In [2]:
```
%%javascript
/*************************************************************
Known Mathjax Issue with Chrome - a rounding issue adds a border
https://github.com/mathjax/MathJax/issues/1300
A quick hack to fix this based on stackoverflow discussions:
http://stackoverflow.com/questions/34277967/chrome-rendering-mat
*************************************************************

$('.math>span').css("border-left-color","transparent")
```

```
<IPython.core.display.Javascript object>
```

In [3]:
```
%reload_ext autoreload
%autoreload 2
```

MIDS - w261 Machine Learning At Scale

Course Lead: Dr James G. Shanahan (**email** Jimi via James.Shanahan *AT* gmail.com)

Assignment - HW3

Name: Chris Caudill
Class: MIDS w261 Spring 2017 Group 1
Email: CSCAUDILL@iSchool.Berkeley.edu
StudentId 3032134574 **End of StudentId**
Week: 3

NOTE: please replace 1234567 with your student id above
Due Time: HW is due the Tuesday of the following week by 8AM (West coast time). I.e., Tuesday, Jan 31, 2017 in the case of this homework.

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1 Instructions

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MIDS UC Berkeley, Machine Learning at Scale DATSCIW261 ASSIGNMENT #3

Version 2017-26-1

IMPORTANT

This homework can be completed locally on your computer

=== INSTRUCTIONS for SUBMISSIONS ===

Follow the instructions for submissions carefully.

NEW: Going forward, each student will have a `HW-<user>` repository for all assignments.

Click this link to enable you to create a github repo within the MIDS261 Classroom: https://classroom.github.com/assignment-invitations/3b1d6c8e58351209f9dd865537111ff8 (https://classroom.github.com/assignment-invitations/3b1d6c8e58351209f9dd865537111ff8)
and follow the instructions to create a HW repo.

Push the following to your HW github repo into the master branch:

- Your local HW3 directory. Your repo file structure should look like this:

```
HW-<user>
    --HW3
       |__MIDS-W261-HW-03-<Student_id>.ipnb
       |__MIDS-W261-HW-03-<Student_id>.pdf
       |__some other hw3 file
    --HW4
       |__MIDS-W261-HW-04-<Student_id>.ipnb
       |__MIDS-W261-HW-04-<Student_id>.pdf
       |__some other hw4 file
    etc..
```

HW3.0.

1. How do you merge two sorted lists/arrays of records of the form [key, value]?
2. Where is this used in Hadoop MapReduce? [Hint within the shuffle]
3. What is a combiner function in the context of Hadoop?
4. Give an example where it can be used and justify why it should be used in the context of this problem.
5. What is the Hadoop shuffle?

HW3.0 Answers

1. With the form [key, value], we merge two sorted lists using Priority Queue. This is initially done my establishing 3 pointers: One at the the start of each sorted list, and one at start of the merged list. We start by picking off the smallest element of the two sorted lists and add them to the merged list, incrementing the pointers along the way until we reach the end of the two sorted lists.
2. sorting of merged lists occurs in the combiners
3. A combiner is used to merge the intermediary lists generated from the mappers.
4. In the context of our wordcount example, the mappers will intake records and establish an intermediary counts for each word that occurs. Although the mappers can technically perform local aggregation using arrays, a single word could still occur across multiple records or mappers. The combiner is used in this context to take those intermediary arrays and merge them into a single list. This is useful because we will be utilizing less memory by maintaining fewer lists of terms/counts.
5. The Hadoop shuffle is the entire process that happens between the mapper output and the reducer input. This includes:

```
a. Partition, sort, combine
b. Mergesort
c. Send to reducer
d. Mergesort partition files
e. Stream to reducer
```

Type *Markdown* and LaTeX: α^2

HW3.1 consumer complaints dataset: Use Counters to do EDA (exploratory data analysis and to monitor progress)

Counters are lightweight objects in Hadoop that allow you to keep track of system progress in both the map and reduce stages of processing. By default, Hadoop defines a number of standard counters in "groups"; these show up in the jobtracker webapp, giving you information such as "Map input records", "Map output records", etc.

While processing information/data using MapReduce job, it is a challenge to monitor the progress of parallel threads running across nodes of distributed clusters. Moreover, it is also complicated to distinguish between the data that has been processed and the data which is yet to be processed. The MapReduce Framework offers a provision of user-defined Counters, which can be effectively utilized to monitor the progress of data across nodes of distributed clusters.

Use the Consumer Complaints Dataset provide here to complete this question:

```
 https://www.dropbox.com/s/vbalm3yva2rr86m/Consumer_Compl
aints.csv?dl=0
```

The consumer complaints dataset consists of diverse consumer complaints, which have been reported across the United States regarding various types of loans. The dataset consists of records of the form:

Complaint ID,Product,Sub-product,Issue,Sub-issue,State,ZIP code,Submitted via,Date received,Date sent to company,Company,Company response,Timely response?,Consumer disputed?

Here's is the first few lines of the of the Consumer Complaints Dataset:

```
Complaint ID,Product,Sub-product,Issue,Sub-issue,State,ZI
P code,Submitted via,Date received,Date sent to company,C
ompany,Company response,Timely response?,Consumer dispute
d?
1114245,Debt collection,Medical,Disclosure verification o
f debt,Not given enough info to verify debt,FL,32219,Web,
11/13/2014,11/13/2014,"Choice Recovery, Inc.",Closed with
 explanation,Yes,
1114488,Debt collection,Medical,Disclosure verification o
f debt,Right to dispute notice not received,TX,75006,Web,
11/13/2014,11/13/2014,"Expert Global Solutions, Inc.",In
progress,Yes,
1114255,Bank account or service,Checking account,Deposits
 and withdrawals,NY,11102,Web,11/13/2014,11/13/2014,"ENI
```

In [2]:
```
# Create HDFS directories
!mkdir ConsumerComplaints
```

```
mkdir: cannot create directory `ConsumerComplaints': File exist
s
```

In [20]:
```
# Put the data into HDFS
!curl 'https://www.dropbox.com/s/vbalm3yva2rr86m/Consumer_Compla
!cp ./ccd.csv ./ConsumerComplaints/
```

```
  % Total    % Received % Xferd  Average Speed   Time    Time
   Time  Current
                                 Dload  Upload   Total   Spent
   Left  Speed
  0     0    0     0    0     0      0      0 --:--:-- --:--:--
 --:--:--     0
100 48.5M  100 48.5M    0     0  4774k      0  0:00:10  0:00:10
 --:--:-- 5558k
```

In [47]:
```
%%writefile complaintCountsMapper.py
#!/usr/bin/env python

# # START STUDENT CODE HW31MAPPER

import sys
from collections import defaultdict

# Set up counters to monitor/understand the number of times a ma

prods = defaultdict(int)

for line in sys.stdin:
    if 'debt collection' in line.lower():
        prods['debt collection'] += 1
        sys.stderr.write("reporter:counter:HW3.1 Mapper Debt Col

    elif 'mortgage' in line.lower():
        prods['mortgage'] += 1
        sys.stderr.write("reporter:counter:HW3.1 Mapper Mortgage

    else:
        prods['other'] += 1
        sys.stderr.write("reporter:counter:HW3.1 Mapper Other Co

for key in sorted(prods):
    print '%s\t%s' % (key, prods[key])

# END STUDENT CODE HW31MAPPER
```

```
Overwriting complaintCountsMapper.py
```

