MIDS W261: Machine Learning at Scale

- **Author**: Karthik Chepudira, Konniam Chan
- **Email**: kchepudira@berkeley.edu, konniam.chan@berkeley.edu

- **Class**: W261-3 Spring 2016
- **Week**: 3
- **Submission Date**: 02-04-2016

HW3.0.

What is a merge sort? Where is it used in Hadoop? How is a combiner function in the context of Hadoop? Give an example where it can be used and justify why it should be used in the context of this problem. What is the Hadoop shuffle?

Solution

Merge sort is an algorithm that belongs to family of Merge algorithms that takes an approach of divide and conquer by splitting up a list of n unsorted elements into n sublists with 1 element each and further repeatedly merges sublists while sorting them until only 1 sorted sublist remains.

Conceptually, a merge sort works as follows:

```
1. Divide the unsorted list into n sublists, each containing 1 element (a list of 1 element is considered sorted).
2. Repeatedly merge sublists to produce new sorted sublists until there is only 1 sublist remaining. This will be t
he sorted list.
```

merge sort has a time complexity of $O(n \log n)$

Merge sort in Hadoop could be used in situation where individual sorted lists need to be merged and sorted. This is used in hadoop to merge partition files stream to reducer.

merge sort of sorted lists has a time complexity of $O(n)$

Combiners are an optimization in MapReduce that allows for aggregation before the shuffe phase. In a word count problem in MapReduce combiners and be used for aggregation to reduce the number of tuples transferred across the network from mappers to reducers.

```
Input:
 It is a sunny day
 It is a rainy day

Mapper output :
 [ (It,1) (is,1) (a,1) (sunny,1) (day,1) (It,1) (is,1) (a,1) (rainy,1) (day,1) ]

Combiner Output:
 [ (It,2) (is,2) (a,2) (sunny,1) (day,2) (rainy,1) ]
```

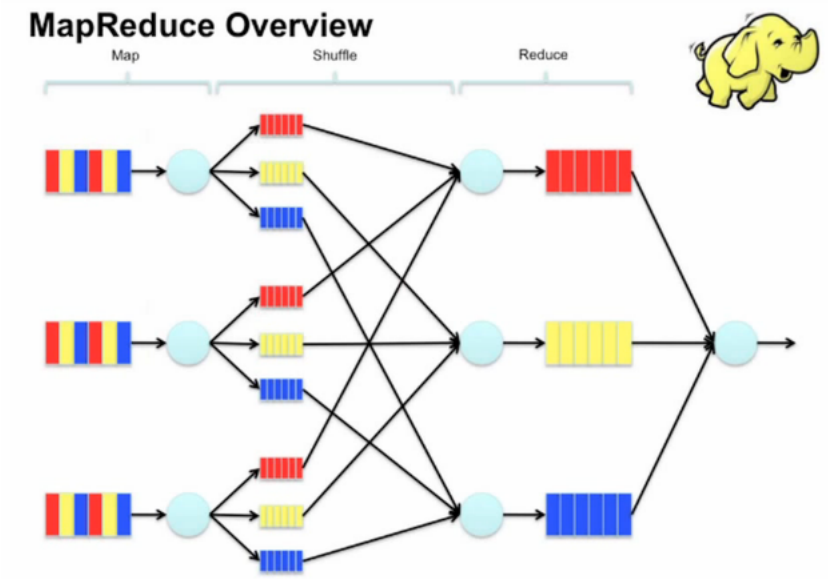
Hadoop shuffle refers to processes that happen between the mapper producing the output and the reducer consuming it. When the map function starts producing output it's not simply written to disk. The shuffle patitions, sorts, and combines mapper outputs before sending them to the reducers, taking advantage of buffering write in memory and doing some presorting for efficiency reasons. In the end, the reducer receives a merged partition file sorted by key.

References:

1. Wikipedia Merge Sort (https://en.wikipedia.org/wiki/Merge_sort).
2. Merge sort in detail (http://www.personal.kent.edu/~rmuhamma/Algorithms/MyAlgorithms/Sorting/mergeSort.htm).

In [1]:
```
from IPython.display import Image
Image(filename='HadoopShuffle.png')
```

Out[1]:



HW3.1

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_Complaints.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,ZIP code,Submitted via,Date received,Date sent to company,Company,Company response,Timely response?,Consumer disputed?
1114245,Debt collection,Medical,Disclosure verification of 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 of 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,"FNIS (Fidelity National Information Services, Inc.)",In progress,Yes,
1115106,Debt collection,"Other (phone, health club, etc.)",Communication tactics,Frequent or repeated calls,GA,31721,Web,11/13/2014,11/13/2014,"Expert Global Solutions, Inc.",In progress,Yes,

User-defined Counters

Now, let's use Hadoop Counters to identify the number of complaints pertaining to debt collection, mortgage and other categories (all other categories get lumped into this one) in the consumer complaints dataset. Basically produce the distribution of the Product column in this dataset using counters (limited to 3 counters here).

Hadoop offers Job Tracker, an UI tool to determine the status and statistics of all jobs. Using the job tracker UI, developers can view the Counters that have been created. Screenshot your job tracker UI as your job completes and include it here. Make sure that your user defined counters are visible.

In [1]:
```
# Start hadoop
!start-dfs.sh
!start-yarn.sh
```

```
16/01/29 11:22:41 WARN util.NativeCodeLoader: Unable to load native-hadoop library for your platform... using buil
tin-java classes where applicable
Starting namenodes on [localhost]
localhost: starting namenode, logging to /Users/InfernoIX/hadoop-2.7.1/logs/hadoop-InfernoIX-namenode-Konniams-Mac
Book-Air.local.out
localhost: starting datanode, logging to /Users/InfernoIX/hadoop-2.7.1/logs/hadoop-InfernoIX-datanode-Konniams-Mac
Book-Air.local.out
Starting secondary namenodes [0.0.0.0]
0.0.0.0: starting secondarynamenode, logging to /Users/InfernoIX/hadoop-2.7.1/logs/hadoop-InfernoIX-secondarynamen
ode-Konniams-MacBook-Air.local.out
16/01/29 11:23:03 WARN util.NativeCodeLoader: Unable to load native-hadoop library for your platform... using buil
tin-java classes where applicable
starting yarn daemons
starting resourcemanager, logging to /Users/InfernoIX/hadoop-2.7.1/logs/yarn-InfernoIX-resourcemanager-Konniams-Ma
cBook-Air.local.out
localhost: starting nodemanager, logging to /Users/InfernoIX/hadoop-2.7.1/logs/yarn-InfernoIX-nodemanager-Konniams
-MacBook-Air.local.out
```

In [2]:
```
# Remove header of the CSV file to simplify later steps
# !tail -n +2 Consumer_Complaints.csv > Consumer_Fixed.csv
# !mv Consumer_Fixed.csv Consumer_Complaints.csv
```

In [7]:
```
# Place in HDFS
!hdfs dfs -put Consumer_Complaints.csv /user/konniam/week_03
```

```
16/01/29 12:04:06 WARN util.NativeCodeLoader: Unable to load native-hadoop library for your platform... using buil
tin-java classes where applicable
```

In [3]:
```
%%writefile mapper.py
#!/usr/bin/env python
# Use mapper to do EDA using counters
import sys

for line in sys.stdin:
    complaint = line.strip().split(',')
    # Second column contains the product info
    if complaint[1] == "Debt collection":
        sys.stderr.write("reporter:counter:Debt-Counter,debt,1\n")
    elif complaint[1] == "Mortgage":
        sys.stderr.write("reporter:counter:Mortgage-Counter,mortgage,1\n")
    else:
        sys.stderr.write("reporter:counter:Other-Counter,other,1\n")
    # Output original line
    print line
```

```
Writing mapper.py
```

In [4]:
```
!chmod a+x mapper.py
```

In [39]:
```
!hdfs dfs -rm -r /user/konniam/week_03/hw_3_1_output
```

```
16/01/29 15:03:36 WARN util.NativeCodeLoader: Unable to load native-hadoop library for your platform... using buil
tin-java classes where applicable
16/01/29 15:03:39 INFO fs.TrashPolicyDefault: Namenode trash configuration: Deletion interval = 0 minutes, Emptier
 interval = 0 minutes.
Deleted /user/konniam/week_03/hw_3_1_output
```

In [5]:
```
!hdfs dfs -rm -r /user/konniam/week_03/hw_3_1_output
# Run MR job to increment counters, with Identity Reducer
!hadoop jar $HADOOP_HOME/share/hadoop/tools/lib/hadoop-streaming-*.jar \
-mapper $PWD/mapper.py \
-reducer /bin/cat \
-input /user/konniam/week_03/Consumer_Complaints.csv \
-output /user/konniam/week_03/hw_3_1_output
```

```
16/01/31 16:37:59 WARN util.NativeCodeLoader: Unable to load native-hadoop library for your platform... using buil
tin-java classes where applicable
16/01/31 16:38:00 INFO fs.TrashPolicyDefault: Namenode trash configuration: Deletion interval = 0 minutes, Emptier
 interval = 0 minutes.
Deleted /user/konniam/week_03/hw_3_1_output
16/01/31 16:38:02 WARN util.NativeCodeLoader: Unable to load native-hadoop library for your platform... using buil
tin-java classes where applicable
packageJobJar: [/var/folders/l8/h51_59852qscq403fs6q0xlh0000gn/T/hadoop-unjar5873106299045917131/] [] /var/folders
/l8/h51_59852qscq403fs6q0xlh0000gn/T/streamjob1911821617765572003.jar tmpDir=null
```

```
16/01/31 16:38:03 INFO client.RMProxy: Connecting to ResourceManager at /0.0.0.0:8032
16/01/31 16:38:04 INFO client.RMProxy: Connecting to ResourceManager at /0.0.0.0:8032
16/01/31 16:38:05 INFO mapred.FileInputFormat: Total input paths to process : 1
16/01/31 16:38:05 INFO mapreduce.JobSubmitter: number of splits:2
16/01/31 16:38:05 INFO mapreduce.JobSubmitter: Submitting tokens for job: job_1454277284610_0002
16/01/31 16:38:06 INFO impl.YarnClientImpl: Submitted application application_1454277284610_0002
16/01/31 16:38:06 INFO mapreduce.Job: The url to track the job: http://Konniams-MacBook-Air.local:8088/proxy/appli
cation_1454277284610_0002/
16/01/31 16:38:06 INFO mapreduce.Job: Running job: job_1454277284610_0002
16/01/31 16:38:16 INFO mapreduce.Job: Job job_1454277284610_0002 running in uber mode : false
16/01/31 16:38:16 INFO mapreduce.Job:  map 0% reduce 0%
16/01/31 16:38:32 INFO mapreduce.Job:  map 67% reduce 0%
16/01/31 16:38:33 INFO mapreduce.Job:  map 100% reduce 0%
16/01/31 16:38:45 INFO mapreduce.Job:  map 100% reduce 100%
16/01/31 16:38:45 INFO mapreduce.Job: Job job_1454277284610_0002 completed successfully
16/01/31 16:38:45 INFO mapreduce.Job: Counters: 52
        File System Counters
                FILE: Number of bytes read=53659840
                FILE: Number of bytes written=107672125
                FILE: Number of read operations=0
                FILE: Number of large read operations=0
                FILE: Number of write operations=0
                HDFS: Number of bytes read=50910032
                HDFS: Number of bytes written=51845048
                HDFS: Number of read operations=9
                HDFS: Number of large read operations=0
                HDFS: Number of write operations=2
        Job Counters
                Launched map tasks=2
                Launched reduce tasks=1
                Data-local map tasks=2
                Total time spent by all maps in occupied slots (ms)=30890
                Total time spent by all reduces in occupied slots (ms)=8230
                Total time spent by all map tasks (ms)=30890
                Total time spent by all reduce tasks (ms)=8230
                Total vcore-seconds taken by all map tasks=30890
                Total vcore-seconds taken by all reduce tasks=8230
                Total megabyte-seconds taken by all map tasks=31631360
                Total megabyte-seconds taken by all reduce tasks=8427520
        Map-Reduce Framework
                Map input records=312912
                Map output records=625824
                Map output bytes=52126023
                Map output materialized bytes=53659846
                Input split bytes=236
                Combine input records=0
                Combine output records=0
                Reduce input groups=312913
                Reduce shuffle bytes=53659846
                Reduce input records=625824
                Reduce output records=625824
                Spilled Records=1251648
                Shuffled Maps =2
                Failed Shuffles=0
                Merged Map outputs=2
                GC time elapsed (ms)=819
                CPU time spent (ms)=0
                Physical memory (bytes) snapshot=0
                Virtual memory (bytes) snapshot=0
                Total committed heap usage (bytes)=587726848
        Debt-Counter
                debt=44372
        Mortgage-Counter
                mortgage=125752
        Other-Counter
                other=142788
        Shuffle Errors
                BAD_ID=0
                CONNECTION=0
                IO_ERROR=0
                WRONG_LENGTH=0
                WRONG_MAP=0
                WRONG_REDUCE=0
        File Input Format Counters
                Bytes Read=50909796
        File Output Format Counters
                Bytes Written=51845048
16/01/31 16:38:45 INFO streaming.StreamJob: Output directory: /user/konniam/week_03/hw_3_1_output
```

In [7]:
```
from IPython.display import Image
```

3.1 Response

Counters shown below:

In [9]:
```
Image(filename='hw_3_1_counter.png')
```

Out[9]:

	Name	Map	Reduce	Total
Map-Reduce Framework	Combine input records	0	0	0
	Combine output records	0	0	0
	CPU time spent (ms)	0	0	0
	Failed Shuffles	0	0	0
	GC time elapsed (ms)	510	309	819
	Input split bytes	236	0	236
	Map input records	312,912	0	312,912
	Map output bytes	52,126,023	0	52,126,023
	Map output materialized bytes	53,659,846	0	53,659,846
	Map output records	625,824	0	625,824
	Merged Map outputs	0	2	2
	Physical memory (bytes) snapshot	0	0	0
	Reduce input groups	0	312,913	312,913
	Reduce input records	0	625,824	625,824
	Reduce output records	0	625,824	625,824
	Reduce shuffle bytes	0	53,659,846	53,659,846
	Shuffled Maps	0	2	2
	Spilled Records	625,824	625,824	1,251,648
	Total committed heap usage (bytes)	393,740,288	193,986,560	587,726,848
	Virtual memory (bytes) snapshot	0	0	0
Debt-Counter	Name	Map	Reduce	Total
	debt	44,372	0	44,372
Mortgage-Counter	Name	Map	Reduce	Total
	mortgage	125,752	0	125,752
Other-Counter	Name	Map	Reduce	Total
	other	142,788	0	142,788
Shuffle Errors	Name	Map	Reduce	Total
	BAD_ID	0	0	0
	CONNECTION	0	0	0
	IO_ERROR	0	0	0
	WRONG_LENGTH	0	0	0
	WRONG_MAP	0	0	0
	WRONG_REDUCE	0	0	0
File Input Format Counters	Name	Map	Reduce	Total
	Bytes Read	50,909,796	0	50,909,796
File Output Format Counters	Name	Map	Reduce	Total
	Bytes Written	0	51,845,048	51,845,048

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

3.2 Part 1

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

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 time 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.

