit(code);

	}

	public static class CustomPartioner extends Partitioner<Text, LongWritable> {

		@Override
		public int getPartition(Text key, LongWritable value, int numReduceTasks) {
			String[] str = key.toString().split("\t");
			if (str[1].equals("2011"))
				return 0;
			if (str[1].equals("2012"))
				return 1;
			if (str[1].equals("2013"))
				return 2;
```

```
                        if (str[1].equals("2014"))
                                return 3;
                        if (str[1].equals("2015"))
                                return 4;
                        if (str[1].equals("2016"))
                                return 5;
                        else
                                return 6;
                }
        }

        public static class H1BApplnsPerEmployeePerYearMapper extends Mapper<LongWritable, Text, Text,
LongWritable> {
                LongWritable one = new LongWritable(1);

                public void map(LongWritable key, Text value, Context context) throws IOException,
InterruptedException {
                        if (key.get() > 0)

                        {
                                String[] values = value.toString().split(",(?=([^\"]*\"[^\"]*\")*[^\"]*$)");

                                if (values[4] != null && values[4].contains("DATA ENGINEER") && values[8] !=
null
                                                && !values[8].equals("NA")) {
                                        Text answer = new Text(values[8].replaceAll("\"", "") + "\t" +
values[7]);// Location and Year
                                        context.write(answer, one);
                                }
                        }
                }
        }

        public static class H1BApplnsPerEmployeePerYearReducer extends Reducer<Text, LongWritable,
NullWritable, Text> {

                private TreeMap<LongWritable, Text> Top10DataEngineer = new TreeMap<LongWritable,
Text>();
                long sum = 0;

                public void reduce(Text key, Iterable<LongWritable> values, Context context)
                                throws IOException, InterruptedException {
                        sum = 0;
                        for (LongWritable val : values) {
                                sum += val.get();
                        }
                        Top10DataEngineer.put(new LongWritable(sum), new Text(key + "," + sum));
                        if (Top10DataEngineer.size() > 10)
                                Top10DataEngineer.remove(Top10DataEngineer.firstKey());
                }

                protected void cleanup(Context context) throws IOException, InterruptedException {
                        for (Text t : Top10DataEngineer.descendingMap().values())
                                context.write(NullWritable.get(), t);
                }}}
```

6. Code: Categorizing petitions filed for a "CEO" for each year (Binning Data Organization Pattern)

```
public class H1BCEOPetitionsPerYear {

	public static void main(String[] args) throws IOException, ClassNotFoundException,
InterruptedException {
		// TODO Auto-generated method stub

		// Categorizing petitions filed for a "CEO" for each year(BINNING ORGANIZATION
		// PATTERN)

		Configuration conf = new Configuration();

		if (args.length != 2) {
			System.err.println("Usage: H1BDataAnalysis <input> <out>");
			System.exit(2);
		}

		Path input = new Path(args[0]);
		Path outputDir = new Path(args[1]);

		Job job = new Job(conf, "H1B Data Analysis");
		job.setJarByClass(H1BCEOPetitionsPerYear.class);
		job.setMapperClass(H1BCEOPetitionsPerYearMapper.class);
		job.setNumReduceTasks(0);

		job.setMapOutputKeyClass(Text.class);
		job.setMapOutputValueClass(IntWritable.class);

		MultipleOutputs.addNamedOutput(job, "bins", TextOutputFormat.class, Text.class,
NullWritable.class);
		MultipleOutputs.setCountersEnabled(job, true);

		FileInputFormat.addInputPath(job, input);
		FileOutputFormat.setOutputPath(job, outputDir);

		// Delete output if exists
		FileSystem hdfs = FileSystem.get(conf);
		if (hdfs.exists(outputDir))
			hdfs.delete(outputDir, true);

		int code = job.waitForCompletion(true) ? 0 : 1;

		System.exit(code);

	}

	public static class H1BCEOPetitionsPerYearMapper extends Mapper<Object, Text, Text, NullWritable> {

		private MultipleOutputs<Text, NullWritable> mos = null;

		protected void setup(Context context) {
			mos = new MultipleOutputs<Text, NullWritable>(context);
		}
```

```
		public void map(Object key, Text value, Context context) throws IOException,
	InterruptedException {

				String[] values = value.toString().split(",(?=([^\"]*\"[^\"]*\")*[^\"]*$)");
				if (values == null) {
					return;
				}

				if (!values[7].equalsIgnoreCase("YEAR")) {
					if (values[4].substring(1, values[4].length()-1).equalsIgnoreCase("CEO") ||
	values[4].substring(1, values[4].length()-1).equalsIgnoreCase("CHIEF EXECUTIVE OFFICER")
	||values[4].substring(1, values[4].length()-1).equalsIgnoreCase("CHEIF EXECUTIVE OFFICER")) {
						if (values[7].equalsIgnoreCase("2011")) {
							mos.write("bins", value, NullWritable.get(), "Year-2011");
						} else if (values[7].equalsIgnoreCase("2012")) {
							mos.write("bins", value, NullWritable.get(), "Year-2012");
						} else if (values[7].equalsIgnoreCase("2013")) {
							mos.write("bins", value, NullWritable.get(), "Year-2013");
						} else if (values[7].equalsIgnoreCase("2014")) {
							mos.write("bins", value, NullWritable.get(), "Year-2014");
						} else if (values[7].equalsIgnoreCase("2015")) {
							mos.write("bins", value, NullWritable.get(), "Year-2015");
						} else if (values[7].equalsIgnoreCase("2016")) {
							mos.write("bins", value, NullWritable.get(), "Year-2016");
						}
					}
				}
			}

			protected void cleanup(Context context) throws IOException, InterruptedException {
				mos.close();
			}
		}
}
```

7. Successful Petitions based on the Wages (Inverted Index Pattern)