Not required to create reducer, but for the sake of continuity, I've created one

In [40]:
```
%%writefile complaintCountsReducer.py
#!/usr/bin/env python

# START STUDENT CODE HW31REDUCER

import sys
# Set up counters to monitor/understand the number of times a red
sys.stderr.write("reporter:counter:HW3.1 Reducer Counters,Calls,1

d = {}

# For each line from the mapper output, split the three attribute
# Spam/Ham classification, key term, value count
for line in sys.stdin:
    key,value = line.split("\t")

    # check if docClass + key term combination exist in dictionar
    # if so, update the term count value
    if key in d:
        d[key] += int(value)

    # if combination does not exist, add it to the dictionary
    else:
        d[key] = int(value)

# for each value in the dictionary, print the 3 attributes in a
# way that they can later be sorted appropriately
for key, value in d.iteritems():
    print '%s\t%s' % (key, value)

# END STUDENT CODE HW31REDUCER
```

```
Overwriting complaintCountsReducer.py
```

Update Security of Mapper and Reducer

In [41]:
```
!chmod a+x complaintCountsMapper.py
!chmod a+x complaintCountsReducer.py
```

Execute Hadoop calls

In [46]:
```
# Hadoop command
# START STUDENT CODE HW31HADOOP

!hdfs dfs -rm ccd.csv
!hdfs dfs -copyFromLocal ccd.csv
!hdfs dfs -rm -r cc-output

!hadoop jar /usr/lib/hadoop-0.20-mapreduce/contrib/streaming/hado
  -files complaintCountsMapper.py,complaintCountsReducer.py \
  -mapper complaintCountsMapper.py \
  -reducer complaintCountsReducer.py \
  -combiner complaintCountsReducer.py \
  -input ccd.csv \
  -output cc-output  \
  -numReduceTasks 1

# END STUDENT CODE HW31HADOOP
```

```
Deleted ccd.csv
Deleted cc-output
packageJobJar: [] [/usr/lib/hadoop-mapreduce/hadoop-streaming-2
.6.0-cdh5.8.0.jar] /tmp/streamjob5158676712758093896.jar tmpDir
=null
17/01/28 13:33:58 INFO client.RMProxy: Connecting to ResourceMa
nager at /0.0.0.0:8032
17/01/28 13:33:58 INFO client.RMProxy: Connecting to ResourceMa
nager at /0.0.0.0:8032
17/01/28 13:33:58 INFO mapred.FileInputFormat: Total input path
s to process : 1
17/01/28 13:33:58 INFO mapreduce.JobSubmitter: number of splits
:2
17/01/28 13:33:58 INFO mapreduce.JobSubmitter: Submitting token
s for job: job_1484544278544_0363
17/01/28 13:33:59 INFO impl.YarnClientImpl: Submitted applicati
on application_1484544278544_0363
17/01/28 13:33:59 INFO mapreduce.Job: The url to track the job:
 http://quickstart.cloudera:8088/proxy/application_148454427854
4_0363/ (http://quickstart.cloudera:8088/proxy/application_1484
```

Check output counts

In [48]:
```
!hdfs dfs -cat cc-output/part-0000* > cc_counts.txt
!head cc_counts.txt
```

```
debt collection 44372
other   142745
mortgage        125796
```

HW 3.2 Analyze the performance of your Mappers, Combiners and Reducers using Counters

For this brief study the Input file will be one record (the next line only):
`foo foo quux labs foo bar quux`

3.2.A
Perform a word count analysis of this single record dataset using a Mapper and Reducer based WordCount (i.e., no combiners are used here) using user defined Counters to count up how many times the mapper and reducer are called. What is the value of your user defined Mapper Counter, and Reducer Counter after completing this word count job. The answer should be 1 and 4 respectively. Please explain.

3.2.B
Please use mulitple mappers and reducers for these jobs (at least 2 mappers and 2 reducers). Perform a word count analysis of the Issue column of the Consumer Complaints Dataset using a Mapper and Reducer based WordCount (i.e., no combiners used anywhere) using user defined Counters to count up how many time the mapper and reducer are called. What is the value of your user defined Mapper Counter, and Reducer Counter after completing your word count job.

3.2.C
Perform a word count analysis of the Issue column of the Consumer Complaints Dataset using a Mapper, Reducer, and standalone combiner (i.e., not an in-memory combiner) based WordCount using user defined Counters to count up how many time the mapper, combiner, reducer are called. What is the value of your user defined Mapper Counter, and Reducer Counter after completing your word count job.

Using a single reducer:

- What are the top 50 most frequent terms in your word count analysis?
- Present the top 50 terms and their frequency and their relative frequency. If there are ties please sort the tokens in alphanumeric/string order.
- Present bottom 10 tokens (least frequent items).

NOTE: You can use: `WORD_RE = re.compile(r"[\w']+")` to tokenize.

3.2.A SOLUTION

In [70]:
```
%%writefile mapper3.2.A.py
#!/usr/bin/env python
# START STUDENT CODE HW32AMAPPER

import sys
from collections import defaultdict

# Set up counters to monitor/understand the number of times a ma
sys.stderr.write("reporter:counter:HW3.2.A Mapper Counters,Calls

wordCounts = defaultdict(int)

for line in sys.stdin:
    words = line.split()
    for word in words:
            print '%s\t%s' % (word, 1)
#         if word in wordCounts:
#             wordCounts[word] += 1
#         else:
#             wordCounts[word] += 1

# for key in sorted(wordCounts):
#     print '%s\t%s' % (key, wordCounts[key])

# END STUDENT CODE HW32AMAPPER
```

```
Overwriting mapper3.2.A.py
```

In [71]:
```
%%writefile reducer3.2.A.py
#!/usr/bin/env python
# START STUDENT CODE HW32AREDUCER

import sys
# Set up counters to monitor/understand the number of times a red
sys.stderr.write("reporter:counter:HW3.2.A Reducer Counters,Calls

d = {}

# For each line from the mapper output, split the three attribute
# Spam/Ham classification, key term, value count
for line in sys.stdin:
    key,value = line.split("\t")

    # check if docClass + key term combination exist in dictionar
    # if so, update the term count value
    if key in d:
        d[key] += int(value)

    # if combination does not exist, add it to the dictionary
    else:
        d[key] = int(value)

# for each value in the dictionary, print the 3 attributes in a
# way that they can later be sorted appropriately
for key, value in d.iteritems():
    print '%s\t%s' % (key, value)

# END STUDENT CODE HW32AREDUCER
```

```
Overwriting reducer3.2.A.py
```