In [4]:
```
!echo "foo foo quux labs foo bar quux" > input3.2.txt
!hdfs dfs -rm -r /user/konniam/week_03/hw_3_2.txt
!hdfs dfs -put input3.2.txt /user/konniam/week_03/hw_3_2.txt
!hdfs dfs -cat /user/konniam/week_03/hw_3_2.txt
```

```
16/02/01 03:13:17 INFO fs.TrashPolicyDefault: Namenode trash configuration: Deletion interval = 360 minutes, Empti
er interval = 0 minutes.
Moved: 'hdfs://sandbox.hortonworks.com:8020/tmp/3.2/input3.2.txt' to trash at: hdfs://sandbox.hortonworks.com:8020
/user/root/.Trash/Current
foo foo quux labs foo bar quux
```

Mapper

In [1]:
```
%%writefile mapper3.2.py
#!/usr/bin/env python
## reducer3.2.py
## Author: karthik chepudira
## Description: mapper code for HW3.2
import sys

sys.stderr.write("reporter:counter:MRCounter,Mapper,1\n") #increment the counter for Mapper
for line in sys.stdin:
    if not line in ['\n', '\r\n']: # check for empty lines and ignore
        words = line.rstrip().split()
        for word in words:
            print word+'\t'+str(1)
```

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

Reducer

In [2]:
```
%%writefile reducer3.2.py
#!/usr/bin/env python
## reducer3.2.py
## Author: karthik chepudira
## Description: reducer code for HW3.2

import sys
sys.stderr.write("reporter:counter:MRCounter,Reducer,1\n") # increment the counter for Reducer

#funtion to print reducer output by key
def wcount(prev_word ,counts):
    if prev_word != "-1": # check if a valid key
        print(prev_word+ "\t"+str(counts)) # Print reducer output

prev_word = "-1"
counts = 0
linecount=0 #Keep track of total lines of input processed by reducer
for line in sys.stdin:
    line = line.rstrip()
    linecount+=1
    word, value =line.split("\t",1)
    if word!=prev_word: #if all rows of a key are processed
        wcount(prev_word, counts) # call the print function
        prev_word = word # reset key
        counts = 0 #reset key count
    counts += eval(value)
if linecount >0: # if reducer processed atleast 1 line
    if word==prev_word:
        wcount(prev_word, counts)
```

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

In [3]:
```
!chmod a+x mapper3.2.py reducer3.2.py
```

In [6]:
```
!hdfs dfs -rm -r /tmp/3.2/streamout
# Run word count to increment mapper and reducer counters
!hadoop jar /usr/hdp/2.3.0.0-2130/hadoop-mapreduce/hadoop-streaming-2.7.1.2.3.0.0-2130.jar \
-D mapred.job.name="HW3.2" \
-D mapred.output.key.comparator.class=org.apache.hadoop.mapred.lib.KeyFieldBasedComparator \
-D mapred.map.tasks=1 \
-D mapred.reduce.tasks=4 \
-input /tmp/3.2/input3.2.txt \
-output /tmp/3.2/streamout \
-mapper '/usr/bin/python2.6 /usr/tmp/ds261/HW3/mapper3.2.py' \
-reducer '/usr/bin/python2.6 /usr/tmp/ds261/HW3/reducer3.2.py' \
```

```
16/02/02 04:07:25 INFO fs.TrashPolicyDefault: Namenode trash configuration: Deletion interval = 360 minutes, Empti
er interval = 0 minutes.
Moved: 'hdfs://sandbox.hortonworks.com:8020/tmp/3.2/streamout' to trash at: hdfs://sandbox.hortonworks.com:8020/us
er/root/.Trash/Current
WARNING: Use "yarn jar" to launch YARN applications.
packageJobJar: [] [/usr/hdp/2.3.0.0-2130/hadoop-mapreduce/hadoop-streaming-2.7.1.2.3.0.0-2130.jar] /tmp/streamjob9
161353458867003514.jar tmpDir=null
16/02/02 04:07:33 INFO impl.TimelineClientImpl: Timeline service address: http://sandbox.hortonworks.com:8188/ws/v
1/timeline/
16/02/02 04:07:33 INFO client.RMProxy: Connecting to ResourceManager at sandbox.hortonworks.com/192.168.214.133:80
50
16/02/02 04:07:35 INFO impl.TimelineClientImpl: Timeline service address: http://sandbox.hortonworks.com:8188/ws/v
1/timeline/
```

```
16/02/02 04:07:35 INFO client.RMProxy: Connecting to ResourceManager at sandbox.hortonworks.com/192.168.214.133:80
50
16/02/02 04:07:36 INFO mapred.FileInputFormat: Total input paths to process : 1
16/02/02 04:07:37 INFO mapreduce.JobSubmitter: number of splits:1
16/02/02 04:07:39 INFO mapreduce.JobSubmitter: Submitting tokens for job: job_1454374677022_0001
16/02/02 04:07:41 INFO impl.YarnClientImpl: Submitted application application_1454374677022_0001
16/02/02 04:07:42 INFO mapreduce.Job: The url to track the job: http://sandbox.hortonworks.com:8088/proxy/applicat
ion_1454374677022_0001/
16/02/02 04:07:42 INFO mapreduce.Job: Running job: job_1454374677022_0001
16/02/02 04:08:05 INFO mapreduce.Job: Job job_1454374677022_0001 running in uber mode : false
16/02/02 04:08:05 INFO mapreduce.Job:  map 0% reduce 0%
16/02/02 04:08:13 INFO mapreduce.Job:  map 100% reduce 0%
16/02/02 04:08:25 INFO mapreduce.Job:  map 100% reduce 25%
16/02/02 04:08:27 INFO mapreduce.Job:  map 100% reduce 50%
16/02/02 04:08:28 INFO mapreduce.Job:  map 100% reduce 75%
16/02/02 04:08:29 INFO mapreduce.Job:  map 100% reduce 100%
16/02/02 04:08:31 INFO mapreduce.Job: Job job_1454374677022_0001 completed successfully
16/02/02 04:08:32 INFO mapreduce.Job: Counters: 51
        File System Counters
                FILE: Number of bytes read=83
                FILE: Number of bytes written=639228
                FILE: Number of read operations=0
                FILE: Number of large read operations=0
                FILE: Number of write operations=0
                HDFS: Number of bytes read=139
                HDFS: Number of bytes written=26
                HDFS: Number of read operations=15
                HDFS: Number of large read operations=0
                HDFS: Number of write operations=8
        Job Counters
                Launched map tasks=1
                Launched reduce tasks=4
                Data-local map tasks=1
                Total time spent by all maps in occupied slots (ms)=6795
                Total time spent by all reduces in occupied slots (ms)=41630
                Total time spent by all map tasks (ms)=6795
                Total time spent by all reduce tasks (ms)=41630
                Total vcore-seconds taken by all map tasks=6795
                Total vcore-seconds taken by all reduce tasks=41630
                Total megabyte-seconds taken by all map tasks=1698750
                Total megabyte-seconds taken by all reduce tasks=10407500
        Map-Reduce Framework
                Map input records=1
                Map output records=7
                Map output bytes=45
                Map output materialized bytes=83
                Input split bytes=108
                Combine input records=0
                Combine output records=0
                Reduce input groups=4
                Reduce shuffle bytes=83
                Reduce input records=7
                Reduce output records=4
                Spilled Records=14
                Shuffled Maps =4
                Failed Shuffles=0
                Merged Map outputs=4
                GC time elapsed (ms)=891
                CPU time spent (ms)=7460
                Physical memory (bytes) snapshot=762757120
                Virtual memory (bytes) snapshot=5174779904
                Total committed heap usage (bytes)=622854144
        MRCounter
                Mapper=1
                Reducer=4
        Shuffle Errors
                BAD_ID=0
                CONNECTION=0
                IO_ERROR=0
                WRONG_LENGTH=0
                WRONG_MAP=0
                WRONG_REDUCE=0
        File Input Format Counters
                Bytes Read=31
        File Output Format Counters
                Bytes Written=26
16/02/02 04:08:32 INFO streaming.StreamJob: Output directory: /tmp/3.2/streamout
```

3.2 Part 1 Response

1. Invoke the hadoop job specifying the number of Map tasks and reduce tasks by using the following options
   - -D mapred.map.tasks=1 \
   - -D mapred.reduce.tasks=4 \

3.2 Part 2

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.

Mapper 3.2 Part 2

In [7]:
```
%%writefile mapper3.2_2.py
#!/usr/bin/env python
## reducer3.2_2.py
## Author: karthik chepudira
## Description: mapper code for HW3.2 part 2
import sys
import re
from nltk.corpus import stopwords #stopwords from nltk
from csv import reader #csv reader

sys.stderr.write("reporter:counter:MRCounter,Mapper,1\n") #increment the counter for Mapper

# function to remove puntucation from string
def removepunctuation(inputstring):
    punctuations = '''!()-[]{};:'"\,<>./?@#$%^&*_~'''
    ret_string = ""
    for char in inputstring:
        if char not in punctuations:
            ret_string = ret_string + char
    return ret_string

total_count =0
linecount=0 #Keep track of total lines of input processed by mapper
for line in reader(sys.stdin): # use csvreader to process input line.
    if not line in ['\n', '\r\n']:
        linecount+=1
        columns = line
        colissue=columns[3] #third column of csv file has the 'issue' field
        #remove punctuation , lower , split and check alphanumeric.
        words = [w for w in removepunctuation(colissue).lower().split() if not w in stopwords.words('english') and  w.isal
pha()]
        for word in words:
            print word+'\t'+str(1)
            total_count+=1
if linecount >0: # if mapper processed atleast 1 line
    print "*"+"\t"+str(total_count)
```

```
Overwriting mapper3.2_2.py
```

Reducer 3.2 Part 2

In [8]:
```
%%writefile reducer3.2_2.py
#!/usr/bin/env python
## reducer3.2_2.py
## Author: karthik chepudira
## Description: reducer code for HW3.2 part 2
import sys
prev_key="-1"
count=0
total_count=0 #keep count of the keys processed
for line in sys.stdin:
    key,value=line.split("\t",1)
    if key == "*":
        total_count+= eval(value) #increment the total key count from the mapper output.
    else:
        if prev_key != key:
            if prev_key !="-1":
                print prev_key+"\t"+str(count) #print key,value pair
                count = 0 #reset count
            prev_key = key # reset key
            count+=eval(value) #increment count
        else:
            count+=eval(value) # increment count
print prev_key+"\t"+str(count) # print the lasy key
print "*"+"\t"+str(total_count) #print the total key count.
sys.stderr.write("reporter:counter:MRCounter,Reducer,1\n") # increment the counter for Reducer
```

```
Overwriting reducer3.2_2.py
```

In [9]:
```
!chmod a+x mapper3.2_2.py reducer3.2_2.py
```

In [2]:
```
#remove directory
!hdfs dfs -rm -r /tmp/3.2/streamout2
#run hadoop job
!hadoop jar /usr/hdp/2.3.0.0-2130/hadoop-mapreduce/hadoop-streaming-2.7.1.2.3.0.0-2130.jar \
-D mapred.job.name="HW3.2_2" \
-D mapred.map.tasks=2 \
-D mapred.reduce.tasks=2 \
-D mapreduce.job.output.key.comparator.class=org.apache.hadoop.mapred.lib.KeyFieldBasedComparator \
-D mapred.text.key.comparator.options="-k1" \
-input /tmp/3.1/Consumer_Complaints.csv \
-output /tmp/3.2/streamout2 \
-mapper '/usr/bin/python2.6 /usr/tmp/ds261/HW3/mapper3.2_2.py' \
-reducer '/usr/bin/python2.6 /usr/tmp/ds261/HW3/reducer3.2_2.py'
```

```
rm: `/tmp/3.2/streamout2': No such file or directory
WARNING: Use "yarn jar" to launch YARN applications.
packageJobJar: [] [/usr/hdp/2.3.0.0-2130/hadoop-mapreduce/hadoop-streaming-2.7.1.2.3.0.0-2130.jar] /tmp/streamjob8
7586158658960123 56.jar tmpDir=null
16/02/02 20:58:21 INFO impl.TimelineClientImpl: Timeline service address: http://sandbox.hortonworks.com:8188/ws/v
1/timeline/
16/02/02 20:58:21 INFO client.RMProxy: Connecting to ResourceManager at sandbox.hortonworks.com/192.168.177.132:80
50
16/02/02 20:58:22 INFO impl.TimelineClientImpl: Timeline service address: http://sandbox.hortonworks.com:8188/ws/v
1/timeline/
16/02/02 20:58:22 INFO client.RMProxy: Connecting to ResourceManager at sandbox.hortonworks.com/192.168.177.132:80
50
16/02/02 20:58:23 INFO mapred.FileInputFormat: Total input paths to process : 1
16/02/02 20:58:23 INFO mapreduce.JobSubmitter: number of splits:2
16/02/02 20:58:24 INFO mapreduce.JobSubmitter: Submitting tokens for job: job_1454426531297_0003
16/02/02 20:58:24 INFO impl.YarnClientImpl: Submitted application application_1454426531297_0003
16/02/02 20:58:25 INFO mapreduce.Job: The url to track the job: http://sandbox.hortonworks.com:8088/proxy/applicat
ion_1454426531297_0003/
16/02/02 20:58:25 INFO mapreduce.Job: Running job: job_1454426531297_0003
16/02/02 20:58:32 INFO mapreduce.Job: Job job_1454426531297_0003 running in uber mode : false
16/02/02 20:58:32 INFO mapreduce.Job:  map 0% reduce 0%
16/02/02 20:58:44 INFO mapreduce.Job:  map 3% reduce 0%
16/02/02 20:58:47 INFO mapreduce.Job:  map 5% reduce 0%
16/02/02 20:58:50 INFO mapreduce.Job:  map 7% reduce 0%
16/02/02 20:58:53 INFO mapreduce.Job:  map 9% reduce 0%
16/02/02 20:58:56 INFO mapreduce.Job:  map 11% reduce 0%
16/02/02 20:58:59 INFO mapreduce.Job:  map 14% reduce 0%
16/02/02 20:59:02 INFO mapreduce.Job:  map 15% reduce 0%
16/02/02 20:59:03 INFO mapreduce.Job:  map 16% reduce 0%
16/02/02 20:59:05 INFO mapreduce.Job:  map 17% reduce 0%
16/02/02 20:59:06 INFO mapreduce.Job:  map 18% reduce 0%
16/02/02 20:59:08 INFO mapreduce.Job:  map 19% reduce 0%
16/02/02 20:59:09 INFO mapreduce.Job:  map 20% reduce 0%
16/02/02 20:59:11 INFO mapreduce.Job:  map 21% reduce 0%
16/02/02 20:59:12 INFO mapreduce.Job:  map 22% reduce 0%
```

```
16/02/02 20:59:14 INFO mapreduce.Job:  map 23% reduce 0%
16/02/02 20:59:15 INFO mapreduce.Job:  map 24% reduce 0%
16/02/02 20:59:17 INFO mapreduce.Job:  map 25% reduce 0%
16/02/02 20:59:18 INFO mapreduce.Job:  map 26% reduce 0%
16/02/02 20:59:20 INFO mapreduce.Job:  map 27% reduce 0%
16/02/02 20:59:21 INFO mapreduce.Job:  map 28% reduce 0%
16/02/02 20:59:24 INFO mapreduce.Job:  map 29% reduce 0%
16/02/02 20:59:27 INFO mapreduce.Job:  map 30% reduce 0%
16/02/02 20:59:30 INFO mapreduce.Job:  map 32% reduce 0%
16/02/02 20:59:33 INFO mapreduce.Job:  map 33% reduce 0%
16/02/02 20:59:36 INFO mapreduce.Job:  map 35% reduce 0%
16/02/02 20:59:39 INFO mapreduce.Job:  map 37% reduce 0%
16/02/02 20:59:42 INFO mapreduce.Job:  map 39% reduce 0%
16/02/02 20:59:45 INFO mapreduce.Job:  map 41% reduce 0%
16/02/02 20:59:48 INFO mapreduce.Job:  map 43% reduce 0%
16/02/02 20:59:51 INFO mapreduce.Job:  map 45% reduce 0%
16/02/02 20:59:54 INFO mapreduce.Job:  map 47% reduce 0%
16/02/02 20:59:57 INFO mapreduce.Job:  map 49% reduce 0%
16/02/02 21:00:00 INFO mapreduce.Job:  map 51% reduce 0%
16/02/02 21:00:03 INFO mapreduce.Job:  map 53% reduce 0%
16/02/02 21:00:06 INFO mapreduce.Job:  map 56% reduce 0%
16/02/02 21:00:09 INFO mapreduce.Job:  map 58% reduce 0%
16/02/02 21:00:12 INFO mapreduce.Job:  map 60% reduce 0%
16/02/02 21:00:15 INFO mapreduce.Job:  map 63% reduce 0%
16/02/02 21:00:18 INFO mapreduce.Job:  map 81% reduce 0%
16/02/02 21:00:24 INFO mapreduce.Job:  map 82% reduce 0%
16/02/02 21:00:30 INFO mapreduce.Job:  map 83% reduce 0%
16/02/02 21:00:34 INFO mapreduce.Job:  map 83% reduce 8%
16/02/02 21:00:35 INFO mapreduce.Job:  map 100% reduce 17%
16/02/02 21:00:38 INFO mapreduce.Job:  map 100% reduce 77%
16/02/02 21:00:41 INFO mapreduce.Job:  map 100% reduce 94%
16/02/02 21:00:42 INFO mapreduce.Job:  map 100% reduce 100%
16/02/02 21:00:42 INFO mapreduce.Job: Job job_1454426531297_0003 completed successfully
16/02/02 21:00:42 INFO mapreduce.Job: Counters: 51
        File System Counters
                FILE: Number of bytes read=13877162
                FILE: Number of bytes written=28266186
                FILE: Number of read operations=0
                FILE: Number of large read operations=0
                FILE: Number of write operations=0
                HDFS: Number of bytes read=51012846
                HDFS: Number of bytes written=2032
                HDFS: Number of read operations=12
                HDFS: Number of large read operations=0
                HDFS: Number of write operations=4
        Job Counters
                Launched map tasks=2
                Launched reduce tasks=2
                Data-local map tasks=2
                Total time spent by all maps in occupied slots (ms)=224050
                Total time spent by all reduces in occupied slots (ms)=41406
                Total time spent by all map tasks (ms)=224050
                Total time spent by all reduce tasks (ms)=41406
                Total vcore-seconds taken by all map tasks=224050
                Total vcore-seconds taken by all reduce tasks=41406
                Total megabyte-seconds taken by all map tasks=56012500
                Total megabyte-seconds taken by all reduce tasks=10351500
        Map-Reduce Framework
                Map input records=312919
                Map output records=1002221
                Map output bytes=11872708
                Map output materialized bytes=13877174
                Input split bytes=238
                Combine input records=0
                Combine output records=0
                Reduce input groups=152
                Reduce shuffle bytes=13877174
                Reduce input records=1002221
                Reduce output records=153
                Spilled Records=2004442
                Shuffled Maps =4
                Failed Shuffles=0
                Merged Map outputs=4
                GC time elapsed (ms)=439
                CPU time spent (ms)=216790
                Physical memory (bytes) snapshot=693493760
                Virtual memory (bytes) snapshot=4098723840
                Total committed heap usage (bytes)=506986496
        MRCounter
                Mapper=2
```

```
                Reducer=2
        Shuffle Errors
                BAD_ID=0
                CONNECTION=0
                IO_ERROR=0
                WRONG_LENGTH=0
                WRONG_MAP=0
                WRONG_REDUCE=0
        File Input Format Counters
                Bytes Read=51012608
        File Output Format Counters
                Bytes Written=2032
16/02/02 21:00:42 INFO streaming.StreamJob: Output directory: /tmp/3.2/streamout2
```