```
public class H1BWageRangeSummarization {

	public static void main(String[] args) throws IOException, ClassNotFoundException, InterruptedException {
		// TODO Auto-generated method stub

		// Normal Counting of Number of Full time and Part time Petitions

		Configuration conf = new Configuration();

		if (args.length != 2) {
			System.err.println("Usage: H1BDataAnalysis <input> <out>");
			System.exit(2);
		}

		Path input = new Path(args[0]);
		Path outputDir = new Path(args[1]);

		Job job = new Job(conf, "H1B Data Analysis");
		job.setJarByClass(H1BWageRangeSummarizationMapper.class);
		job.setMapperClass(H1BWageRangeSummarizationMapper.class);
		job.setReducerClass(H1BWageRangeSummarizationReducer.class);
		job.setNumReduceTasks(1);

		job.setMapOutputKeyClass(Text.class);
		job.setMapOutputValueClass(IntWritable.class);
		job.setOutputKeyClass(Text.class);
		job.setOutputValueClass(IntWritable.class);

		FileInputFormat.addInputPath(job, input);
		FileOutputFormat.setOutputPath(job, outputDir);

		// Delete output if exists
		FileSystem hdfs = FileSystem.get(conf);
		if (hdfs.exists(outputDir))
			hdfs.delete(outputDir, true);

		int code = job.waitForCompletion(true) ? 0 : 1;

		System.exit(code);

	}

	public static class H1BWageRangeSummarizationMapper extends Mapper<Object, Text, Text, IntWritable> {

		private Text wageRange = new Text();
		private IntWritable ONE = new IntWritable(1);

		public void map(Object key, Text value, Context context) throws IOException, InterruptedException {
			// String[] values = value.toString().split(",");
			String[] values = value.toString().split(",(?=([^\"]*\"[^\"]*\")*[^\"]*$)");
			if (values == null) {
```

```
                return;
            }

            if (!values[1].equals("\"CASE_STATUS\"")) {
                String case_status = values[1].trim();
                if ((case_status.equalsIgnoreCase("\"CERTIFIED\"")
                        || case_status.equalsIgnoreCase("\"CERTIFIED-WITHDRAWN\""))) {
                    double employeeWage = Double.parseDouble(values[6]);
                    // jobtitle_outValue.set(job_title);
                    if (employeeWage >= 0 && employeeWage <= 30000) {
                        wageRange.set("0-30000 Success Range");
                    } else if (employeeWage > 30000 && employeeWage <= 60000) {
                        wageRange.set("30000-60000 Success Range");
                    } else if (employeeWage > 60000 && employeeWage <= 70000) {
                        wageRange.set("60000-70000 Success Range");
                    } else if (employeeWage > 70000 && employeeWage <= 80000) {
                        wageRange.set("70000-80000 Success Range");
                    } else if (employeeWage > 80000 && employeeWage <= 90000) {
                        wageRange.set("80000-90000 Success Range");
                    } else if (employeeWage > 90000 && employeeWage <= 100000) {
                        wageRange.set("90000-100000 Success Range");
                    } else if (employeeWage > 100000) {
                        wageRange.set("100000- Above Success Range");
                    }

                } else {
                    if (!values[6].equals("NA")) {
                        double employeeWage = Double.parseDouble(values[6]);
                        // jobtitle_outValue.set(job_title);
                        if (employeeWage >= 0 && employeeWage <= 30000) {
                            wageRange.set("0-30000 Failure Range");
                        } else if (employeeWage > 30000 && employeeWage <= 60000) {
                            wageRange.set("30000-60000 Failure Range");
                        } else if (employeeWage > 60000 && employeeWage <= 70000) {
                            wageRange.set("60000-70000 Failure Range");
                        } else if (employeeWage > 70000 && employeeWage <= 80000) {
                            wageRange.set("70000-80000 Failure Range");
                        } else if (employeeWage > 80000 && employeeWage <= 90000) {
                            wageRange.set("80000-90000 Failure Range");
                        } else if (employeeWage > 90000 && employeeWage <= 100000) {
                            wageRange.set("90000-100000 Failure Range");
                        } else if (employeeWage > 100000) {
                            wageRange.set("100000- Above Failure Range");
                        }
                    }
                }
                context.write(wageRange, ONE);
            }
        }
}

public static class H1BWageRangeSummarizationReducer extends Reducer<Text, IntWritable, Text, IntWritable> {
```

```
        private IntWritable outvalue = new IntWritable();
        private Text outkey = new Text();

        public void reduce(Text key, Iterable<IntWritable> values, Context context)
                        throws IOException, InterruptedException {
                int sum = 0;
                for (IntWritable s : values) {
                        sum += s.get();
                }
                outvalue.set(sum);
                context.write(key, outvalue);
        }
}
```