Create input file

In [61]:
```
!echo "foo foo quux labs foo bar quux" > ./HW3.2.txt
```

In [82]:
```
# Hadoop command
# START STUDENT CODE HW32AHADOOP

#update security on mapper/reducer
!chmod a+x mapper3.2.A.py
!chmod a+x reducer3.2.A.py

!hdfs dfs -rm HW3.2.txt
!hdfs dfs -copyFromLocal HW3.2.txt
!hdfs dfs -rm -r HW3.2.A-output

!hadoop jar /usr/lib/hadoop-0.20-mapreduce/contrib/streaming/hado
  -files mapper3.2.A.py,reducer3.2.A.py \
  -mapper mapper3.2.A.py \
  -reducer reducer3.2.A.py \
  -input HW3.2.txt \
  -output HW3.2.A-output \
  -numReduceTasks 4

# END STUDENT CODE HW32AHADOOP
```

```
Deleted HW3.2.txt
rm: `HW3.2.A-output': No such file or directory
packageJobJar: [] [/usr/lib/hadoop-mapreduce/hadoop-streaming-2
.6.0-cdh5.8.0.jar] /tmp/streamjob4205658107599752123.jar tmpDir
=null
17/01/28 14:36:41 INFO client.RMProxy: Connecting to ResourceMa
nager at /0.0.0.0:8032
17/01/28 14:36:41 INFO client.RMProxy: Connecting to ResourceMa
nager at /0.0.0.0:8032
17/01/28 14:36:42 INFO mapred.FileInputFormat: Total input path
s to process : 1
17/01/28 14:36:42 INFO mapreduce.JobSubmitter: number of splits
:2
17/01/28 14:36:42 INFO mapreduce.JobSubmitter: Submitting token
s for job: job_1484544278544_0371
17/01/28 14:36:42 INFO impl.YarnClientImpl: Submitted applicati
on application_1484544278544_0371
17/01/28 14:36:42 INFO mapreduce.Job: The url to track the job:
 http://quickstart.cloudera:8088/proxy/application_148454427854
4_0371/ (http://quickstart.cloudera:8088/proxy/application_1484
```

In [107]:
```
# INSERT SCREENSHOT OF JOB TRACKER UI COUNTERS
from IPython.display import Image, HTML
Image('HW32.png')
```

Out[107]:

	Name	Map	Reduce	Total
HW3.2.A Mapper Counters	Calls	2	0	2
HW3.2.A Reducer Counters	Name	Map	Reduce	Total
	Calls	0	4	4

3.2.A EXPLANATION

For mappers, I accepted the defaults and used 2. For reducers, I specified for 4 to be used. These numbers will change based on the settings and configuration that is used within the Hadoop Streaming calls.

3.2.B SOLUTION

3.2.B Mapper

In [108]:
```
%%writefile mapper3.2.B.py
#!/usr/bin/env python
# START STUDENT CODE HW32BMAPPER

import sys
import csv
from collections import defaultdict
import re

# Set up counters to monitor/understand the number of times a ma
sys.stderr.write("reporter:counter:HW3.2.B Mapper Counters,Calls

issueList = defaultdict(int)

ccd = csv.reader(sys.stdin)
for row in ccd:
    issue = row[3]
    if len(issue) > 0 and issue != 'Issue':
        words = re.findall(r'[a-z]+', issue.lower())
        for word in words:
            if word in issueList:
                issueList[word] +=1
            else:
                issueList[word] = 1

for key in sorted(issueList):
    print '%s\t%s' % (key, issueList[key])



# END STUDENT CODE HW32BMAPPER
```

```
Overwriting mapper3.2.B.py
```

3.2.B Reducer

In [109]:
```
%%writefile reducer3.2.B.py
#!/usr/bin/env python
# START STUDENT CODE HW32BREDUCER

import sys
# Set up counters to monitor/understand the number of times a red
sys.stderr.write("reporter:counter:HW3.2.B Reducer Counters,Calls

d = {}

# For each line from the mapper output, split the three attribute
# Spam/Ham classification, key term, value count
for line in sys.stdin:
    key,value = line.split("\t")

    # check if docClass + key term combination exist in dictionar
    # if so, update the term count value
    if key in d:
        d[key] += int(value)

    # if combination does not exist, add it to the dictionary
    else:
        d[key] = int(value)

# for each value in the dictionary, print the 3 attributes in a
# way that they can later be sorted appropriately
for key, value in d.iteritems():
    print '%s\t%s' % (key, value)

# END STUDENT CODE HW32BREDUCER
```

```
Overwriting reducer3.2.B.py
```

3.2.B Hadoop Calls

In [110]:
```
# Hadoop command
# START STUDENT CODE HW32BHADOOP

!chmod a+x mapper3.2.B.py
!chmod a+x reducer3.2.B.py

!hdfs dfs -rm ccd.csv
!hdfs dfs -copyFromLocal ccd.csv
!hdfs dfs -rm -r HW3.2.B-output

!hadoop jar /usr/lib/hadoop-0.20-mapreduce/contrib/streaming/hado
  -files mapper3.2.B.py,reducer3.2.B.py \
  -reducer reducer3.2.B.py \
  -mapper mapper3.2.B.py \
  -input ccd.csv \
  -output HW3.2.B-output \
  -numReduceTasks 4

# END STUDENT CODE HW32BHADOOP
```

```
Deleted ccd.csv
Deleted HW3.2.B-output
packageJobJar: [] [/usr/lib/hadoop-mapreduce/hadoop-streaming-2
.6.0-cdh5.8.0.jar] /tmp/streamjob3908761271563178578.jar tmpDir
=null
17/01/29 15:30:05 INFO client.RMProxy: Connecting to ResourceMa
nager at /0.0.0.0:8032
17/01/29 15:30:06 INFO client.RMProxy: Connecting to ResourceMa
nager at /0.0.0.0:8032
17/01/29 15:30:06 INFO mapred.FileInputFormat: Total input path
s to process : 1
17/01/29 15:30:06 INFO mapreduce.JobSubmitter: number of splits
:2
17/01/29 15:30:06 INFO mapreduce.JobSubmitter: Submitting token
s for job: job_1484544278544_0417
17/01/29 15:30:07 INFO impl.YarnClientImpl: Submitted applicati
on application_1484544278544_0417
17/01/29 15:30:07 INFO mapreduce.Job: The url to track the job:
 http://quickstart.cloudera:8088/proxy/application_148454427854
4_0417/ (http://quickstart.cloudera:8088/proxy/application_1484
```

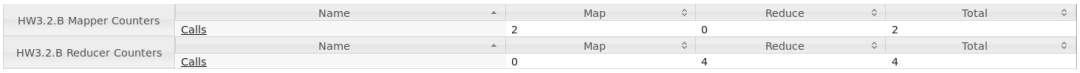
3.2.B Answer

In [111]:
```
# 3.2.B OUTPUT/ANSWER
!hdfs dfs -cat HW3.2.B-output/part-0000* > HW3.2.B_counts.txt
!cat HW3.2.B_counts.txt
```

```
owed    17972
caused  5663
sale    139
acct    163
your    3844
payoff  1155
incorrect       29133
management      16205
delinquent      1061
for     929
transfer        597
the     6248
to      8401
unable  8178
issue   1098
checks  75
available       274
applied 139
workout 350
was     274
```

In [129]:
```
# INSERT SCREENSHOT OF JOB TRACKER UI COUNTERS
from IPython.display import Image, HTML
Image('HW32B.png')
```

Out[129]:



HW3.2.B Mapper Counters	Name	Map	Reduce	Total
	Calls	2	0	2

HW3.2.B Reducer Counters	Name	Map	Reduce	Total
	Calls	0	4	4

3.2.C SOLUTION

3.2.C Mapper

In [117]:
```
%%writefile mapper3.2.C.py
#!/usr/bin/env python
# START STUDENT CODE HW32CMAPPER

import sys
import csv
import re

# Set up counters to monitor/understand the number of times a ma
sys.stderr.write("reporter:counter:HW3.2.B Mapper Counters,Calls

ccd = csv.reader(sys.stdin)
for row in ccd:
    issue = row[3]
    if len(issue) > 0 and issue != 'Issue':
        words = re.findall(r'[a-z]+', issue.lower())
        for word in words:
            print '%s\t%s' % (word, 1)

# END STUDENT CODE HW32CMAPPER
```

```
Overwriting mapper3.2.C.py
```