In [8]:
```
!hdfs dfs -cat /tmp/3.2/streamout2/part* | sort -k2,2rn > output_3.2_2.txt
!cat output_3.2_2.txt
```

```
*       1002219
loan    119491
modificationcollectionforeclosure       70487
account 57448
credit  50897
payments        39993
escrow  36767
servicing       36767
report  30546
incorrect       29069
information     29069
debt    27876
attempts        17972
collect 17972
contd   17972
owed    17972
closing 16205
management      16205
opening 16205
deposits        10555
withdrawals     10555
problems        9484
application     8868
communication   8671
tactics 8671
broker  8625
mortgage        8625
originator      8625
unable  8178
billing 8158
disclosure      7655
verification    7655
disputes        6938
reporting       6560
lease   6337
caused  5663
funds   5663
low     5663
process 5505
managing        5006
improper        4966
companys        4858
investigation   4858
identity        4729
card    4407
get     4357
reportcredit    4357
score   4357
costs   4350
settlement      4350
interest        4238
protection      4143
repaying        3844
fraud   3842
pay     3821
contact 3710
money   3639
false   3621
representation  3621
statements      3621
info    3553
sharing 3489
apr     3431
```

```
rate    3431
embezzlement    3276
theft   3276
makingreceiving 3226
sending 3226
fee     3198
action  2964
illegal 2964
takingthreatening       2964
closingcancelling       2795
decision        2774
underwriting    2774
customer        2734
atm     2422
debit   2422
using   2422
lender  2165
cant    1999
dealing 1944
servicer        1944
collection      1907
late    1797
line    1732
repay   1647
service 1518
determination   1490
transaction     1486
use     1477
monitoring      1453
relations       1367
taking  1242
statement       1220
advertising     1193
marketing       1193
payoff  1155
increasedecrease        1149
issue   1100
delinquent      1061
practices       1003
rewards 1002
charged 976
didnt   925
dispute 904
expect  807
fees    807
shopping        672
issuance        640
unsolicited     640
balance 598
transfer        598
scam    566
issues  538
changes 350
forbearance     350
plans   350
terms   350
workout 350
getting 291
available       274
promised        274
delay   243
processing      243
advance 240
cash    240
privacy 240
bankruptcy      222
received        216
bank    202
wrong   169
arbitration     168
acct    163
applied 139
loandid 139
receive 139
sale    139
charges 131
stop    131
overlimit       127
apply   118
amount  98
```

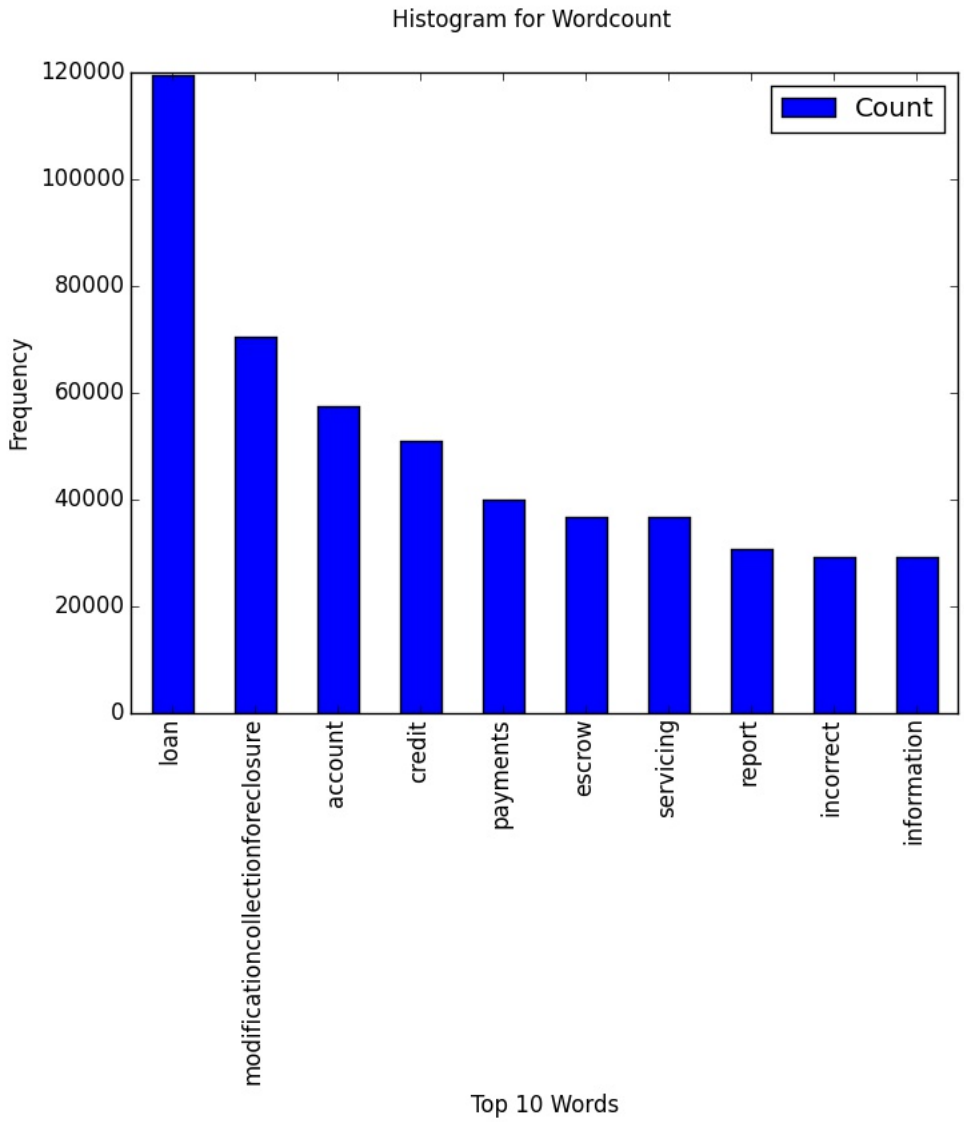
```
credited        92
payment 92
checks  75
convenience     75
amt     71
day     71
disclosures     64
incorrectmissing        64
citibank        1
*       0
```

In [1]:
```
%%writefile wordcountanalysis.py
#!/usr/bin/env python
## wordcountanalysis.py
## Author: karthik chepudira
## Description: HW3.2 part 2
import matplotlib.pyplot as plt
from matplotlib.font_manager import FontProperties
import pandas as pd
import numpy as np
import sys

plt.switch_backend('agg')

def plotmodel(filename,plotname):
    df = pd.read_csv(filename,sep='\t',header=0)
    df.columns =['Word','Count']
    df['Count'] = df['Count'].astype('int')
    fig, ax = plt.subplots()
    fig.suptitle('Histogram for Wordcount')
    df.head(10).plot(x='Word', y='Count',ax = ax, kind='bar')
    ax.set_ylabel('Frequency')
    ax.set_xlabel('Top 10 Words')
    fontP = FontProperties()
    fontP.set_size('small')
    fig.savefig(plotname+".jpg",bbox_inches='tight')

if len(sys.argv) > 2:
    plotname = str(sys.argv[2])
    filename = str(sys.argv[1])
    plotmodel(filename,plotname)
else:
    print "Incorrect number of parameters: please provide model filename "
    exit()
```

```
Overwriting wordcountanalysis.py
```

In [2]:
```
!chmod a+x wordcountanalysis.py
! ./wordcountanalysis.py "output_3.2_2.txt" 'HW3.2'
from IPython.display import Image
Image(filename='HW3.2.jpg')
```

Out[2]:



3.2 Part 2 Response

The value of the user defined Mapper Counter is: 2

The value of the user defined Reducer Counter is: 2

```
MRCounter
 Mapper=2
 Reducer=2
```

3.2 Part 3

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.

Combiner 3.2_3.py

In [10]:
```
%%writefile combiner3.2_3.py
#!/usr/bin/env python
## combiner3.2_3.py
## Author: karthik chepudira
## Description: combiner code for HW3.2 Part 3
import sys
prev_key=-1
count=0
total_count =0 #keep count of the keys processed
for line in sys.stdin:
    key,value=line.split("\t",1)
    if key == "*":
        total_count+= eval(value)  #increment the total key count from the mapper output.
    else:
        if prev_key != key:
            if prev_key !=-1:
                print prev_key+"\t"+str(count) #print key,value pair
                count = 0 #reset count
            prev_key = key # reset key
            count+=eval(value)
        else:
            count+=eval(value) # increment count
print prev_key+"\t"+str(count) # print the lasy key
print "*"+"\t"+str(total_count) #print the total key count.
sys.stderr.write("reporter:counter:MRCounter,Combiner,1\n") # increment the counter for Combiner
```

```
Overwriting combiner3.2_3.py
```

In [11]:
```
!chmod a+x combiner3.2_3.py
```

In [12]:
```
#remove directory
!hdfs dfs -rm -r /tmp/3.2/streamout3
#run hadoop job
!hadoop jar /usr/hdp/2.3.0.0-2130/hadoop-mapreduce/hadoop-streaming-2.7.1.2.3.0.0-2130.jar \
-D mapred.job.name="HW3.2_2" \
-D mapred.map.tasks=2 \
-D mapred.reduce.tasks=2 \
-input /tmp/3.1/Consumer_Complaints.csv \
-output /tmp/3.2/streamout3 \
-mapper '/usr/bin/python2.6 /usr/tmp/ds261/HW3/mapper3.2_2.py' \
-reducer '/usr/bin/python2.6 /usr/tmp/ds261/HW3/reducer3.2_2.py' \
-combiner '/usr/bin/python2.6 /usr/tmp/ds261/HW3/combiner3.2_3.py'
```

```
16/02/01 03:48:35 INFO fs.TrashPolicyDefault: Namenode trash configuration: Deletion interval = 360 minutes, Empti
er interval = 0 minutes.
Moved: 'hdfs://sandbox.hortonworks.com:8020/tmp/3.2/streamout3' to trash at: hdfs://sandbox.hortonworks.com:8020/u
ser/root/.Trash/Current
WARNING: Use "yarn jar" to launch YARN applications.
packageJobJar: [] [/usr/hdp/2.3.0.0-2130/hadoop-mapreduce/hadoop-streaming-2.7.1.2.3.0.0-2130.jar] /tmp/streamjob4
395809441324277872.jar tmpDir=null
16/02/01 03:48:41 INFO impl.TimelineClientImpl: Timeline service address: http://sandbox.hortonworks.com:8188/ws/v
1/timeline/
16/02/01 03:48:42 INFO client.RMProxy: Connecting to ResourceManager at sandbox.hortonworks.com/192.168.214.133:80
50
16/02/01 03:48:43 INFO impl.TimelineClientImpl: Timeline service address: http://sandbox.hortonworks.com:8188/ws/v
1/timeline/
16/02/01 03:48:43 INFO client.RMProxy: Connecting to ResourceManager at sandbox.hortonworks.com/192.168.214.133:80
50
16/02/01 03:48:44 INFO mapred.FileInputFormat: Total input paths to process : 1
16/02/01 03:48:44 INFO mapreduce.JobSubmitter: number of splits:2
16/02/01 03:48:44 INFO mapreduce.JobSubmitter: Submitting tokens for job: job_1454250779452_0041
16/02/01 03:48:45 INFO impl.YarnClientImpl: Submitted application application_1454250779452_0041
16/02/01 03:48:45 INFO mapreduce.Job: The url to track the job: http://sandbox.hortonworks.com:8088/proxy/applicat
ion_1454250779452_0041/
16/02/01 03:48:45 INFO mapreduce.Job: Running job: job_1454250779452_0041
16/02/01 03:48:56 INFO mapreduce.Job: Job job_1454250779452_0041 running in uber mode : false
16/02/01 03:48:56 INFO mapreduce.Job:  map 0% reduce 0%
16/02/01 03:49:13 INFO mapreduce.Job:  map 2% reduce 0%
16/02/01 03:49:16 INFO mapreduce.Job:  map 3% reduce 0%
16/02/01 03:49:19 INFO mapreduce.Job:  map 4% reduce 0%
16/02/01 03:49:22 INFO mapreduce.Job:  map 5% reduce 0%
16/02/01 03:49:25 INFO mapreduce.Job:  map 6% reduce 0%
16/02/01 03:49:28 INFO mapreduce.Job:  map 7% reduce 0%
16/02/01 03:49:31 INFO mapreduce.Job:  map 8% reduce 0%
16/02/01 03:49:34 INFO mapreduce.Job:  map 9% reduce 0%
16/02/01 03:49:37 INFO mapreduce.Job:  map 10% reduce 0%
16/02/01 03:49:40 INFO mapreduce.Job:  map 11% reduce 0%
16/02/01 03:49:43 INFO mapreduce.Job:  map 12% reduce 0%
16/02/01 03:49:47 INFO mapreduce.Job:  map 13% reduce 0%
```

```
16/02/01 03:49:50 INFO mapreduce.Job:  map 14% reduce 0%
16/02/01 03:49:53 INFO mapreduce.Job:  map 15% reduce 0%
16/02/01 03:49:56 INFO mapreduce.Job:  map 16% reduce 0%
16/02/01 03:49:59 INFO mapreduce.Job:  map 18% reduce 0%
16/02/01 03:50:02 INFO mapreduce.Job:  map 19% reduce 0%
16/02/01 03:50:05 INFO mapreduce.Job:  map 20% reduce 0%
16/02/01 03:50:08 INFO mapreduce.Job:  map 21% reduce 0%
16/02/01 03:50:11 INFO mapreduce.Job:  map 22% reduce 0%
16/02/01 03:50:14 INFO mapreduce.Job:  map 24% reduce 0%
16/02/01 03:50:17 INFO mapreduce.Job:  map 25% reduce 0%
16/02/01 03:50:20 INFO mapreduce.Job:  map 26% reduce 0%
16/02/01 03:50:23 INFO mapreduce.Job:  map 27% reduce 0%
16/02/01 03:50:26 INFO mapreduce.Job:  map 28% reduce 0%
16/02/01 03:50:27 INFO mapreduce.Job:  map 29% reduce 0%
16/02/01 03:50:30 INFO mapreduce.Job:  map 30% reduce 0%
16/02/01 03:50:33 INFO mapreduce.Job:  map 31% reduce 0%
16/02/01 03:50:35 INFO mapreduce.Job:  map 32% reduce 0%
16/02/01 03:50:39 INFO mapreduce.Job:  map 33% reduce 0%
16/02/01 03:50:42 INFO mapreduce.Job:  map 34% reduce 0%
16/02/01 03:50:45 INFO mapreduce.Job:  map 35% reduce 0%
16/02/01 03:50:47 INFO mapreduce.Job:  map 36% reduce 0%
16/02/01 03:50:50 INFO mapreduce.Job:  map 37% reduce 0%
16/02/01 03:50:53 INFO mapreduce.Job:  map 38% reduce 0%
16/02/01 03:50:58 INFO mapreduce.Job:  map 39% reduce 0%
16/02/01 03:51:01 INFO mapreduce.Job:  map 41% reduce 0%
16/02/01 03:51:04 INFO mapreduce.Job:  map 42% reduce 0%
16/02/01 03:51:07 INFO mapreduce.Job:  map 43% reduce 0%
16/02/01 03:51:10 INFO mapreduce.Job:  map 44% reduce 0%
16/02/01 03:51:13 INFO mapreduce.Job:  map 45% reduce 0%
16/02/01 03:51:16 INFO mapreduce.Job:  map 46% reduce 0%
16/02/01 03:51:19 INFO mapreduce.Job:  map 47% reduce 0%
16/02/01 03:51:22 INFO mapreduce.Job:  map 48% reduce 0%
16/02/01 03:51:25 INFO mapreduce.Job:  map 49% reduce 0%
16/02/01 03:51:28 INFO mapreduce.Job:  map 50% reduce 0%
16/02/01 03:51:31 INFO mapreduce.Job:  map 51% reduce 0%
16/02/01 03:51:34 INFO mapreduce.Job:  map 52% reduce 0%
16/02/01 03:51:37 INFO mapreduce.Job:  map 53% reduce 0%
16/02/01 03:51:40 INFO mapreduce.Job:  map 54% reduce 0%
16/02/01 03:51:43 INFO mapreduce.Job:  map 55% reduce 0%
16/02/01 03:51:46 INFO mapreduce.Job:  map 56% reduce 0%
16/02/01 03:51:49 INFO mapreduce.Job:  map 57% reduce 0%
16/02/01 03:51:52 INFO mapreduce.Job:  map 59% reduce 0%
16/02/01 03:51:55 INFO mapreduce.Job:  map 60% reduce 0%
16/02/01 03:51:58 INFO mapreduce.Job:  map 61% reduce 0%
16/02/01 03:52:01 INFO mapreduce.Job:  map 62% reduce 0%
16/02/01 03:52:05 INFO mapreduce.Job:  map 63% reduce 0%
16/02/01 03:52:08 INFO mapreduce.Job:  map 64% reduce 0%
16/02/01 03:52:12 INFO mapreduce.Job:  map 81% reduce 0%
16/02/01 03:52:14 INFO mapreduce.Job:  map 82% reduce 0%
16/02/01 03:52:23 INFO mapreduce.Job:  map 83% reduce 0%
16/02/01 03:52:31 INFO mapreduce.Job:  map 83% reduce 8%
16/02/01 03:52:32 INFO mapreduce.Job:  map 83% reduce 17%
16/02/01 03:52:34 INFO mapreduce.Job:  map 100% reduce 17%
16/02/01 03:52:37 INFO mapreduce.Job:  map 100% reduce 100%
16/02/01 03:52:38 INFO mapreduce.Job: Job job_1454250779452_0041 completed successfully
16/02/01 03:52:38 INFO mapreduce.Job: Counters: 52
        File System Counters
                FILE: Number of bytes read=4284
                FILE: Number of bytes written=520662
                FILE: Number of read operations=0
                FILE: Number of large read operations=0
                FILE: Number of write operations=0
                HDFS: Number of bytes read=51012846
                HDFS: Number of bytes written=2032
                HDFS: Number of read operations=12
                HDFS: Number of large read operations=0
                HDFS: Number of write operations=4
        Job Counters
                Launched map tasks=2
                Launched reduce tasks=2
                Data-local map tasks=2
                Total time spent by all maps in occupied slots (ms)=410332
                Total time spent by all reduces in occupied slots (ms)=45334
                Total time spent by all map tasks (ms)=410332
                Total time spent by all reduce tasks (ms)=45334
                Total vcore-seconds taken by all map tasks=410332
                Total vcore-seconds taken by all reduce tasks=45334
                Total megabyte-seconds taken by all map tasks=102583000
                Total megabyte-seconds taken by all reduce tasks=11333500
        Map-Reduce Framework
                Map input records=212010
```

```
                Map input records=312919
                Map output records=1002221
                Map output bytes=11872708
                Map output materialized bytes=4296
                Input split bytes=238
                Combine input records=1002221
                Combine output records=282
                Reduce input groups=157
                Reduce shuffle bytes=4296
                Reduce input records=282
                Reduce output records=153
                Spilled Records=564
                Shuffled Maps =4
                Failed Shuffles=0
                Merged Map outputs=4
                GC time elapsed (ms)=1068
                CPU time spent (ms)=380050
                Physical memory (bytes) snapshot=689311744
                Virtual memory (bytes) snapshot=4096471040
                Total committed heap usage (bytes)=495452160
        MRCounter
                Combiner=4
                Mapper=2
                Reducer=2
        Shuffle Errors
                BAD_ID=0
                CONNECTION=0
                IO_ERROR=0
                WRONG_LENGTH=0
                WRONG_MAP=0
                WRONG_REDUCE=0
        File Input Format Counters
                Bytes Read=51012608
        File Output Format Counters
                Bytes Written=2032
16/02/01 03:52:38 INFO streaming.StreamJob: Output directory: /tmp/3.2/streamout3
```

3.2 Part 3 Response

The value of the user defined Mapper Counter is: 2

The value of the user defined Combiner Counter is: 4

The value of the user defined Reducer Counter is: 2

```
MRCounter
    Combiner=4
    Mapper=2
    Reducer=2
```

3.2 Part 4

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. 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).

mapper 3.2_4

In [13]:
```
%%writefile mapper3.2_4.py
#!/usr/bin/env python
## mapper3.2_4.py
## Author: karthik chepudira
## Description: mapper code for HW3.2 part 4
import sys
import re

for line in sys.stdin:
    if not line in ['\n', '\r\n']: #check for blank lines
        print line.rstrip() #print line

sys.stderr.write("reporter:counter:MRCounter,Mapper,1\n") # increment the counter for Mapper
```

```
Overwriting mapper3.2_4.py
```

Reducer 3.2_4

In [7]:
```
%%writefile reducer3.2_4.py
#!/usr/bin/env python
## reducer3.2_4.py
## Author: karthik chepudira
## Description: reducer code for HW3.2 part 4
import sys
import Queue

n_max, n_min = 50, 10 #number of most and least frequent items
q_min = Queue.Queue(n_min) # implement a queue for least frequent items
a_max = [] # list of most frequent items
total_count=0

for line in sys.stdin:
    word,count=line.rstrip().split("\t",1)
    if word == "*":
        total_count += eval(count) # Total number of records
    else:
        # put the biggest
        if len(a_max) < n_max:
            a_max.append(word+","+count) #append the most frequent items to the list
        if q_min.full():
            q_min.get()
        q_min.put(word+","+count) #insert next least frequnet item to queue

print '\n%d Most Frequent  records:' %n_max
for record in a_max:
    word,count=record.split(",",1)
    print record+","+str((1.0*eval(count))/(total_count)) # calculate relative frequency and print record

print '\n%d Least Frequent records:' %n_min
for i in range(n_min):
    word,count=q_min.get().split(",",1)
    print word+","+count+","+str((1.0*eval(count))/(total_count)) # calculate relative frequency and print record

sys.stderr.write("reporter:counter:MRCounter,Reducer,1\n") #increment the Reducer Counter
```

```
Overwriting reducer3.2_4.py
```

In [8]:
```
!chmod a+x mapper3.2_4.py reducer3.2_4.py
```

MapReduce Job 1 to calculate frequency for all items and Total Count

In [21]:
```
## remove directory
!hdfs dfs -rm -r /tmp/3.2/streamout4
#run hadoop job
!hadoop jar /usr/hdp/2.3.0.0-2130/hadoop-mapreduce/hadoop-streaming-2.7.1.2.3.0.0-2130.jar \
-D mapred.job.name="HW3.2_4" \
-D mapred.map.tasks=2 \
-D mapred.reduce.tasks=1 \
-D stream.num.map.output.key.fields=2 \
-D mapreduce.partition.keypartitioner.options=-k1,1 \
-D mapreduce.job.output.key.comparator.class=org.apache.hadoop.mapred.lib.KeyFieldBasedComparator \
-D mapred.text.key.comparator.options="-k1 -k2nr" \
-input /tmp/3.1/Consumer_Complaints.csv \
-output /tmp/3.2/streamout4 \
-mapper '/usr/bin/python2.6 /usr/tmp/ds261/HW3/mapper3.2_2.py' \
-reducer '/usr/bin/python2.6 /usr/tmp/ds261/HW3/reducer3.2_2.py' \
-partitioner org.apache.hadoop.mapred.lib.KeyFieldBasedPartitioner \
-combiner '/usr/bin/python2.6 /usr/tmp/ds261/HW3/combiner3.2_3.py'
```

```
16/02/01 04:32:50 INFO fs.TrashPolicyDefault: Namenode trash configuration: Deletion interval = 360 minutes, Empti
er interval = 0 minutes.
Moved: 'hdfs://sandbox.hortonworks.com:8020/tmp/3.2/streamout4' to trash at: hdfs://sandbox.hortonworks.com:8020/u
ser/root/.Trash/Current
WARNING: Use "yarn jar" to launch YARN applications.
packageJobJar: [] [/usr/hdp/2.3.0.0-2130/hadoop-mapreduce/hadoop-streaming-2.7.1.2.3.0.0-2130.jar] /tmp/streamjob8
5037138404013378.jar tmpDir=null
16/02/01 04:32:56 INFO impl.TimelineClientImpl: Timeline service address: http://sandbox.hortonworks.com:8188/ws/v
1/timeline/
16/02/01 04:32:56 INFO client.RMProxy: Connecting to ResourceManager at sandbox.hortonworks.com/192.168.214.133:80
50
16/02/01 04:32:57 INFO impl.TimelineClientImpl: Timeline service address: http://sandbox.hortonworks.com:8188/ws/v
1/timeline/
16/02/01 04:32:57 INFO client.RMProxy: Connecting to ResourceManager at sandbox.hortonworks.com/192.168.214.133:80

50
```

```
16/02/01 04:32:58 INFO mapred.FileInputFormat: Total input paths to process : 1
16/02/01 04:32:58 INFO mapreduce.JobSubmitter: number of splits:2
16/02/01 04:32:59 INFO mapreduce.JobSubmitter: Submitting tokens for job: job_1454250779452_0044
16/02/01 04:33:00 INFO impl.YarnClientImpl: Submitted application application_1454250779452_0044
16/02/01 04:33:00 INFO mapreduce.Job: The url to track the job: http://sandbox.hortonworks.com:8088/proxy/applicat
ion_1454250779452_0044/
16/02/01 04:33:00 INFO mapreduce.Job: Running job: job_1454250779452_0044
16/02/01 04:33:14 INFO mapreduce.Job: Job job_1454250779452_0044 running in uber mode : false
16/02/01 04:33:14 INFO mapreduce.Job:  map 0% reduce 0%
16/02/01 04:33:30 INFO mapreduce.Job:  map 1% reduce 0%
16/02/01 04:33:31 INFO mapreduce.Job:  map 2% reduce 0%
16/02/01 04:33:33 INFO mapreduce.Job:  map 3% reduce 0%
16/02/01 04:33:36 INFO mapreduce.Job:  map 4% reduce 0%
16/02/01 04:33:37 INFO mapreduce.Job:  map 5% reduce 0%
16/02/01 04:33:40 INFO mapreduce.Job:  map 6% reduce 0%
16/02/01 04:33:43 INFO mapreduce.Job:  map 7% reduce 0%
16/02/01 04:33:45 INFO mapreduce.Job:  map 8% reduce 0%
16/02/01 04:33:48 INFO mapreduce.Job:  map 9% reduce 0%
16/02/01 04:33:51 INFO mapreduce.Job:  map 10% reduce 0%
16/02/01 04:33:52 INFO mapreduce.Job:  map 11% reduce 0%
16/02/01 04:33:55 INFO mapreduce.Job:  map 12% reduce 0%
16/02/01 04:33:57 INFO mapreduce.Job:  map 13% reduce 0%
16/02/01 04:34:01 INFO mapreduce.Job:  map 14% reduce 0%
16/02/01 04:34:04 INFO mapreduce.Job:  map 16% reduce 0%
16/02/01 04:34:07 INFO mapreduce.Job:  map 17% reduce 0%
16/02/01 04:34:10 INFO mapreduce.Job:  map 18% reduce 0%
16/02/01 04:34:13 INFO mapreduce.Job:  map 19% reduce 0%
16/02/01 04:34:16 INFO mapreduce.Job:  map 21% reduce 0%
16/02/01 04:34:20 INFO mapreduce.Job:  map 22% reduce 0%
16/02/01 04:34:23 INFO mapreduce.Job:  map 23% reduce 0%
16/02/01 04:34:26 INFO mapreduce.Job:  map 24% reduce 0%
16/02/01 04:34:29 INFO mapreduce.Job:  map 25% reduce 0%
16/02/01 04:34:32 INFO mapreduce.Job:  map 26% reduce 0%
16/02/01 04:34:35 INFO mapreduce.Job:  map 27% reduce 0%
16/02/01 04:34:38 INFO mapreduce.Job:  map 28% reduce 0%
16/02/01 04:34:41 INFO mapreduce.Job:  map 29% reduce 0%
16/02/01 04:34:44 INFO mapreduce.Job:  map 30% reduce 0%
16/02/01 04:34:47 INFO mapreduce.Job:  map 32% reduce 0%
16/02/01 04:34:50 INFO mapreduce.Job:  map 33% reduce 0%
16/02/01 04:34:53 INFO mapreduce.Job:  map 34% reduce 0%
16/02/01 04:34:56 INFO mapreduce.Job:  map 36% reduce 0%
16/02/01 04:34:59 INFO mapreduce.Job:  map 37% reduce 0%
16/02/01 04:35:02 INFO mapreduce.Job:  map 38% reduce 0%
16/02/01 04:35:05 INFO mapreduce.Job:  map 39% reduce 0%
16/02/01 04:35:08 INFO mapreduce.Job:  map 40% reduce 0%
16/02/01 04:35:12 INFO mapreduce.Job:  map 41% reduce 0%
16/02/01 04:35:18 INFO mapreduce.Job:  map 42% reduce 0%
16/02/01 04:35:21 INFO mapreduce.Job:  map 43% reduce 0%
16/02/01 04:35:27 INFO mapreduce.Job:  map 44% reduce 0%
16/02/01 04:35:30 INFO mapreduce.Job:  map 45% reduce 0%
16/02/01 04:35:33 INFO mapreduce.Job:  map 46% reduce 0%
16/02/01 04:35:37 INFO mapreduce.Job:  map 47% reduce 0%
16/02/01 04:35:40 INFO mapreduce.Job:  map 48% reduce 0%
16/02/01 04:35:43 INFO mapreduce.Job:  map 49% reduce 0%
16/02/01 04:35:46 INFO mapreduce.Job:  map 50% reduce 0%
16/02/01 04:35:50 INFO mapreduce.Job:  map 51% reduce 0%
16/02/01 04:35:56 INFO mapreduce.Job:  map 52% reduce 0%
16/02/01 04:35:59 INFO mapreduce.Job:  map 53% reduce 0%
16/02/01 04:36:02 INFO mapreduce.Job:  map 54% reduce 0%
16/02/01 04:36:05 INFO mapreduce.Job:  map 55% reduce 0%
16/02/01 04:36:08 INFO mapreduce.Job:  map 56% reduce 0%
16/02/01 04:36:11 INFO mapreduce.Job:  map 57% reduce 0%
16/02/01 04:36:14 INFO mapreduce.Job:  map 58% reduce 0%
16/02/01 04:36:17 INFO mapreduce.Job:  map 59% reduce 0%
16/02/01 04:36:20 INFO mapreduce.Job:  map 60% reduce 0%
16/02/01 04:36:23 INFO mapreduce.Job:  map 61% reduce 0%
16/02/01 04:36:26 INFO mapreduce.Job:  map 62% reduce 0%
16/02/01 04:36:29 INFO mapreduce.Job:  map 64% reduce 0%
16/02/01 04:36:32 INFO mapreduce.Job:  map 65% reduce 0%
16/02/01 04:36:38 INFO mapreduce.Job:  map 66% reduce 0%
16/02/01 04:36:42 INFO mapreduce.Job:  map 83% reduce 0%
16/02/01 04:36:55 INFO mapreduce.Job:  map 100% reduce 0%
16/02/01 04:36:57 INFO mapreduce.Job:  map 100% reduce 100%
16/02/01 04:36:57 INFO mapreduce.Job: Job job_1454250779452_0044 completed successfully
16/02/01 04:36:57 INFO mapreduce.Job: Counters: 52
        File System Counters
                FILE: Number of bytes read=4266
                FILE: Number of bytes written=395015
                FILE: Number of read operations=0

                FILE: Number of large read operations=0
```

```
                FILE: Number of large read operations=0
                FILE: Number of write operations=0
                HDFS: Number of bytes read=51012846
                HDFS: Number of bytes written=2028
                HDFS: Number of read operations=9
                HDFS: Number of large read operations=0
                HDFS: Number of write operations=2
        Job Counters
                Launched map tasks=2
                Launched reduce tasks=1
                Data-local map tasks=2
                Total time spent by all maps in occupied slots (ms)=425688
                Total time spent by all reduces in occupied slots (ms)=11795
                Total time spent by all map tasks (ms)=425688
                Total time spent by all reduce tasks (ms)=11795
                Total vcore-seconds taken by all map tasks=425688
                Total vcore-seconds taken by all reduce tasks=11795
                Total megabyte-seconds taken by all map tasks=106422000
                Total megabyte-seconds taken by all reduce tasks=2948750
        Map-Reduce Framework
                Map input records=312919
                Map output records=1002221
                Map output bytes=12874929
                Map output materialized bytes=4272
                Input split bytes=238
                Combine input records=1002221
                Combine output records=280
                Reduce input groups=154
                Reduce shuffle bytes=4272
                Reduce input records=280
                Reduce output records=152
                Spilled Records=560
                Shuffled Maps =2
                Failed Shuffles=0
                Merged Map outputs=2
                GC time elapsed (ms)=1015
                CPU time spent (ms)=398290
                Physical memory (bytes) snapshot=545005568
                Virtual memory (bytes) snapshot=3052392448
                Total committed heap usage (bytes)=382730240
        MRCounter
                Combiner=2
                Mapper=2
                Reducer=1
        Shuffle Errors
                BAD_ID=0
                CONNECTION=0
                IO_ERROR=0
                WRONG_LENGTH=0
                WRONG_MAP=0
                WRONG_REDUCE=0
        File Input Format Counters
                Bytes Read=51012608
        File Output Format Counters
                Bytes Written=2028
16/02/01 04:36:57 INFO streaming.StreamJob: Output directory: /tmp/3.2/streamout4
```