3.2.C Combiner

In [122]:
```
%%writefile combiner3.2.C.py
#!/usr/bin/env python
# START STUDENT CODE HW32CCOMBINER
import sys
from collections import defaultdict

# Set up counters to monitor/understand the number of times a re
sys.stderr.write("reporter:counter:HW3.2.C Combiner Counters,Cal

issueDict = defaultdict(int)

for line in sys.stdin:
    word,count = line.split("\t")
    if word in issueDict:
        issueDict[word] += int(count)
    else:
        issueDict[word] = int(count)

for key in sorted(issueDict):
    print '%s\t%s' % (key, issueDict[key])

# END STUDENT CODE HW32CCOMBINER
```

```
Overwriting combiner3.2.C.py
```

3.2.C Reducer

In [123]:
```
%%writefile reducer3.2.C.py
#!/usr/bin/env python
# START STUDENT CODE HW32CREDUCER

import sys
# Set up counters to monitor/understand the number of times a red
sys.stderr.write("reporter:counter:HW3.2.C Reducer Counters,Calls

d = {}

# For each line from the mapper output, split the three attribute
# Spam/Ham classification, key term, value count
for line in sys.stdin:
    key,value = line.split("\t",1)

    # check if docClass + key term combination exist in dictionar
    # if so, update the term count value
    if key in d:
        d[key] += int(value)

    # if combination does not exist, add it to the dictionary
    else:
        d[key] = int(value)

# for each value in the dictionary, print the 3 attributes in a
# way that they can later be sorted appropriately
for key, value in d.iteritems():
    print '%s\t%s' % (key, value)

# END STUDENT CODE HW32CREDUCER
```

```
Overwriting reducer3.2.C.py
```

3.2.C Hadoop Calls

In [124]:
```
# Hadoop command
# START STUDENT CODE HW32CHADOOP

!chmod a+x mapper3.2.C.py
!chmod a+x combiner3.2.C.py
!chmod a+x reducer3.2.C.py

!hdfs dfs -rm ccd.csv
!hdfs dfs -copyFromLocal ccd.csv
!hdfs dfs -rm -r HW3.2.C-output

!hadoop jar /usr/lib/hadoop-0.20-mapreduce/contrib/streaming/hado
  -files mapper3.2.C.py,combiner3.2.C.py,reducer3.2.C.py \
  -reducer reducer3.2.C.py \
  -combiner combiner3.2.C.py \
  -mapper mapper3.2.C.py \
  -input ccd.csv \
  -output HW3.2.C-output \
  -numReduceTasks 1


# END STUDENT CODE HW32CHADOOP
```

```
Deleted ccd.csv
Deleted HW3.2.C-output
packageJobJar: [] [/usr/lib/hadoop-mapreduce/hadoop-streaming-2
.6.0-cdh5.8.0.jar] /tmp/streamjob6631041556751413680.jar tmpDir
=null
17/01/29 15:54:13 INFO client.RMProxy: Connecting to ResourceMa
nager at /0.0.0.0:8032
17/01/29 15:54:13 INFO client.RMProxy: Connecting to ResourceMa
nager at /0.0.0.0:8032
17/01/29 15:54:14 INFO mapred.FileInputFormat: Total input path
s to process : 1
17/01/29 15:54:14 INFO mapreduce.JobSubmitter: number of splits
:2
17/01/29 15:54:14 INFO mapreduce.JobSubmitter: Submitting token
s for job: job_1484544278544_0420
17/01/29 15:54:14 INFO impl.YarnClientImpl: Submitted applicati
on application_1484544278544_0420
17/01/29 15:54:14 INFO mapreduce.Job: The url to track the job:
 http://quickstart.cloudera:8088/proxy/application_148454427854
4_0420/ (http://quickstart.cloudera:8088/proxy/application_1484
```

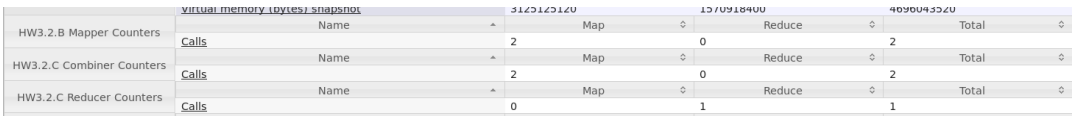
3.2.C Answer

In [125]:
```
# 3.2.C OUTPUT/ANSWER
!hdfs dfs -cat HW3.2.C-output/part-0000* > HW3.2.C_counts.txt
!cat HW3.2.C_counts.txt
```

```
unsolicited     640
foreclosure     70487
being   5663
caused  5663
scam    566
embezzlement    3276
report  34903
attempts        17972
settlement      4350
underwriting    2774
issues  538
payoff  1155
delinquent      1061
credited        92
deposits        10555
amt     71
late    1797
to      8401
other   7886
money   3639
```

In [128]:
```
# INSERT SCREENSHOT OF JOB TRACKER UI COUNTERS
from IPython.display import Image, HTML
Image('HW32C.png')
```

Out[128]:



3.2.1

Using **2 reducers**: What are the top **50 most frequent terms** in your word count analysis?

Present the top 50 terms and their frequency and their relative frequency. Present the top 50 terms and their frequency and their relative frequency. If there are ties please sort the tokens in alphanumeric/string order. Present bottom 10 tokens (least frequent items). Please **use a combiner.**

START STUDENT CODE HW321 (INSERT CELLS BELOW AS NEEDED)

3.2.C Frequency Mapper

In [152]:
```
%%writefile frequencies_mapper3.2.C.py
#!/usr/bin/env python
# START STUDENT CODE HW32CFREQMAPPER

import sys, csv, re

# Set up counters to monitor/understand the number of times a ma
sys.stderr.write("reporter:counter:HW3.2.C Mapper Counters,Calls

ccd = csv.reader(sys.stdin)
for row in ccd:
    issue = row[3]
    if len(issue) > 0 and issue != 'Issue':
        words = re.findall(r'[a-z]+', issue.lower())
        for word in words:
            print '%s\t%s\t%s' % (word, 1,10)

# END STUDENT CODE HW32CFREQMAPPER
```

```
Overwriting frequencies_mapper3.2.C.py
```

3.2.C Frequency Reducer

In [165]:
```
%%writefile frequencies_reducer3.2.C.py
#!/usr/bin/env python
# START STUDENT CODE HW32CFREQREDUCER

import sys
# Set up counters to monitor/understand the number of times a red
sys.stderr.write("reporter:counter:HW3.2.C Reducer Counters,Calls

d = {}
total = 0
# For each line from the mapper output, split the three attribute
# Spam/Ham classification, key term, value count
for line in sys.stdin:
    key,value,x = line.split("\t",2)

    # check if docClass + key term combination exist in dictionar
    # if so, update the term count value
    if key in d:
        d[key] += int(value)

    # if combination does not exist, add it to the dictionary
    else:
        d[key] = int(value)

for key, value in d.iteritems():
    total += int(value)

# for each value in the dictionary, print the 3 attributes in a
# way that they can later be sorted appropriately
for key, value in d.iteritems():
    freq = 0
    freq = round((float(value) / float(total)),4)
    print '%s\t%s\t%s' % (key, value, freq)

# END STUDENT CODE HW32CFREQREDUCER
```

```
Overwriting frequencies_reducer3.2.C.py
```