MapReduce Job 2 to sort and filter for Most Frequent and Least Frequent Items

In [22]:
```
## remove directory
!hdfs dfs -rm -r /tmp/3.2/streamout4_2
#run hadoop job
!hadoop jar /usr/hdp/2.3.0.0-2130/hadoop-mapreduce/hadoop-streaming-2.7.1.2.3.0.0-2130.jar \
-D mapred.job.name="HW3.2_4" \
-D mapred.map.tasks=2 \
-D mapred.reduce.tasks=1 \
-D stream.num.map.output.key.fields=2 \
-D mapreduce.partition.keypartitioner.options=-k1,1 \
-D mapreduce.job.output.key.comparator.class=org.apache.hadoop.mapred.lib.KeyFieldBasedComparator \
-D mapred.text.key.comparator.options="-k2nr -k1" \
-input /tmp/3.2/streamout4/* \
-output /tmp/3.2/streamout4_2 \
-mapper '/usr/bin/python2.6 /usr/tmp/ds261/HW3/mapper3.2_4.py' \
-reducer '/usr/bin/python2.6 /usr/tmp/ds261/HW3/reducer3.2_4.py' \
-partitioner org.apache.hadoop.mapred.lib.KeyFieldBasedPartitioner
#-combiner '/usr/bin/python2.6 /usr/tmp/ds261/HW3/combiner3.2_3.py'
```

```
16/02/01 04:37:26 INFO fs.TrashPolicyDefault: Namenode trash configuration: Deletion interval = 360 minutes, Empti
er interval = 0 minutes.
```

```
Moved: 'hdfs://sandbox.hortonworks.com:8020/tmp/3.2/streamout4_2' to trash at: hdfs://sandbox.hortonworks.com:8020
/user/root/.Trash/Current
WARNING: Use "yarn jar" to launch YARN applications.
packageJobJar: [] [/usr/hdp/2.3.0.0-2130/hadoop-mapreduce/hadoop-streaming-2.7.1.2.3.0.0-2130.jar] /tmp/streamjob8
371278169569604881.jar tmpDir=null
16/02/01 04:37:31 INFO impl.TimelineClientImpl: Timeline service address: http://sandbox.hortonworks.com:8188/ws/v
1/timeline/
16/02/01 04:37:32 INFO client.RMProxy: Connecting to ResourceManager at sandbox.hortonworks.com/192.168.214.133:80
50
16/02/01 04:37:32 INFO impl.TimelineClientImpl: Timeline service address: http://sandbox.hortonworks.com:8188/ws/v
1/timeline/
16/02/01 04:37:32 INFO client.RMProxy: Connecting to ResourceManager at sandbox.hortonworks.com/192.168.214.133:80
50
16/02/01 04:37:33 INFO mapred.FileInputFormat: Total input paths to process : 1
16/02/01 04:37:33 INFO mapreduce.JobSubmitter: number of splits:2
16/02/01 04:37:34 INFO mapreduce.JobSubmitter: Submitting tokens for job: job_1454250779452_0045
16/02/01 04:37:34 INFO impl.YarnClientImpl: Submitted application application_1454250779452_0045
16/02/01 04:37:34 INFO mapreduce.Job: The url to track the job: http://sandbox.hortonworks.com:8088/proxy/applicat
ion_1454250779452_0045/
16/02/01 04:37:34 INFO mapreduce.Job: Running job: job_1454250779452_0045
16/02/01 04:37:44 INFO mapreduce.Job: Job job_1454250779452_0045 running in uber mode : false
16/02/01 04:37:44 INFO mapreduce.Job:  map 0% reduce 0%
16/02/01 04:37:55 INFO mapreduce.Job:  map 100% reduce 0%
16/02/01 04:38:03 INFO mapreduce.Job:  map 100% reduce 100%
16/02/01 04:38:03 INFO mapreduce.Job: Job job_1454250779452_0045 completed successfully
16/02/01 04:38:03 INFO mapreduce.Job: Counters: 51
        File System Counters
                FILE: Number of bytes read=2490
                FILE: Number of bytes written=390305
                FILE: Number of read operations=0
                FILE: Number of large read operations=0
                FILE: Number of write operations=0
                HDFS: Number of bytes read=3276
                HDFS: Number of bytes written=1963
                HDFS: Number of read operations=9
                HDFS: Number of large read operations=0
                HDFS: Number of write operations=2
        Job Counters
                Launched map tasks=2
                Launched reduce tasks=1
                Data-local map tasks=2
                Total time spent by all maps in occupied slots (ms)=17428
                Total time spent by all reduces in occupied slots (ms)=5989
                Total time spent by all map tasks (ms)=17428
                Total time spent by all reduce tasks (ms)=5989
                Total vcore-seconds taken by all map tasks=17428
                Total vcore-seconds taken by all reduce tasks=5989
                Total megabyte-seconds taken by all map tasks=4357000
                Total megabyte-seconds taken by all reduce tasks=1497250
        Map-Reduce Framework
                Map input records=152
                Map output records=152
                Map output bytes=2180
                Map output materialized bytes=2496
                Input split bytes=234
                Combine input records=0
                Combine output records=0
                Reduce input groups=152
                Reduce shuffle bytes=2496
                Reduce input records=152
                Reduce output records=64
                Spilled Records=304
                Shuffled Maps =2
                Failed Shuffles=0
                Merged Map outputs=2
                GC time elapsed (ms)=285
                CPU time spent (ms)=3710
                Physical memory (bytes) snapshot=556621824
                Virtual memory (bytes) snapshot=3073245184
                Total committed heap usage (bytes)=375914496
        MRCounter
                Mapper=2
                Reducer=1
        Shuffle Errors
                BAD_ID=0
                CONNECTION=0
                IO_ERROR=0
                WRONG_LENGTH=0
                WRONG_MAP=0
                WRONG_REDUCE=0
```

```
        File Input Format Counters
                Bytes Read=3042
        File Output Format Counters
                Bytes Written=1963
16/02/01 04:38:03 INFO streaming.StreamJob: Output directory: /tmp/3.2/streamout4_2
```

In [23]:
```
!hdfs dfs -cat /tmp/3.2/streamout4_2/part-00000
```

```
50 Most Frequent  records:
loan,119491,0.119226436537
modificationcollectionforeclosure,70487,0.0703309356538
account,57448,0.0573208051334
credit,50897,0.050784309617
payments,39993,0.039904452021
escrow,36767,0.0366855946654
servicing,36767,0.0366855946654
report,30546,0.0304783685003
incorrect,29069,0.0290046387067
information,29069,0.0290046387067
debt,27876,0.0278142801124
attempts,17972,0.0179322084295
collect,17972,0.0179322084295
contd,17972,0.0179322084295
owed,17972,0.0179322084295
closing,16205,0.0161691207211
management,16205,0.0161691207211
opening,16205,0.0161691207211
deposits,10555,0.0105316303123
withdrawals,10555,0.0105316303123
problems,9484,0.00946300159945
application,8868,0.00884836547701
communication,8671,0.00865180165213
tactics,8671,0.00865180165213
broker,8625,0.00860590350013
mortgage,8625,0.00860590350013
originator,8625,0.00860590350013
unable,8178,0.008159893197
billing,8158,0.00813993747873
disclosure,7655,0.00763805116447
verification,7655,0.00763805116447
disputes,6938,0.0069226386648
reporting,6560,0.00654547558967
lease,6337,0.00632296933105
caused,5663,0.00565046162565
funds,5663,0.00565046162565
low,5663,0.00565046162565
process,5505,0.00549281145139
managing,5006,0.00499491628077
improper,4966,0.00495500484425
companys,4858,0.00484724396564
investigation,4858,0.00484724396564
identity,4729,0.00471852958286
card,4407,0.00439724251885
get,4357,0.0043473532232
reportcredit,4357,0.0043473532232
score,4357,0.0043473532232
costs,4350,0.00434036872181
settlement,4350,0.00434036872181
interest,4238,0.00422861669954

10 Least Frequent records:
amount,98,9.77830194798e-05
credited,92,9.17963040014e-05
payment,92,9.17963040014e-05
checks,75,7.48339434794e-05
convenience,75,7.48339434794e-05
amt,71,7.08427998272e-05
day,71,7.08427998272e-05
disclosures,64,6.38582984358e-05
incorrectmissing,64,6.38582984358e-05
citibank,1,9.97785913059e-07
```

3.2 Part 4 Response

We used 2 Mapreduce jobs:

```
Job 1. First one to get frequencies of all the terms and the count of documents
Job 2. To sort the terms,terms frequencies by value,key columns
       filter , print 50 most frequent terms and 10 least frequent terms
```

3.2.1 OPTIONAL

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).

MapReduce Job 1 to calculate frequency for all items and Total Count

In [1]:
```
## remove directory
!hdfs dfs -rm -r /tmp/3.2/streamout5
#run hadoop job
!hadoop jar /usr/hdp/2.3.0.0-2130/hadoop-mapreduce/hadoop-streaming-2.7.1.2.3.0.0-2130.jar \
-D mapred.job.name="HW3.2.1" \
-D mapred.map.tasks=2 \
-D mapred.reduce.tasks=2 \
-D stream.num.map.output.key.fields=2 \
-D mapreduce.partition.keypartitioner.options=-k1,1 \
-D mapreduce.job.output.key.comparator.class=org.apache.hadoop.mapred.lib.KeyFieldBasedComparator \
-D mapreduce.partition.keycomparator.options="-k1,1 -k2,2nr" \
-D mapred.text.key.comparator.options="-k1,1 -k2,2nr" \
-input /tmp/3.1/Consumer_Complaints.csv \
-output /tmp/3.2/streamout5 \
-mapper '/usr/bin/python2.6 /usr/tmp/ds261/HW3/mapper3.2_2.py' \
-reducer '/usr/bin/python2.6 /usr/tmp/ds261/HW3/reducer3.2_2.py' \
-partitioner org.apache.hadoop.mapred.lib.KeyFieldBasedPartitioner \
-combiner '/usr/bin/python2.6 /usr/tmp/ds261/HW3/combiner3.2_3.py'
```

```
rm: `/tmp/3.2/streamout5': No such file or directory
WARNING: Use "yarn jar" to launch YARN applications.
packageJarJar: [] [/usr/hdp/2.3.0.0-2130/hadoop-mapreduce/hadoop-streaming-2.7.1.2.3.0.0-2130.jar] /tmp/streamjob2
879157563458909815.jar tmpDir=null
16/02/01 21:30:02 INFO impl.TimelineClientImpl: Timeline service address: http://sandbox.hortonworks.com:8188/ws/v
1/timeline/
16/02/01 21:30:02 INFO client.RMProxy: Connecting to ResourceManager at sandbox.hortonworks.com/192.168.177.132:80
50
16/02/01 21:30:02 INFO impl.TimelineClientImpl: Timeline service address: http://sandbox.hortonworks.com:8188/ws/v
1/timeline/
16/02/01 21:30:02 INFO client.RMProxy: Connecting to ResourceManager at sandbox.hortonworks.com/192.168.177.132:80
50
16/02/01 21:30:03 INFO mapred.FileInputFormat: Total input paths to process : 1
16/02/01 21:30:03 INFO mapreduce.JobSubmitter: number of splits:2
16/02/01 21:30:03 INFO mapreduce.JobSubmitter: Submitting tokens for job: job_1454357458596_0001
16/02/01 21:30:04 INFO impl.YarnClientImpl: Submitted application application_1454357458596_0001
16/02/01 21:30:04 INFO mapreduce.Job: The url to track the job: http://sandbox.hortonworks.com:8088/proxy/applicat
ion_1454357458596_0001/
16/02/01 21:30:04 INFO mapreduce.Job: Running job: job_1454357458596_0001
16/02/01 21:30:15 INFO mapreduce.Job: Job job_1454357458596_0001 running in uber mode : false
16/02/01 21:30:15 INFO mapreduce.Job:  map 0% reduce 0%
16/02/01 21:30:27 INFO mapreduce.Job:  map 4% reduce 0%
16/02/01 21:30:30 INFO mapreduce.Job:  map 6% reduce 0%
16/02/01 21:30:33 INFO mapreduce.Job:  map 8% reduce 0%
16/02/01 21:30:36 INFO mapreduce.Job:  map 10% reduce 0%
16/02/01 21:30:39 INFO mapreduce.Job:  map 12% reduce 0%
16/02/01 21:30:42 INFO mapreduce.Job:  map 15% reduce 0%
16/02/01 21:30:45 INFO mapreduce.Job:  map 17% reduce 0%
16/02/01 21:30:48 INFO mapreduce.Job:  map 19% reduce 0%
16/02/01 21:30:51 INFO mapreduce.Job:  map 21% reduce 0%
16/02/01 21:30:54 INFO mapreduce.Job:  map 24% reduce 0%
16/02/01 21:30:57 INFO mapreduce.Job:  map 26% reduce 0%
16/02/01 21:31:00 INFO mapreduce.Job:  map 28% reduce 0%
16/02/01 21:31:03 INFO mapreduce.Job:  map 30% reduce 0%
16/02/01 21:31:06 INFO mapreduce.Job:  map 32% reduce 0%
16/02/01 21:31:09 INFO mapreduce.Job:  map 34% reduce 0%
16/02/01 21:31:12 INFO mapreduce.Job:  map 35% reduce 0%
16/02/01 21:31:15 INFO mapreduce.Job:  map 37% reduce 0%
16/02/01 21:31:18 INFO mapreduce.Job:  map 39% reduce 0%
16/02/01 21:31:21 INFO mapreduce.Job:  map 41% reduce 0%
16/02/01 21:31:24 INFO mapreduce.Job:  map 43% reduce 0%
16/02/01 21:31:27 INFO mapreduce.Job:  map 45% reduce 0%
16/02/01 21:31:30 INFO mapreduce.Job:  map 48% reduce 0%
```

```
16/02/01 21:31:33 INFO mapreduce.Job:  map 50% reduce 0%
16/02/01 21:31:36 INFO mapreduce.Job:  map 52% reduce 0%
16/02/01 21:31:39 INFO mapreduce.Job:  map 54% reduce 0%
16/02/01 21:31:42 INFO mapreduce.Job:  map 57% reduce 0%
16/02/01 21:31:45 INFO mapreduce.Job:  map 59% reduce 0%
16/02/01 21:31:48 INFO mapreduce.Job:  map 61% reduce 0%
16/02/01 21:31:51 INFO mapreduce.Job:  map 63% reduce 0%
16/02/01 21:31:54 INFO mapreduce.Job:  map 64% reduce 0%
16/02/01 21:31:56 INFO mapreduce.Job:  map 81% reduce 0%
16/02/01 21:31:57 INFO mapreduce.Job:  map 82% reduce 0%
16/02/01 21:32:00 INFO mapreduce.Job:  map 83% reduce 0%
16/02/01 21:32:11 INFO mapreduce.Job:  map 100% reduce 8%
16/02/01 21:32:12 INFO mapreduce.Job:  map 100% reduce 58%
16/02/01 21:32:13 INFO mapreduce.Job:  map 100% reduce 100%
16/02/01 21:32:14 INFO mapreduce.Job: Job job_1454357458596_0001 completed successfully
16/02/01 21:32:14 INFO mapreduce.Job: Counters: 52
        File System Counters
                FILE: Number of bytes read=4284
                FILE: Number of bytes written=523894
                FILE: Number of read operations=0
                FILE: Number of large read operations=0
                FILE: Number of write operations=0
                HDFS: Number of bytes read=51012846
                HDFS: Number of bytes written=2032
                HDFS: Number of read operations=12
                HDFS: Number of large read operations=0
                HDFS: Number of write operations=4
        Job Counters
                Launched map tasks=2
                Launched reduce tasks=2
                Data-local map tasks=2
                Total time spent by all maps in occupied slots (ms)=214521
                Total time spent by all reduces in occupied slots (ms)=24570
                Total time spent by all map tasks (ms)=214521
                Total time spent by all reduce tasks (ms)=24570
                Total vcore-seconds taken by all map tasks=214521
                Total vcore-seconds taken by all reduce tasks=24570
                Total megabyte-seconds taken by all map tasks=53630250
                Total megabyte-seconds taken by all reduce tasks=6142500
        Map-Reduce Framework
                Map input records=312919
                Map output records=1002221
                Map output bytes=12874929
                Map output materialized bytes=4296
                Input split bytes=238
                Combine input records=1002221
                Combine output records=282
                Reduce input groups=157
                Reduce shuffle bytes=4296
                Reduce input records=282
                Reduce output records=153
                Spilled Records=564
                Shuffled Maps =4
                Failed Shuffles=0
                Merged Map outputs=4
                GC time elapsed (ms)=408
                CPU time spent (ms)=197350
                Physical memory (bytes) snapshot=688414720
                Virtual memory (bytes) snapshot=4103147520
                Total committed heap usage (bytes)=504889344
        MRCounter
                Combiner=4
                Mapper=2
                Reducer=2
        Shuffle Errors
                BAD_ID=0
                CONNECTION=0
                IO_ERROR=0
                WRONG_LENGTH=0
                WRONG_MAP=0
                WRONG_REDUCE=0
        File Input Format Counters
                Bytes Read=51012608
        File Output Format Counters
                Bytes Written=2032
16/02/01 21:32:14 INFO streaming.StreamJob: Output directory: /tmp/3.2/streamout5
```