3.2.C Hadoop Calls

In [266]:
```
# Hadoop command
# START STUDENT CODE HW32CFREQHADOOP

!chmod a+x frequencies_mapper3.2.C.py
!chmod a+x frequencies_reducer3.2.C.py

!hdfs dfs -rm ccd.csv
!hdfs dfs -copyFromLocal ccd.csv
!hdfs dfs -rm -r HW3.2.C.freq-output

!hadoop jar /usr/lib/hadoop-0.20-mapreduce/contrib/streaming/hado
  -files frequencies_mapper3.2.C.py,frequencies_reducer3.2.C.py \
  -reducer frequencies_reducer3.2.C.py \
  -combiner frequencies_reducer3.2.C.py \
  -mapper frequencies_mapper3.2.C.py \
  -input ccd.csv \
  -output HW3.2.C.freq-output \
  -numReduceTasks 2

# END STUDENT CODE HW32CFREQHADOOP
```

```
Deleted ccd.csv
Deleted HW3.2.C.freq-output
packageJobJar: [] [/usr/lib/hadoop-mapreduce/hadoop-streaming-2
.6.0-cdh5.8.0.jar] /tmp/streamjob4385493534662397680.jar tmpDir
=null
17/01/30 21:21:52 INFO client.RMProxy: Connecting to ResourceMa
nager at /0.0.0.0:8032
17/01/30 21:21:52 INFO client.RMProxy: Connecting to ResourceMa
nager at /0.0.0.0:8032
17/01/30 21:21:53 INFO mapred.FileInputFormat: Total input path
s to process : 1
17/01/30 21:21:53 INFO mapreduce.JobSubmitter: number of splits
:2
17/01/30 21:21:53 INFO mapreduce.JobSubmitter: Submitting token
s for job: job_1484544278544_0457
17/01/30 21:21:53 INFO impl.YarnClientImpl: Submitted applicati
on application_1484544278544_0457
17/01/30 21:21:53 INFO mapreduce.Job: The url to track the job:
 http://quickstart.cloudera:8088/proxy/application_148454427854
4_0457/ (http://quickstart.cloudera:8088/proxy/application_1484
```

3.2.C Answer

50 Most Frequent Terms

In [267]:
```
# 3.2.C OUTPUT/ANSWER
!hdfs dfs -cat HW3.2.C.freq-output/part-0000* > HW3.2.C.freq_cou
!cat HW3.2.C.freq_counts.txt | sort -k2,2nr | head -n50
```

```
loan    119630  0.1707
collection      72394   0.1033
foreclosure     70487   0.1047
modification    70487   0.1006
account 57448   0.0853
credit  55251   0.0821
or      40508   0.0602
payments        39993   0.0594
escrow  36767   0.0546
servicing       36767   0.0525
report  34903   0.0498
incorrect       29133   0.0433
information     29069   0.0415
on      29069   0.0432
debt    27874   0.0414
closing 19000   0.0282
not     18477   0.0274
attempts        17972   0.0256
collect 17972   0.0256
cont    17972   0.0256
```

10 Least Frequent Terms

In [173]:
```
# 3.2.C OUTPUT/ANSWER
!hdfs dfs -cat HW3.2.C.freq-output/part-0000* > HW3.2.C.freq_cou
!cat HW3.2.C.freq_counts.txt | sort -k2,2n | head -n10
```

```
disclosures     64      0.0001
missing 64      0.0001
amt     71      0.0001
day     71      0.0001
checks  75      0.0001
convenience     75      0.0001
credited        92      0.0001
payment 92      0.0001
amount  98      0.0001
apply   118     0.0002
```

END STUDENT CODE HW321

HW3.3. Shopping Cart Analysis

Product Recommendations: The action or practice of selling additional products or services to existing customers is called cross-selling. Giving product recommendation is one of the examples of cross-selling that are frequently used by online retailers. One simple method to give product recommendations is to recommend products that are frequently browsed together by the customers.

For this homework use the online browsing behavior dataset located at:

```
    https://www.dropbox.com/s/zlfyiwa70poqg74/ProductPurch
aseData.txt?dl=0
```

Each line in this dataset represents a browsing session of a customer. On each line, each string of 8 characters represents the id of an item browsed during that session. The items are separated by spaces.

Here are the first few lines of the ProductPurchaseData FRO11987 ELE17451 ELE89019 SNA90258 GRO99222 GRO99222 GRO12298 FRO12685 ELE91550 SNA11465 ELE26917 ELE52966 FRO90334 SNA30755 ELE17451 FRO84225 SNA80192 ELE17451 GRO73461 DAI22896 SNA99873 FRO86643 ELE17451 ELE37798 FRO86643 GRO56989 ELE23393 SNA11465 ELE17451 SNA69641 FRO86643 FRO78087 SNA11465 GRO39357 ELE28573 ELE11375 DAI54444

Do some exploratory data analysis of this dataset guided by the following questions:.

How many unique items are available from this supplier?

Using a single reducer: Report your findings such as number of unique products; largest basket; report the top 50 most frequently purchased items, their frequency, and their relative frequency (break ties by sorting the products alphabetical order) etc. using Hadoop Map-Reduce.

START STUDENT CODE HW33 (INSERT CELLS BELOW AS NEEDED)

In [174]:
```
!curl 'https://www.dropbox.com/s/zlfyiva70pogg74/ProductPurchaseD
```

```
  % Total    % Received % Xferd  Average Speed   Time    Time
   Time  Current
                                 Dload  Upload   Total   Spent
    Left  Speed
  0     0    0     0    0     0      0      0 --:--:-- --:--:--
 --:--:--     0
100 3377k  100 3377k    0     0  1371k      0  0:00:02  0:00:02
 --:--:-- 2356k
```

In [175]:
```
!head ProductPurchaseData.txt
```

```
FRO11987 ELE17451 ELE89019 SNA90258 GRO99222
GRO99222 GRO12298 FRO12685 ELE91550 SNA11465 ELE26917 ELE52966
FRO90334 SNA30755 ELE17451 FRO84225 SNA80192
ELE17451 GRO73461 DAI22896 SNA99873 FRO86643
ELE17451 ELE37798 FRO86643 GRO56989 ELE23393 SNA11465
ELE17451 SNA69641 FRO86643 FRO78087 SNA11465 GRO39357 ELE28573
ELE11375 DAI54444
ELE17451 GRO73461 DAI22896 SNA99873 FRO18919 DAI50921 SNA80192
GRO75578
ELE17451 ELE59935 FRO18919 ELE23393 SNA80192 SNA85662 SNA91554
DAI22177
ELE17451 SNA69641 FRO18919 SNA90258 ELE28573 ELE11375 DAI14125
FRO78087
ELE17451 GRO73461 DAI22896 SNA80192 SNA85662 SNA90258 DAI46755
FRO81176 ELE66810 DAI49199 DAI91535 GRO94758 ELE94711 DAI22177
ELE17451 SNA69641 DAI91535 GRO94758 GRO99222 FRO76833 FRO81176
SNA80192 DAI54690 ELE37798 GRO56989
```

3.3 Mapper

In [176]:
```
%%writefile mapper3.3.py
#!/usr/bin/env python

import sys

# Set up counters to monitor/understand the number of times a ma
sys.stderr.write("reporter:counter:HW3.3 Mapper Counters,Calls,1

for line in sys.stdin:
    prods = line.split()
    for item in prods:
        print '%s\t%s\t%s' % (item, 1,10)
```

```
Writing mapper3.3.py
```

3.3 Reducer

In [179]:
```
%%writefile reducer3.3.py
#!/usr/bin/env python

import sys
# Set up counters to monitor/understand the number of times a red
sys.stderr.write("reporter:counter:HW3.3 Reducer Counters,Calls,1

d = {}
total = 0
# For each line from the mapper output, split the three attribute
# Spam/Ham classification, key term, value count
for line in sys.stdin:
    key,value,x = line.split("\t",2)

    # check if docClass + key term combination exist in dictionar
    # if so, update the term count value
    if key in d:
        d[key] += int(value)

    # if combination does not exist, add it to the dictionary
    else:
        d[key] = int(value)

for key, value in d.iteritems():
    total += int(value)

# for each value in the dictionary, print the 3 attributes in a
# way that they can later be sorted appropriately
for key, value in d.iteritems():
    freq = 0
    freq = round((float(value) / float(total)),4)
    print '%s\t%s\t%s' % (key, value, freq)
```

```
Overwriting reducer3.3.py
```

3.3 Hadoop Calls

In [185]:
```
# Hadoop command

!chmod a+x mapper3.3.py
!chmod a+x reducer3.3.py

!hdfs dfs -rm ProductPurchaseData.txt
!hdfs dfs -copyFromLocal ProductPurchaseData.txt
!hdfs dfs -rm -r HW3.3-output

!hadoop jar /usr/lib/hadoop-0.20-mapreduce/contrib/streaming/hado
  -files mapper3.3.py,reducer3.3.py \
  -reducer reducer3.3.py \
  -combiner reducer3.3.py \
  -mapper mapper3.3.py \
  -input ProductPurchaseData.txt \
  -output HW3.3-output \
  -numReduceTasks 1
```

```
Deleted ProductPurchaseData.txt
Deleted HW3.3-output
packageJobJar: [] [/usr/lib/hadoop-mapreduce/hadoop-streaming-2
.6.0-cdh5.8.0.jar] /tmp/streamjob6402019114965539630.jar tmpDir
=null
17/01/29 17:08:42 INFO client.RMProxy: Connecting to ResourceMa
nager at /0.0.0.0:8032
17/01/29 17:08:43 INFO client.RMProxy: Connecting to ResourceMa
nager at /0.0.0.0:8032
17/01/29 17:08:43 INFO mapred.FileInputFormat: Total input path
s to process : 1
17/01/29 17:08:43 INFO mapreduce.JobSubmitter: number of splits
:2
17/01/29 17:08:43 INFO mapreduce.JobSubmitter: Submitting token
s for job: job_1484544278544_0432
17/01/29 17:08:44 INFO impl.YarnClientImpl: Submitted applicati
on application_1484544278544_0432
17/01/29 17:08:44 INFO mapreduce.Job: The url to track the job:
 http://quickstart.cloudera:8088/proxy/application_148454427854
4_0432/ (http://quickstart.cloudera:8088/proxy/application_1484
```

3.3 ANSWER

Top 50 Items

In [187]:
```
# 3.3 OUTPUT/ANSWER
!hdfs dfs -cat HW3.3-output/part-0000* > HW3.3counts.txt
!cat HW3.3counts.txt | sort -k2 -nr | head -n50
```

```
DAI62779        6667    0.0175
FRO40251        3881    0.0102
ELE17451        3875    0.0102
GRO73461        3602    0.0095
SNA80324        3044    0.008
ELE32164        2851    0.0075
DAI75645        2736    0.0072
SNA45677        2455    0.0064
FRO31317        2330    0.0061
DAI85309        2293    0.006
ELE26917        2292    0.006
FRO80039        2233    0.0059
GRO21487        2115    0.0056
SNA99873        2083    0.0055
GRO59710        2004    0.0053
GRO71621        1920    0.005
FRO85978        1918    0.005
GRO30386        1840    0.0048
ELE74009        1816    0.0048
GRO56726        1784    0.0047
```

Number of Unique Items

In [186]:
```
!cat HW3.3counts.txt | wc -l
```

```
12592
```

END STUDENT CODE HW33

HW3.3.1 OPTIONAL

Using 2 reducers: Report your findings such as number of unique products; largest basket; report the top 50 most frequently purchased items, their frequency, and their relative frequency (break ties by sorting the products alphabetical order) etc. using Hadoop Map-Reduce.

START STUDENT CODE HW331 (INSERT CELLS BELOW AS NEEDED)

END STUDENT CODE HW331

HW3.4. (Computationally prohibitive but then again Hadoop can handle this) Pairs

Suppose we want to recommend new products to the customer based on the products they have already browsed on the online website. Write a map-reduce program to find products which are frequently browsed together. Fix the support count (cooccurence count) to s = 100 (i.e. product pairs need to occur together at least 100 times to be considered frequent) and find pairs of items (sometimes referred to itemsets of size 2 in association rule mining) that have a support count of 100 or more.

List the top 50 product pairs with corresponding support count (aka frequency), and relative frequency or support (number of records where they coccur, the number of records where they coccur/the number of baskets in the dataset) in decreasing order of support for frequent (100>count) itemsets of size 2.

Use the Pairs pattern (lecture 3) to extract these frequent itemsets of size 2. Free free to use combiners if they bring value. Instrument your code with counters for count the number of times your mapper, combiner and reducers are called.

Please output records of the following form for the top 50 pairs (itemsets of size 2):

```
item1, item2, support count, support
```

Fix the ordering of the pairs lexicographically (left to right), and break ties in support (between pairs, if any exist) by taking the first ones in lexicographically increasing order.

Report the compute time for the Pairs job. Describe the computational setup used (E.g., single computer; dual core; linux, number of mappers, number of reducers) Instrument your mapper, combiner, and reducer to count how many times each is called using Counters and report these counts.

START STUDENT CODE HW34 (INSERT CELLS BELOW AS NEEDED)

In [47]:
```
%%writefile mapper3.4.py
#!/usr/bin/env python

import sys

# Set up counters to monitor/understand the number of times a map
sys.stderr.write("reporter:counter:HW3.4 Mapper Counters,Calls,1\

for line in sys.stdin:
    prods = line.split()
    # The outer loop runs through each individual item in a baske
    for item1 in prods:
        # The inner loop sorts through all of the other basket it
        for item2 in prods:
            if item1 != item2:

                # the '10' is just a placeholder because the redu
                print '%s\t%s\t%s\t%s' % (item1, item2, 1,10)
```

```
Overwriting mapper3.4.py
```

In [99]:
```
%%writefile reducer3.4.py
#!/usr/bin/env python

import sys
from collections import defaultdict

# Set up counters to monitor/understand the number of times a red
sys.stderr.write("reporter:counter:HW3.4 Reducer Counters,Calls,1

d = defaultdict(int)
total = 0

for line in sys.stdin:

    # the x is actually only a placeholder because the true input
    # but the output has 4
    prod1,prod2,count,x = line.split('\t',3)
    prod1 = prod1.strip()
    prod2 = prod2.strip()
    count = int(count)

    # add the count to the dictionary where appropriate
    if (prod1, prod2) in d:
        d[(prod1,prod2)] += count
    else:
    #elif (prod2, prod1) not in d:
        d[(prod1,prod2)] = count

# Calculate the total number of product interactions
for key, value in d.iteritems():
    if value >= 100:
        total += int(value)

# As mentioned in the prompt, calculate the relative frequency of
# but only for ones that have at least 100 co-occurrences
for key, value in d.iteritems():
    if value >= 100:
        freq = 0
        freq = round((float(value) / float(total)),4)
        print '%s\t%s\t%s\t%s' % (key[0], key[1], value, freq)
```

```
Overwriting reducer3.4.py
```