MapReduce Job 2 to sort and filter for Most Frequent and Least Frequent Items

In [9]:
```
## remove directory
!hdfs dfs -rm -r /tmp/3.2/streamout5_2
#run hadoop job
!hadoop jar /usr/hdp/2.3.0.0-2130/hadoop-mapreduce/hadoop-streaming-2.7.1.2.3.0.0-2130.jar \
-D mapred.job.name="HW3.2.1_2" \
-D mapred.map.tasks=2 \
-D mapred.reduce.tasks=1 \
-D stream.num.map.output.key.fields=2 \
-D mapreduce.partition.keypartitioner.options=-k1,1 \
-D mapreduce.job.output.key.comparator.class=org.apache.hadoop.mapred.lib.KeyFieldBasedComparator \
-D mapred.text.key.comparator.options="-k2nr -k1" \
-input /tmp/3.2/streamout5/* \
-output /tmp/3.2/streamout5_2 \
-mapper '/usr/bin/python2.6 /usr/tmp/ds261/HW3/mapper3.2_4.py' \
-reducer '/usr/bin/python2.6 /usr/tmp/ds261/HW3/reducer3.2_4.py' \
-partitioner org.apache.hadoop.mapred.lib.KeyFieldBasedPartitioner
#-combiner '/usr/bin/python2.6 /usr/tmp/ds261/HW3/combiner3.2_3.py'
```

```
16/02/01 21:39:29 INFO fs.TrashPolicyDefault: Namenode trash configuration: Deletion interval = 360 minutes, Empti
er interval = 0 minutes.
Moved: 'hdfs://sandbox.hortonworks.com:8020/tmp/3.2/streamout5_2' to trash at: hdfs://sandbox.hortonworks.com:8020
/user/root/.Trash/Current
WARNING: Use "yarn jar" to launch YARN applications.
packageJobJar: [] [/usr/hdp/2.3.0.0-2130/hadoop-mapreduce/hadoop-streaming-2.7.1.2.3.0.0-2130.jar] /tmp/streamjob2
876634080924659687.jar tmpDir=null
16/02/01 21:39:32 INFO impl.TimelineClientImpl: Timeline service address: http://sandbox.hortonworks.com:8188/ws/v
1/timeline/
16/02/01 21:39:32 INFO client.RMProxy: Connecting to ResourceManager at sandbox.hortonworks.com/192.168.177.132:80
50
16/02/01 21:39:33 INFO impl.TimelineClientImpl: Timeline service address: http://sandbox.hortonworks.com:8188/ws/v
1/timeline/
16/02/01 21:39:33 INFO client.RMProxy: Connecting to ResourceManager at sandbox.hortonworks.com/192.168.177.132:80
50
16/02/01 21:39:33 INFO mapred.FileInputFormat: Total input paths to process : 2
16/02/01 21:39:33 INFO mapreduce.JobSubmitter: number of splits:2
16/02/01 21:39:33 INFO mapreduce.JobSubmitter: Submitting tokens for job: job_1454357458596_0003
16/02/01 21:39:34 INFO impl.YarnClientImpl: Submitted application application_1454357458596_0003
16/02/01 21:39:34 INFO mapreduce.Job: The url to track the job: http://sandbox.hortonworks.com:8088/proxy/applicat
ion_1454357458596_0003/
16/02/01 21:39:34 INFO mapreduce.Job: Running job: job_1454357458596_0003
16/02/01 21:39:39 INFO mapreduce.Job: Job job_1454357458596_0003 running in uber mode : false
16/02/01 21:39:39 INFO mapreduce.Job:  map 0% reduce 0%
16/02/01 21:39:45 INFO mapreduce.Job:  map 100% reduce 0%
16/02/01 21:39:51 INFO mapreduce.Job:  map 100% reduce 100%
16/02/01 21:39:51 INFO mapreduce.Job: Job job_1454357458596_0003 completed successfully
16/02/01 21:39:51 INFO mapreduce.Job: Counters: 51
        File System Counters
                FILE: Number of bytes read=2497
                FILE: Number of bytes written=390325
                FILE: Number of read operations=0
                FILE: Number of large read operations=0
                FILE: Number of write operations=0
                HDFS: Number of bytes read=2266
                HDFS: Number of bytes written=1963
                HDFS: Number of read operations=9
                HDFS: Number of large read operations=0
                HDFS: Number of write operations=2
        Job Counters
                Launched map tasks=2
                Launched reduce tasks=1
                Data-local map tasks=2
                Total time spent by all maps in occupied slots (ms)=8388
                Total time spent by all reduces in occupied slots (ms)=2962
                Total time spent by all map tasks (ms)=8388
                Total time spent by all reduce tasks (ms)=2962
                Total vcore-seconds taken by all map tasks=8388
                Total vcore-seconds taken by all reduce tasks=2962
                Total megabyte-seconds taken by all map tasks=2097000
                Total megabyte-seconds taken by all reduce tasks=740500
        Map-Reduce Framework
                Map input records=153
                Map output records=153
                Map output bytes=2185
                Map output materialized bytes=2503
                Input split bytes=234
                Combine input records=0
                Combine output records=0
                Reduce input groups=153
                Reduce shuffle bytes=2503
                Reduce input records=153
```

```
                Reduce output records=64
                Spilled Records=306
                Shuffled Maps =2
                Failed Shuffles=0
                Merged Map outputs=2
                GC time elapsed (ms)=150
                CPU time spent (ms)=2180
                Physical memory (bytes) snapshot=558735360
                Virtual memory (bytes) snapshot=3083964416
                Total committed heap usage (bytes)=371195904
        MRCounter
                Mapper=2
                Reducer=1
        Shuffle Errors
                BAD_ID=0
                CONNECTION=0
                IO_ERROR=0
                WRONG_LENGTH=0
                WRONG_MAP=0
                WRONG_REDUCE=0
        File Input Format Counters
                Bytes Read=2032
        File Output Format Counters
                Bytes Written=1963
16/02/01 21:39:51 INFO streaming.StreamJob: Output directory: /tmp/3.2/streamout5_2
```

In [12]:
```
!hdfs dfs -cat /tmp/3.2/streamout5_2/part*
```

```
50 Most Frequent  records:
loan,119491,0.119226436537
modificationcollectionforeclosure,70487,0.0703309356538
account,57448,0.0573208051334
credit,50897,0.050784309617
payments,39993,0.039904452021
escrow,36767,0.0366855946654
servicing,36767,0.0366855946654
report,30546,0.0304783685003
incorrect,29069,0.0290046387067
information,29069,0.0290046387067
debt,27876,0.0278142801124
attempts,17972,0.0179322084295
collect,17972,0.0179322084295
contd,17972,0.0179322084295
owed,17972,0.0179322084295
closing,16205,0.0161691207211
management,16205,0.0161691207211
opening,16205,0.0161691207211
deposits,10555,0.0105316303123
withdrawals,10555,0.0105316303123
problems,9484,0.00946300159945
application,8868,0.00884836547701
communication,8671,0.00865180165213
tactics,8671,0.00865180165213
broker,8625,0.00860590350013
mortgage,8625,0.00860590350013
originator,8625,0.00860590350013
unable,8178,0.008159893197
billing,8158,0.00813993747873
disclosure,7655,0.00763805116447
verification,7655,0.00763805116447
disputes,6938,0.0069226386648
reporting,6560,0.00654547558967
lease,6337,0.00632296933105
caused,5663,0.00565046162565
funds,5663,0.00565046162565
low,5663,0.00565046162565
process,5505,0.00549281145139
managing,5006,0.00499491628077
improper,4966,0.00495500484425
companys,4858,0.00484724396564
investigation,4858,0.00484724396564
identity,4729,0.00471852958286
card,4407,0.00439724251885
get,4357,0.0043473532232
reportcredit,4357,0.0043473532232
score,4357,0.0043473532232
costs,4350,0.00434036872181
settlement,4350,0.00434036872181
interest,4238,0.00422861669954

10 Least Frequent records:
amount,98,9.77830194798e-05
credited,92,9.17963040014e-05
payment,92,9.17963040014e-05
checks,75,7.48339434794e-05
convenience,75,7.48339434794e-05
amt,71,7.08427998272e-05
day,71,7.08427998272e-05
disclosures,64,6.38582984358e-05
incorrectmissing,64,6.38582984358e-05
citibank,1,9.97785913059e-07
```

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/ProductPurchaseData.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.

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.

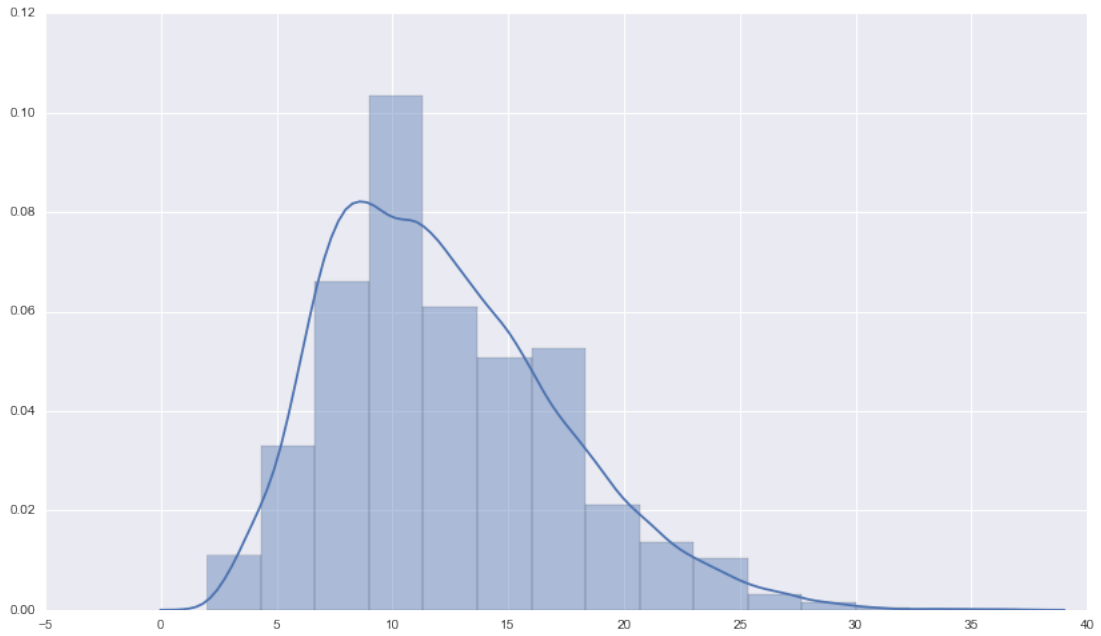
3.3 EDA Using Python

In [39]:
```
# Use Python to do EDA
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns
from collections import Counter
%matplotlib inline
```

We'll use Python to perform some exploratory data analysis before we use the MapReduce framework.

In [181]:
```
def hw_3_3_eda():
    # Items dictionary
    items = Counter()
    # Basket size variable
    basket = []
    # Iterate over records
    with open("ProductPurchaseData.txt", "r") as f:
        for line in f:
            # Split into individual items
            record = line.strip().split()
            # Add items to dictionary and to basket
            items += Counter(record)
            basket.append(len(record))
    # Print result and plot basket size distribution
    print ("The number of total items: {}.".format(sum(items.values())))
    print ("The number of unique items: {}.".format(len(items)))
    print ("The average size of the basket: {:.2f}.".format(np.mean(basket)))
    plt.figure(figsize=(14,8))
    sns.distplot(basket, bins=15)

hw_3_3_eda()
```

```
The number of total items: 380824.
The number of unique items: 12592.
The average size of the basket: 12.24.
```



3.3 MapReduce

Strategy:

- 1st stage:
  Mapper: purchase_record -> (item, 1, basketsize) (including (*,count) for order inversion in relative frequency calculation)
  Reducer: (item, count) -> (item, total count, relative frequency, largest basketsize)
- 2nd stage:
  Sort 1st stage output by total count.

In [196]:
```
!hdfs dfs -put ProductPurchaseData.txt /user/konniam/week_03/
```

```
16/01/29 23:59:04 WARN util.NativeCodeLoader: Unable to load native-hadoop library for your platform... using buil
tin-java classes where applicable
```

In [42]:
```
%%writefile mapper_3_3.py
#!/usr/bin/env python
# Mapper for 3.3
# Author: Konniam Chan
# Shopping cart analysis
# Output goes to 1 reducer
import sys

# Count how many mappers called
sys.stderr.write("reporter:counter:MR-Counter,Num_mapper_calls,1\n")

for line in sys.stdin:
    record = line.strip().split()
    basketsize = len(record)
    # Assume 1 reducer in the next step
    # Emit count and basketsize, (*) stands for the total
    for item in record:
        print '%s\t%s\t%s' % ('*', 1, basketsize)
        print '%s\t%s\t%s' % (item, 1, basketsize)
```

```
Overwriting mapper_3_3.py
```

In [43]:
```
%%writefile combiner_3_3.py
#!/usr/bin/env python
## Combiner for 3.3
# Author: Konniam Chan
# Shopping cart analysis
import sys
current_item = None
current_count = 0
current_basketsize = 0
item = None

# Count how many combiners called
sys.stderr.write("reporter:counter:MR-Counter,Num_combiner_calls,1\n")

for line in sys.stdin:
    # Obtain item and intermediate counts
    line = line.strip()
    item, count, basketsize = line.split('\t')
    count = int(count)
    basketsize = int(basketsize)
    # Rely on sorting to increment item counts
    if current_item == item:
        current_count += count
        current_basketsize = max(current_basketsize, basketsize)
    else:
        if current_item:
            print '%s\t%s\t%s' % (current_item, current_count, current_basketsize)
        current_count = count
        current_item = item
        current_basketsize = basketsize

# Output last item
if current_item == item:
    print '%s\t%s\t%s' % (current_item, current_count, current_basketsize)
```

```
Overwriting combiner_3_3.py
```

In [45]:
```
%%writefile reducer_3_3.py
#!/usr/bin/env python
# Reducer for 3.3
# Author: Konniam Chan
# Shopping cart analysis
# Assume 1 reducer
from __future__ import division
import sys
current_item = None
current_count = 0
current_basketsize = 0
item = None

# Count how many reducers called
sys.stderr.write("reporter:counter:MR-Counter,Num_reducer_calls,1\n")

for line in sys.stdin:
    # Obtain item and intermediate counts
    line = line.strip()
    item, count, basketsize = line.split('\t')
    count = int(count)
    basketsize = int(basketsize)
    # Rely on sorting to increment item counts
    if current_item == item:
        current_count += count
        current_basketsize = max(current_basketsize, basketsize)
    else:
        # Obtain total count and save to memory
        if current_item == '*':
            total = current_count
        # Compute counts and relative frequencies for regular items
        elif current_item:
            # Output (item, count, relative frequency)
            print '%s\t%s\t%s\t%s' % (current_item, current_count, current_count / total, current_basketsize)
        current_count = count
        current_item = item
        current_basketsize = basketsize

# Output last item
if current_item == item:
    print '%s\t%s\t%s\t%s' % (current_item, current_count, current_count / total, current_basketsize)
```

```
Writing reducer_3_3.py
```

In [47]:
```
!chmod a+x *_3_3.py
```

In [48]:
```
# Shopping cart analysis, with counters for number of mappers, combiners, and reducers
!hdfs dfs -rm -r /user/konniam/week_03/hw_3_3
# Use 4 mapper and 1 reducer
!hadoop jar $HADOOP_HOME/share/hadoop/tools/lib/hadoop-streaming-*.jar \
-D mapreduce.job.maps=4 \
-D mapreduce.job.reduces=1 \
-mapper $PWD/mapper_3_3.py \
-reducer $PWD/reducer_3_3.py \
-combiner $PWD/combiner_3_3.py \
-input /user/konniam/week_03/ProductPurchaseData.txt \
-output /user/konniam/week_03/hw_3_3
```

```
16/01/31 17:30:35 WARN util.NativeCodeLoader: Unable to load native-hadoop library for your platform... using buil
tin-java classes where applicable
16/01/31 17:30:38 INFO fs.TrashPolicyDefault: Namenode trash configuration: Deletion interval = 0 minutes, Emptier
 interval = 0 minutes.
Deleted /user/konniam/week_03/hw_3_3
16/01/31 17:30:41 WARN util.NativeCodeLoader: Unable to load native-hadoop library for your platform... using buil
tin-java classes where applicable
packageJobJar: [/var/folders/l8/h51_59852qscq403fs6q0xlh0000gn/T/hadoop-unjar5571571146201173397/] [] /var/folders
/l8/h51_59852qscq403fs6q0xlh0000gn/T/streamjob6445029810789433212.jar tmpDir=null
16/01/31 17:30:42 INFO client.RMProxy: Connecting to ResourceManager at /0.0.0.0:8032
16/01/31 17:30:43 INFO client.RMProxy: Connecting to ResourceManager at /0.0.0.0:8032
16/01/31 17:30:44 INFO mapred.FileInputFormat: Total input paths to process : 1
16/01/31 17:30:45 INFO mapreduce.JobSubmitter: number of splits:4
16/01/31 17:30:45 INFO mapreduce.JobSubmitter: Submitting tokens for job: job_1454277284610_0013
16/01/31 17:30:45 INFO impl.YarnClientImpl: Submitted application application_1454277284610_0013
16/01/31 17:30:45 INFO mapreduce.Job: The url to track the job: http://Konniams-MacBook-Air.local:8088/proxy/appli
cation_1454277284610_0013/
16/01/31 17:30:45 INFO mapreduce.Job: Running job: job_1454277284610_0013
16/01/31 17:30:56 INFO mapreduce.Job: Job job_1454277284610_0013 running in uber mode : false
16/01/31 17:30:56 INFO mapreduce.Job:  map 0% reduce 0%
16/01/31 17:31:16 INFO mapreduce.Job:  map 67% reduce 0%
```

```
16/01/31 17:31:18 INFO mapreduce.Job:  map 100% reduce 0%
16/01/31 17:31:26 INFO mapreduce.Job:  map 100% reduce 100%
16/01/31 17:31:27 INFO mapreduce.Job: Job job_1454277284610_0013 completed successfully
16/01/31 17:31:27 INFO mapreduce.Job: Counters: 52
        File System Counters
                FILE: Number of bytes read=399805
                FILE: Number of bytes written=1389203
                FILE: Number of read operations=0
                FILE: Number of large read operations=0
                FILE: Number of write operations=0
                HDFS: Number of bytes read=3469551
                HDFS: Number of bytes written=404717
                HDFS: Number of read operations=15
                HDFS: Number of large read operations=0
                HDFS: Number of write operations=2
        Job Counters
                Launched map tasks=4
                Launched reduce tasks=1
                Data-local map tasks=4
                Total time spent by all maps in occupied slots (ms)=81420
                Total time spent by all reduces in occupied slots (ms)=5922
                Total time spent by all map tasks (ms)=81420
                Total time spent by all reduce tasks (ms)=5922
                Total vcore-seconds taken by all map tasks=81420
                Total vcore-seconds taken by all reduce tasks=5922
                Total megabyte-seconds taken by all map tasks=83374080
                Total megabyte-seconds taken by all reduce tasks=6064128
        Map-Reduce Framework
                Map input records=31101
                Map output records=761648
                Map output bytes=7845208
                Map output materialized bytes=399823
                Input split bytes=472
                Combine input records=761648
                Combine output records=24800
                Reduce input groups=12593
                Reduce shuffle bytes=399823
                Reduce input records=24800
                Reduce output records=12592
                Spilled Records=49600
                Shuffled Maps =4
                Failed Shuffles=0
                Merged Map outputs=4
                GC time elapsed (ms)=769
                CPU time spent (ms)=0
                Physical memory (bytes) snapshot=0
                Virtual memory (bytes) snapshot=0
                Total committed heap usage (bytes)=812122112
        MR-Counter
                Num_combiner_calls=4
                Num_mapper_calls=4
                Num_reducer_calls=1
        Shuffle Errors
                BAD_ID=0
                CONNECTION=0
                IO_ERROR=0
                WRONG_LENGTH=0
                WRONG_MAP=0
                WRONG_REDUCE=0
        File Input Format Counters
                Bytes Read=3469079
        File Output Format Counters
                Bytes Written=404717
16/01/31 17:31:27 INFO streaming.StreamJob: Output directory: /user/konniam/week_03/hw_3_3
```

Top 50 Purchased Items MR:

In [4]:
```
%%writefile reducer_top50.py
#!/usr/bin/env python
# Reducer for 3.3
# Author: Konniam Chan
# Apriori Algorithm
import sys
N = 50
counter = 0
for line in sys.stdin:
    # Ouput N items only
    if counter >= N:
        continue
    print line.strip()
    counter += 1
```

```
Overwriting reducer_top50.py
```

In [3]:
```
!chmod a+x reducer_top50.py
```

In [5]:
```
# Sort results by count from 1st MR stage
!hdfs dfs -rm -r /user/konniam/week_03/hw_3_3_sorted_count
# Use 4 mapper and 1 reducer
!hadoop jar $HADOOP_HOME/share/hadoop/tools/lib/hadoop-streaming-*.jar \
-D mapreduce.job.maps=4 \
-D mapreduce.job.reduces=1 \
-D mapreduce.job.output.key.comparator.class=org.apache.hadoop.mapreduce.lib.partition.KeyFieldBasedComparator \
-D stream.num.map.output.key.fields=2 \
-D mapreduce.partition.keycomparator.options='-k2,2nr -k1,1' \
-mapper /bin/cat \
-reducer $PWD/reducer_top50.py \
-input /user/konniam/week_03/hw_3_3/part* \
-output /user/konniam/week_03/hw_3_3_sorted_count
```

```
16/02/03 11:23:52 WARN util.NativeCodeLoader: Unable to load native-hadoop library for your platform... using buil
tin-java classes where applicable
16/02/03 11:23:53 INFO fs.TrashPolicyDefault: Namenode trash configuration: Deletion interval = 0 minutes, Emptier
 interval = 0 minutes.
Deleted /user/konniam/week_03/hw_3_3_sorted_count
16/02/03 11:23:54 WARN util.NativeCodeLoader: Unable to load native-hadoop library for your platform... using buil
tin-java classes where applicable
packageJarJar: [/var/folders/l8/h51_59852qscq403fs6q0xlh0000gn/T/hadoop-unjar2509895711049292365/] [] /var/folders
/l8/h51_59852qscq403fs6q0xlh0000gn/T/streamjob8194126334403388460.jar tmpDir=null
16/02/03 11:23:56 INFO client.RMProxy: Connecting to ResourceManager at /0.0.0.0:8032
16/02/03 11:23:57 INFO client.RMProxy: Connecting to ResourceManager at /0.0.0.0:8032
16/02/03 11:23:58 INFO mapred.FileInputFormat: Total input paths to process : 1
16/02/03 11:23:58 INFO mapreduce.JobSubmitter: number of splits:4
16/02/03 11:23:59 INFO mapreduce.JobSubmitter: Submitting tokens for job: job_1454487534358_0022
16/02/03 11:23:59 INFO impl.YarnClientImpl: Submitted application application_1454487534358_0022
16/02/03 11:23:59 INFO mapreduce.Job: The url to track the job: http://Konniams-MacBook-Air.local:8088/proxy/appli
cation_1454487534358_0022/
16/02/03 11:23:59 INFO mapreduce.Job: Running job: job_1454487534358_0022
16/02/03 11:24:08 INFO mapreduce.Job: Job job_1454487534358_0022 running in uber mode : false
16/02/03 11:24:08 INFO mapreduce.Job:  map 0% reduce 0%
16/02/03 11:24:29 INFO mapreduce.Job:  map 50% reduce 0%
16/02/03 11:24:30 INFO mapreduce.Job:  map 100% reduce 0%
16/02/03 11:24:38 INFO mapreduce.Job:  map 100% reduce 100%
16/02/03 11:24:39 INFO mapreduce.Job: Job job_1454487534358_0022 completed successfully
16/02/03 11:24:40 INFO mapreduce.Job: Counters: 49
        File System Counters
                FILE: Number of bytes read=429907
                FILE: Number of bytes written=1449877
                FILE: Number of read operations=0
                FILE: Number of large read operations=0
                FILE: Number of write operations=0
                HDFS: Number of bytes read=408395
                HDFS: Number of bytes written=1689
                HDFS: Number of read operations=15
                HDFS: Number of large read operations=0
                HDFS: Number of write operations=2
        Job Counters
                Launched map tasks=4
                Launched reduce tasks=1
                Data-local map tasks=4
                Total time spent by all maps in occupied slots (ms)=74628
                Total time spent by all reduces in occupied slots (ms)=6591
                Total time spent by all map tasks (ms)=74628
                Total time spent by all reduce tasks (ms)=6591
                Total vcore-seconds taken by all map tasks=74628
                Total vcore-seconds taken by all reduce tasks=6591
```

```
                Total megabyte-seconds taken by all map tasks=76419072
                Total megabyte-seconds taken by all reduce tasks=6749184
        Map-Reduce Framework
                Map input records=12592
                Map output records=12592
                Map output bytes=404717
                Map output materialized bytes=429925
                Input split bytes=448
                Combine input records=0
                Combine output records=0
                Reduce input groups=12592
                Reduce shuffle bytes=429925
                Reduce input records=12592
                Reduce output records=50
                Spilled Records=25184
                Shuffled Maps =4
                Failed Shuffles=0
                Merged Map outputs=4
                GC time elapsed (ms)=884
                CPU time spent (ms)=0
                Physical memory (bytes) snapshot=0
                Virtual memory (bytes) snapshot=0
                Total committed heap usage (bytes)=798490624
        Shuffle Errors
                BAD_ID=0
                CONNECTION=0
                IO_ERROR=0
                WRONG_LENGTH=0
                WRONG_MAP=0
                WRONG_REDUCE=0
        File Input Format Counters
                Bytes Read=407947
        File Output Format Counters
                Bytes Written=1689
16/02/03 11:24:40 INFO streaming.StreamJob: Output directory: /user/konniam/week_03/hw_3_3_sorted_count
```

Top 50 Purchased Items Results:

Result format:
(Item, Count, Relative Frequency, Largest Basket in Which Item was Included)

In [6]:
```
!hdfs dfs -cat /user/konniam/week_03/hw_3_3_sorted_count/part-*
```

```
16/02/03 11:25:44 WARN util.NativeCodeLoader: Unable to load native-hadoop library for your platform... using buil
tin-java classes where applicable
DAI62779        6667    0.0175067747831 36
FRO40251        3881    0.010191059387  37
ELE17451        3875    0.0101753040775 37
GRO73461        3602    0.00945843749344        37
SNA80324        3044    0.00799319370628        36
ELE32164        2851    0.0074863979161 36
DAI75645        2736    0.00718442114993        37
SNA45677        2455    0.0064465474865 36
FRO31317        2330    0.0061183118711 37
DAI85309        2293    0.00602115412894        36
ELE26917        2292    0.00601852824402        33
FRO80039        2233    0.00586360103355        34
GRO21487        2115    0.00555374661261        37
SNA99873        2083    0.00546971829507        35
GRO59710        2004    0.00526227338613        37
GRO71621        1920    0.00504169905258        36
FRO85978        1918    0.00503644728273        37
GRO30386        1840    0.00483162825872        36
ELE74009        1816    0.00476860702057        35
GRO56726        1784    0.00468457870302        36
DAI63921        1773    0.00465569396887        35
GRO46854        1756    0.00461105392517        37
ELE66600        1713    0.00449814087347        37
DAI83733        1712    0.00449551498855        36
FRO32293        1702    0.00446925613932        36
ELE66810        1697    0.0044561267147 36
SNA55762        1646    0.00432220658362        37
DAI22177        1627    0.00427231477008        36
FRO78087        1531    0.00402022981745        37
ELE99737        1516    0.0039808415436 33
ELE34057        1489    0.00390994265067        35
GRO94758        1489    0.00390994265067        36
FRO35904        1436    0.00377077074974        36
FRO53271        1420    0.00372875659097        36
SNA93860        1407    0.00369462008697        36
SNA90094        1390    0.00364998004327        36
GRO38814        1352    0.00355019641619        37
ELE56788        1345    0.00353181522173        36
GRO61133        1321    0.00346879398357        37
DAI88807        1316    0.00345566455896        35
ELE74482        1316    0.00345566455896        35
ELE59935        1311    0.00344253513434        36
SNA96271        1295    0.00340052097557        36
DAI43223        1290    0.00338739155095        37
ELE91337        1289    0.00338476566603        33
GRO15017        1275    0.0033480032771 37
DAI31081        1261    0.00331124088818        35
GRO81087        1220    0.00320357960633        36
DAI22896        1219    0.0032009537214 36
GRO85051        1214    0.00318782429679        34
```

Largest Basket MR

In [7]:
```
%%writefile reducer_top1.py
#!/usr/bin/env python
# Reducer for 3.3
# Author: Konniam Chan
# Apriori Algorithm
import sys
N = 1
counter = 0
for line in sys.stdin:
    # Ouput N items only
    if counter >= N:
        continue
    print line.strip()
    counter += 1
```

```
Writing reducer_top1.py
```