Hadoop Calls

In [100]:
```
# Hadoop commands

!chmod a+x mapper3.4.py
!chmod a+x reducer3.4.py

!hdfs dfs -rm ProductPurchaseData.txt
!hdfs dfs -copyFromLocal ProductPurchaseData.txt
!hdfs dfs -rm -r HW3.4-output

!hadoop jar /usr/lib/hadoop-0.20-mapreduce/contrib/streaming/hado
  -files mapper3.4.py,reducer3.4.py \
  -reducer reducer3.4.py \
  -combiner reducer3.4.py \
  -mapper mapper3.4.py \
  -input ProductPurchaseData.txt \
  -output HW3.4-output \
  -numReduceTasks 1
```

```
Deleted ProductPurchaseData.txt
Deleted HW3.4-output
packageJobJar: [] [/usr/lib/hadoop-mapreduce/hadoop-streaming-2
.6.0-cdh5.8.0.jar] /tmp/streamjob2065350177640137035.jar tmpDir
=null
17/01/31 00:39:58 INFO client.RMProxy: Connecting to ResourceMa
nager at /0.0.0.0:8032
17/01/31 00:39:58 INFO client.RMProxy: Connecting to ResourceMa
nager at /0.0.0.0:8032
17/01/31 00:39:59 INFO mapred.FileInputFormat: Total input path
s to process : 1
17/01/31 00:39:59 INFO mapreduce.JobSubmitter: number of splits
:2
17/01/31 00:39:59 INFO mapreduce.JobSubmitter: Submitting token
s for job: job_1484544278544_0486
17/01/31 00:40:00 INFO impl.YarnClientImpl: Submitted applicati
on application_1484544278544_0486
17/01/31 00:40:00 INFO mapreduce.Job: The url to track the job:
 http://quickstart.cloudera:8088/proxy/application_148454427854
4_0486/ (http://quickstart.cloudera:8088/proxy/application_1484
```

3.4 ANSWER

Pairs Job Runtime: 26 seconds

My personal PC: Single PC, 4 cores, 16GB RAM, MacOS

My Virtual Machine: 3 processors, 9GB RAM, Linux

MapReduce Configuration: 2 Mappers, 1 Reducer, 2 Map Calls, 5 Reducer Calls

In [101]:
```
# 3.4 OUTPUT/ANSWER
!hdfs dfs -cat HW3.4-output/part-0000* > HW3.4counts.txt
!cat HW3.4counts.txt | sort -k1,2 | head -n50
```

```
DAI22177        DAI62779        327     0.0017
DAI22177        DAI85309        128     0.0007
DAI22177        FRO85978        106     0.0005
DAI22177        GRO73461        146     0.0007
DAI22240        ELE37048        113     0.0006
DAI22896        DAI62779        261     0.0013
DAI22896        DAI75645        127     0.0006
DAI22896        GRO38814        141     0.0007
DAI22896        GRO73461        211     0.0011
DAI22896        SNA72163        102     0.0005
DAI23334        DAI62779        247     0.0013
DAI23334        ELE92920        140     0.0007
DAI31081        DAI62779        330     0.0017
DAI31081        DAI75645        122     0.0006
DAI31081        ELE17451        104     0.0005
DAI31081        ELE32164        265     0.0013
DAI31081        FRO40251        173     0.0009
DAI31081        GRO73461        159     0.0008
DAI31081        SNA80324        110     0.0006
DAI35347        DAI62779        107     0.0005
```

END STUDENT CODE HW34

HW3.5: Stripes

Repeat 3.4 using the stripes design pattern for finding cooccuring pairs.

Report the compute times for stripes job versus the Pairs job. Describe the computational setup used (E.g., single computer; dual core; linux, number of mappers, number of reducers)

Instrument your mapper, combiner, and reducer to count how many times each is called using Counters and report these counts. Discuss the differences in these counts between the Pairs and Stripes jobs

START STUDENT CODE HW35 (INSERT CELLS BELOW AS NEEDED)

3.5 Mapper

In [50]:
```
%%writefile mapper3.5.py
#!/usr/bin/env python

import sys
from collections import defaultdict
# Set up counters to monitor/understand the number of times a ma
sys.stderr.write("reporter:counter:HW3.5 Mapper Counters,Calls,1
d = {}
for line in sys.stdin:
    line.strip()
    prods = line.split()

    # The outer loop runs through each individual item in a baske
    for item1 in prods:
        if item1 not in d:
            d[item1] = {}

        # The inner loop sorts through all of the other basket i
        for item2 in prods:
            if item1 != item2:

                # This section is creating a hash table for the
                if item2 in d[item1]:
                    d[item1][item2] += 1
                else:
                    d[item1][item2] = 1

for key in d.iteritems():
    print '%s\t%s' % (key[0], key[1])
```

```
Overwriting mapper3.5.py
```

3.5 Combiner

In [102]:
```
%%writefile combiner3.5.py
#!/usr/bin/env python

import sys
from collections import defaultdict
import ast

# Set up counters to monitor/understand the number of times a re
sys.stderr.write("reporter:counter:HW3.5 Reducer Counters,Calls,1

d = defaultdict(int)

for line in sys.stdin:

    prod,stripe = line.split('\t')
    prod = prod.strip()

    # this will take the string and convert it to a dictionary
    stripe = ast.literal_eval(stripe)


    # add the count to the dictionary where appropriate
    if prod in d:
        for key in stripe.iteritems():
            if key[0] in d[prod]:
                d[prod][key[0]] += stripe[key[0]]
            else:
                d[prod][key[0]] = stripe[key[0]]
    else:
        d[prod] = stripe

for key in d.iteritems():
    print '%s\t%s' % (key[0], key[1])
```

```
Overwriting combiner3.5.py
```

3.5 Reducer

In [103]:
```
%%writefile reducer3.5.py
#!/usr/bin/env python

import sys
from collections import defaultdict
import ast

# Set up counters to monitor/understand the number of times a re
sys.stderr.write("reporter:counter:HW3.5 Reducer Counters,Calls,1

d = defaultdict(int)
total = 0

for line in sys.stdin:

    prod,stripe = line.split('\t')
    prod = prod.strip()

    # this will take the string and convert it to a dictionary
    stripe = ast.literal_eval(stripe)

    # add the count to the dictionary where appropriate
    if prod in d:
        for key in stripe.iteritems():
            if key[0] in d[prod]:
                d[prod][key[0]] += stripe[key[0]]
            else:
                d[prod][key[0]] = stripe[key[0]]
    else:
        d[prod] = stripe


# increment the total amount
for key in d.iteritems():
    for key2, value in key[1].iteritems():
        if value >= 100:
            total += int(value)

# calculate the frequency and print the values
for key in d.iteritems():
    for key2, value in key[1].iteritems():
        if value >= 100:
            freq = 0
            freq = round((float(value) / float(total)), 4)
            print '%s\t%s\t%s\t%s' % (key[0], key2, value, freq)
```

```
Overwriting reducer3.5.py
```

Hadoop Calls

In [105]:
```
# Hadoop commands

!chmod a+x mapper3.5.py
!chmod a+x reducer3.5.py
!chmod a+x combiner3.5.py

!hdfs dfs -rm ProductPurchaseData.txt
!hdfs dfs -copyFromLocal ProductPurchaseData.txt
!hdfs dfs -rm -r HW3.5-output

!hadoop jar /usr/lib/hadoop-0.20-mapreduce/contrib/streaming/hado
  -files mapper3.5.py,combiner3.5.py,reducer3.5.py \
  -reducer reducer3.5.py \
  -combiner combiner3.5.py \
  -mapper mapper3.5.py \
  -input ProductPurchaseData.txt \
  -output HW3.5-output \
  -numReduceTasks 1
```

```
Deleted ProductPurchaseData.txt
Deleted HW3.5-output
packageJobJar: [] [/usr/lib/hadoop-mapreduce/hadoop-streaming-2
.6.0-cdh5.8.0.jar] /tmp/streamjob1532552472890765337.jar tmpDir
=null
17/01/31 00:43:30 INFO client.RMProxy: Connecting to ResourceMa
nager at /0.0.0.0:8032
17/01/31 00:43:31 INFO client.RMProxy: Connecting to ResourceMa
nager at /0.0.0.0:8032
17/01/31 00:43:31 INFO mapred.FileInputFormat: Total input path
s to process : 1
17/01/31 00:43:31 INFO mapreduce.JobSubmitter: number of splits
:2
17/01/31 00:43:31 INFO mapreduce.JobSubmitter: Submitting token
s for job: job_1484544278544_0487
17/01/31 00:43:32 INFO impl.YarnClientImpl: Submitted applicati
on application_1484544278544_0487
17/01/31 00:43:32 INFO mapreduce.Job: The url to track the job:
 http://quickstart.cloudera:8088/proxy/application_148454427854
4_0487/ (http://quickstart.cloudera:8088/proxy/application_1484
```

Pairs Job Runtime: 39 seconds

My personal PC: Single PC, 4 cores, 16GB RAM, MacOS

My Virtual Machine: 3 processors, 9GB RAM, Linux

MapReduce Configuration: 2 Mappers, 1 Reducer, 2 Map Calls, 3 Reducer Calls

In [106]:
```
# 3.5 OUTPUT/ANSWER
!hdfs dfs -cat HW3.5-output/part-0000* > HW3.5counts.txt
!cat HW3.5counts.txt | sort -k1,2 | head -n50
```

```
DAI16732        FRO78087        106     0.0002
DAI18527        SNA44451        102     0.0002
DAI22177        DAI31081        127     0.0003
DAI22177        DAI62779        382     0.0008
DAI22177        DAI63921        136     0.0003
DAI22177        DAI75645        123     0.0003
DAI22177        DAI83733        126     0.0003
DAI22177        DAI85309        172     0.0004
DAI22177        ELE17451        203     0.0004
DAI22177        ELE26917        134     0.0003
DAI22177        ELE32164        155     0.0003
DAI22177        ELE34057        107     0.0002
DAI22177        ELE56788        134     0.0003
DAI22177        ELE66600        101     0.0002
DAI22177        ELE66810        105     0.0002
DAI22177        ELE74009        108     0.0002
DAI22177        ELE91337        150     0.0003
DAI22177        FRO31317        160     0.0003
DAI22177        FRO32293        128     0.0003
DAI22177        FRO40251        181     0.0004
```

END STUDENT CODE HW35

OPTIONAL

QUESTIONS BELOW THIS LINE ARE OPTIONAL

HW3.6 Computing Relative Frequencies on 100K WikiPedia pages (93Meg)

Dataset description For this assignment you will explore a set of 100,000 Wikipedia documents:

https://www.dropbox.com/s/n5lfbnztclo93ej/wikitext_100k.txt?dl=0 (https://www.dropbox.com/s/n5lfbnztclo93ej/wikitext_100k.txt?dl=0) s3://cs9223 /wikitext_100k.txt, or https://s3.amazonaws.com/cs9223/wikitext_100k.txt (https://s3.amazonaws.com/cs9223/wikitext_100k.txt) Each line in this file consists of the plain text extracted from a Wikipedia document.

Task Compute the relative frequencies of each word that occurs in the documents in wikitext_100k.txt and output the top 100 word pairs sorted by decreasing order of relative frequency.

Recall that the relative frequency (RF) of word B given word A is defined as follows:

f(B|A) = Count(A, B) / Count (A) = Count(A, B) / sum_B'(Count (A, B')

where count(A,B) is the number of times A and B co-occur within a window of two words (co-occurrence window size of two) in a document and count(A) the number of times A occurs with anything else. Intuitively, given a document collection, the relative frequency captures the proportion of time the word B appears in the same document as A. (See Section 3.3, in Data-Intensive Text Processing with MapReduce).

In the async lecture you learned different approaches to do this, and in this assignment, you will implement them:

a. Write a mapreduce program which uses the Stripes approach and writes its output in a file named rfstripes.txt

b. Write a mapreduce program which uses the Pairs approach and writes its output in a file named rfpairs.txt

c. Compare the performance of the two approaches and output the relative performance to a file named rfcomp.txt. Compute the relative performance as follows: (running time for Pairs/ running time for Stripes). Also include an analysis comparing the communication costs for the two approaches. Instrument your mapper and reduces for counters where necessary to aid with your analysis.

NOTE: please limit your analysis to the top 100 word pairs sorted by decreasing order of relative frequency for each word (tokens with all alphabetical letters).

Please include markdown cell named rf.txt that describes the following:

HW3.7 Apriori Algorithm

What is the Apriori algorithm? Describe an example use in your domain of expertise and what kind of . Define confidence and lift.

NOTE: For the remaining homework use the online browsing behavior dataset located at (same dataset as used above):

```
    https://www.dropbox.com/s/zlfyiwa70poqg74/ProductPurch
aseData.txt?dl=0
```

Each line in this dataset represents a browsing session of a customer. On each line, each string of 8 characters represents the id of an item browsed during that session. The items are separated by spaces.

Here are the first few lines of the ProductPurchaseData FRO11987 ELE17451 ELE89019 SNA90258 GRO99222 GRO99222 GRO12298 FRO12685 ELE91550 SNA11465 ELE26917 ELE52966 FRO90334 SNA30755 ELE17451 FRO84225 SNA80192 ELE17451 GRO73461 DAI22896 SNA99873 FRO86643 ELE17451 ELE37798 FRO86643 GRO56989 ELE23393 SNA11465 ELE17451 SNA69641 FRO86643 FRO78087 SNA11465 GRO39357 ELE28573 ELE11375 DAI54444

HW3.8. Shopping Cart Analysis

Product Recommendations: The action or practice of selling additional products or services to existing customers is called cross-selling. Giving product recommendation is one of the examples of cross-selling that are frequently used by online retailers. One simple method to give product recommendations is to recommend products that are frequently browsed together by the customers.

Suppose we want to recommend new products to the customer based on the products they have already browsed on the online website. Write a program using the A-priori algorithm to find products which are frequently browsed together. Fix the support to s = 100 (i.e. product sets need to occur together at least 100 times to be considered frequent) and find itemsets of size 2 and 3.

Then extract association rules from these frequent items.

A rule is of the form:

(item1, item5) ⇒ item2.

List the top 10 discovered rules in descreasing order of confidence in the following format

(item1, item5) ⇒ item2, supportCount ,support, confidence

HW3.8.1

Benchmark your results using the pyFIM implementation of the Apriori algorithm (Apriori - Association Rule Induction / Frequent Item Set Mining implemented by Christian Borgelt). You can download pyFIM from here:

http://www.borgelt.net/pyfim.html (http://www.borgelt.net/pyfim.html)

Comment on the results from both implementations (your Hadoop MapReduce of apriori versus pyFIM) in terms of results and execution times.

END OF HOMEWORK