In [8]:
```
!chmod a+x reducer_top1.py
```

In [9]:
```
# Sort results by basketsize from 1st MR stage
```

```
!hdfs dfs -rm -r /user/konniam/week_03/hw_3_3_sorted_basket
# Use 4 mapper and 1 reducer
!hadoop jar $HADOOP_HOME/share/hadoop/tools/lib/hadoop-streaming-*.jar \
-D mapreduce.job.maps=4 \
-D mapreduce.job.reduces=1 \
-D mapreduce.job.output.key.comparator.class=org.apache.hadoop.mapreduce.lib.partition.KeyFieldBasedComparator \
-D stream.num.map.output.key.fields=4 \
-D mapreduce.partition.keycomparator.options='-k4,4nr -k1,1' \
-mapper /bin/cat \
-reducer $PWD/reducer_top1.py \
-input /user/konniam/week_03/hw_3_3/part* \
-output /user/konniam/week_03/hw_3_3_sorted_basket
```

```
16/02/03 11:27:45 WARN util.NativeCodeLoader: Unable to load native-hadoop library for your platform... using buil
tin-java classes where applicable
16/02/03 11:27:46 INFO fs.TrashPolicyDefault: Namenode trash configuration: Deletion interval = 0 minutes, Emptier
 interval = 0 minutes.
Deleted /user/konniam/week_03/hw_3_3_sorted_basket
16/02/03 11:27:48 WARN util.NativeCodeLoader: Unable to load native-hadoop library for your platform... using buil
tin-java classes where applicable
packageJobJar: [/var/folders/l8/h51_59852qscq403fs6q0xlh0000gn/T/hadoop-unjar6127660119398537226/] [] /var/folders
/l8/h51_59852qscq403fs6q0xlh0000gn/T/streamjob2025001027078091936.jar tmpDir=null
16/02/03 11:27:49 INFO client.RMProxy: Connecting to ResourceManager at /0.0.0.0:8032
16/02/03 11:27:50 INFO client.RMProxy: Connecting to ResourceManager at /0.0.0.0:8032
16/02/03 11:27:51 INFO mapred.FileInputFormat: Total input paths to process : 1
16/02/03 11:27:51 INFO mapreduce.JobSubmitter: number of splits:4
16/02/03 11:27:51 INFO mapreduce.JobSubmitter: Submitting tokens for job: job_1454487534358_0023
16/02/03 11:27:52 INFO impl.YarnClientImpl: Submitted application application_1454487534358_0023
16/02/03 11:27:52 INFO mapreduce.Job: The url to track the job: http://Konniams-MacBook-Air.local:8088/proxy/appli
cation_1454487534358_0023/
16/02/03 11:27:52 INFO mapreduce.Job: Running job: job_1454487534358_0023
16/02/03 11:28:00 INFO mapreduce.Job: Job job_1454487534358_0023 running in uber mode : false
16/02/03 11:28:00 INFO mapreduce.Job:  map 0% reduce 0%
16/02/03 11:28:19 INFO mapreduce.Job:  map 100% reduce 0%
16/02/03 11:28:28 INFO mapreduce.Job:  map 100% reduce 100%
16/02/03 11:28:29 INFO mapreduce.Job: Job job_1454487534358_0023 completed successfully
16/02/03 11:28:29 INFO mapreduce.Job: Counters: 49
        File System Counters
                FILE: Number of bytes read=442499
                FILE: Number of bytes written=1475061
                FILE: Number of read operations=0
                FILE: Number of large read operations=0
                FILE: Number of write operations=0
                HDFS: Number of bytes read=408395
                HDFS: Number of bytes written=34
                HDFS: Number of read operations=15
                HDFS: Number of large read operations=0
                HDFS: Number of write operations=2
        Job Counters
                Launched map tasks=4
                Launched reduce tasks=1
                Data-local map tasks=4
                Total time spent by all maps in occupied slots (ms)=70134
                Total time spent by all reduces in occupied slots (ms)=5322
                Total time spent by all map tasks (ms)=70134
                Total time spent by all reduce tasks (ms)=5322
                Total vcore-seconds taken by all map tasks=70134
                Total vcore-seconds taken by all reduce tasks=5322
                Total megabyte-seconds taken by all map tasks=71817216
                Total megabyte-seconds taken by all reduce tasks=5449728
        Map-Reduce Framework
                Map input records=12592
                Map output records=12592
                Map output bytes=417309
                Map output materialized bytes=442517
                Input split bytes=448
                Combine input records=0
                Combine output records=0
                Reduce input groups=12592
                Reduce shuffle bytes=442517
                Reduce input records=12592
                Reduce output records=1
                Spilled Records=25184
                Shuffled Maps =4
                Failed Shuffles=0
                Merged Map outputs=4
                GC time elapsed (ms)=860
                CPU time spent (ms)=0
                Physical memory (bytes) snapshot=0
                Virtual memory (bytes) snapshot=0
                Total committed heap usage (bytes)=836763648
```

```
        Shuffle Errors
                BAD_ID=0
                CONNECTION=0
                IO_ERROR=0
                WRONG_LENGTH=0
                WRONG_MAP=0
                WRONG_REDUCE=0
        File Input Format Counters
                Bytes Read=407947
        File Output Format Counters
                Bytes Written=34
16/02/03 11:28:29 INFO streaming.StreamJob: Output directory: /user/konniam/week_03/hw_3_3_sorted_basket
```

Largest Basket: 37
Note: the largest basket of 37 occurred for many items, and not specific to the one item shown (it is simply the one that came out in alphabetical order)

In [10]:
```
!hdfs dfs -cat /user/konniam/week_03/hw_3_3_sorted_basket/part-*
```

```
16/02/03 11:28:42 WARN util.NativeCodeLoader: Unable to load native-hadoop library for your platform... using buil
tin-java classes where applicable
DAI35347        1060    0.00278343801861        37
```

Number of Unique Items: 12592

In [99]:
```
!hdfs dfs -cat /user/konniam/week_03/hw_3_3/part-* | wc -l
```

```
16/01/30 16:51:00 WARN util.NativeCodeLoader: Unable to load native-hadoop library for your platform... using buil
tin-java classes where applicable
   12592
```

3.3.1 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.

3.3.1 Strategy

The key is to direct total counts from the first mapper to the 2 reducers using two * keys ('*0' and '*1') for order inversion. The rest is same as above.

3.31 Mapper

In [1]:
```
%%writefile mapper_3_3_1.py
#!/usr/bin/env python
# Mapper for 3.3.1
# Author: Konniam Chan
# Shopping cart analysis
# Output goes to 1 reducer
import sys

# Count how many mappers called
sys.stderr.write("reporter:counter:MR-Counter,Num_mapper_calls,1\n")

for line in sys.stdin:
    record = line.strip().split()
    basketsize = len(record)
    # Assume 2 reducers in the next step
    # Emit count and basketsize, (*) stands for the total
    for item in record:
        print '%s\t%s\t%s' % ('*0', 1, basketsize)
        print '%s\t%s\t%s' % ('*1', 1, basketsize)
        print '%s\t%s\t%s' % (item, 1, basketsize)
```

```
Writing mapper_3_3_1.py
```

3.3.1 Combiner

Can use the combiner from 3.3

3.3.1 Reducer

In [2]:
```
%%writefile reducer_3_3_1.py
#!/usr/bin/env python
# Reducer for 3.3.1
# Author: Konniam Chan
# Shopping cart analysis
# Assume 2 reducers
from __future__ import division
import sys
current_item = None
current_count = 0
current_basketsize = 0
item = None

# Count how many reducers called
sys.stderr.write("reporter:counter:MR-Counter,Num_reducer_calls,1\n")

for line in sys.stdin:
    # Obtain item and intermediate counts
    line = line.strip()
    item, count, basketsize = line.split('\t')
    count = int(count)
    basketsize = int(basketsize)
    # Rely on sorting to increment item counts
    if current_item == item:
        current_count += count
        current_basketsize = max(current_basketsize, basketsize)
    else:
        # Obtain total count and save to memory
        if current_item in ['*0', '*1']:
            total = current_count
        # Compute counts and relative frequencies for regular items
        elif current_item:
            # Output (item, count, relative frequency)
            print '%s\t%s\t%s\t%s' % (current_item, current_count, current_count / total, current_basketsize)
        current_count = count
        current_item = item
        current_basketsize = basketsize

# Output last item
if current_item == item:
    print '%s\t%s\t%s\t%s' % (current_item, current_count, current_count / total, current_basketsize)
```

```
Writing reducer_3_3_1.py
```

In [3]:
```
!chmod a+x *_3_3_1.py
```

3.3.1 1st Stage MR

In [4]:
```
# Shopping cart analysis, with counters for number of mappers, combiners, and reducers
!hdfs dfs -rm -r /user/konniam/week_03/hw_3_3_1
# Use 2 mappers and 2 reducers
!hadoop jar $HADOOP_HOME/share/hadoop/tools/lib/hadoop-streaming-*.jar \
-D mapreduce.job.maps=2 \
-D mapreduce.job.reduces=2 \
-mapper $PWD/mapper_3_3_1.py \
-reducer $PWD/reducer_3_3_1.py \
-combiner $PWD/combiner_3_3.py \
-input /user/konniam/week_03/ProductPurchaseData.txt \
-output /user/konniam/week_03/hw_3_3_1
```

```
16/02/01 11:07:29 WARN util.NativeCodeLoader: Unable to load native-hadoop library for your platform... using buil
tin-java classes where applicable
rm: `/user/konniam/week_03/hw_3_3_1': No such file or directory
16/02/01 11:07:32 WARN util.NativeCodeLoader: Unable to load native-hadoop library for your platform... using buil
tin-java classes where applicable
packageJobJar: [/var/folders/l8/h51_59852qscq403fs6q0xlh0000gn/T/hadoop-unjar2188033139595451417/] [] /var/folders
/l8/h51_59852qscq403fs6q0xlh0000gn/T/streamjob1897984548306338732.jar tmpDir=null
16/02/01 11:07:33 INFO client.RMProxy: Connecting to ResourceManager at /0.0.0.0:8032
16/02/01 11:07:33 INFO client.RMProxy: Connecting to ResourceManager at /0.0.0.0:8032
16/02/01 11:07:35 INFO mapred.FileInputFormat: Total input paths to process : 1
16/02/01 11:07:35 INFO mapreduce.JobSubmitter: number of splits:2
16/02/01 11:07:35 INFO mapreduce.JobSubmitter: Submitting tokens for job: job_1454277284610_0021
16/02/01 11:07:35 INFO impl.YarnClientImpl: Submitted application application_1454277284610_0021
16/02/01 11:07:36 INFO mapreduce.Job: The url to track the job: http://Konniams-MacBook-Air.local:8088/proxy/appli
cation_1454277284610_0021/
16/02/01 11:07:36 INFO mapreduce.Job: Running job: job_1454277284610_0021
```

```
16/02/01 11:07:45 INFO mapreduce.Job: Job job_1454277284610_0021 running in uber mode : false
16/02/01 11:07:45 INFO mapreduce.Job:  map 0% reduce 0%
16/02/01 11:07:59 INFO mapreduce.Job:  map 67% reduce 0%
16/02/01 11:08:01 INFO mapreduce.Job:  map 100% reduce 0%
16/02/01 11:08:10 INFO mapreduce.Job:  map 100% reduce 50%
16/02/01 11:08:11 INFO mapreduce.Job:  map 100% reduce 100%
16/02/01 11:08:11 INFO mapreduce.Job: Job job_1454277284610_0021 completed successfully
16/02/01 11:08:12 INFO mapreduce.Job: Counters: 52
        File System Counters
                FILE: Number of bytes read=286952
                FILE: Number of bytes written=1045582
                FILE: Number of read operations=0
                FILE: Number of large read operations=0
                FILE: Number of write operations=0
                HDFS: Number of bytes read=3462103
                HDFS: Number of bytes written=404717
                HDFS: Number of read operations=12
                HDFS: Number of large read operations=0
                HDFS: Number of write operations=4
        Job Counters
                Launched map tasks=2
                Launched reduce tasks=2
                Data-local map tasks=2
                Total time spent by all maps in occupied slots (ms)=28778
                Total time spent by all reduces in occupied slots (ms)=12942
                Total time spent by all map tasks (ms)=28778
                Total time spent by all reduce tasks (ms)=12942
                Total vcore-seconds taken by all map tasks=28778
                Total vcore-seconds taken by all reduce tasks=12942
                Total megabyte-seconds taken by all map tasks=29468672
                Total megabyte-seconds taken by all reduce tasks=13252608
        Map-Reduce Framework
                Map input records=31101
                Map output records=1142472
                Map output bytes=11196576
                Map output materialized bytes=286964
                Input split bytes=236
                Combine input records=1142472
                Combine output records=17749
                Reduce input groups=12594
                Reduce shuffle bytes=286964
                Reduce input records=17749
                Reduce output records=12592
                Spilled Records=35498
                Shuffled Maps =4
                Failed Shuffles=0
                Merged Map outputs=4
                GC time elapsed (ms)=458
                CPU time spent (ms)=0
                Physical memory (bytes) snapshot=0
                Virtual memory (bytes) snapshot=0
                Total committed heap usage (bytes)=595591168
        MR-Counter
                Num_combiner_calls=4
                Num_mapper_calls=2
                Num_reducer_calls=2
        Shuffle Errors
                BAD_ID=0
                CONNECTION=0
                IO_ERROR=0
                WRONG_LENGTH=0
                WRONG_MAP=0
                WRONG_REDUCE=0
        File Input Format Counters
                Bytes Read=3461867
        File Output Format Counters
                Bytes Written=404717
16/02/01 11:08:12 INFO streaming.StreamJob: Output directory: /user/konniam/week_03/hw_3_3_1
```

3.3.1 Top 50 Purchased Items MR:

In [1]:
```
# Sort results by count from 1st MR stage
!hdfs dfs -rm -r /user/konniam/week_03/hw_3_3_1_sorted_count
# Use 2 mappers and 1 reducer
!hadoop jar $HADOOP_HOME/share/hadoop/tools/lib/hadoop-streaming-*.jar \
-D mapreduce.job.maps=2 \
-D mapreduce.job.reduces=1 \
-D mapreduce.job.output.key.comparator.class=org.apache.hadoop.mapreduce.lib.partition.KeyFieldBasedComparator \
```

```
-D stream.num.map.output.key.fields=2 \
-D mapreduce.partition.keycomparator.options='-k2,2nr -k1,1' \
-mapper /bin/cat \
-reducer $PWD/reducer_top50.py \
-input /user/konniam/week_03/hw_3_3_1/part* \
-output /user/konniam/week_03/hw_3_3_1_sorted_count
```

```
16/02/03 11:42:55 WARN util.NativeCodeLoader: Unable to load native-hadoop library for your platform... using buil
tin-java classes where applicable
16/02/03 11:42:56 INFO fs.TrashPolicyDefault: Namenode trash configuration: Deletion interval = 0 minutes, Emptier
 interval = 0 minutes.
Deleted /user/konniam/week_03/hw_3_3_1_sorted_count
16/02/03 11:42:58 WARN util.NativeCodeLoader: Unable to load native-hadoop library for your platform... using buil
tin-java classes where applicable
packageJobJar: [/var/folders/l8/h51_59852qscq403fs6q0xlh0000gn/T/hadoop-unjar4222233125874937807/] [] /var/folders
/l8/h51_59852qscq403fs6q0xlh0000gn/T/streamjob4453936316448288606.jar tmpDir=null
16/02/03 11:43:00 INFO client.RMProxy: Connecting to ResourceManager at /0.0.0.0:8032
16/02/03 11:43:00 INFO client.RMProxy: Connecting to ResourceManager at /0.0.0.0:8032
16/02/03 11:43:01 INFO mapred.FileInputFormat: Total input paths to process : 2
16/02/03 11:43:01 INFO mapreduce.JobSubmitter: number of splits:2
16/02/03 11:43:02 INFO mapreduce.JobSubmitter: Submitting tokens for job: job_1454487534358_0024
16/02/03 11:43:02 INFO impl.YarnClientImpl: Submitted application application_1454487534358_0024
16/02/03 11:43:02 INFO mapreduce.Job: The url to track the job: http://Konniams-MacBook-Air.local:8088/proxy/appli
cation_1454487534358_0024/
16/02/03 11:43:02 INFO mapreduce.Job: Running job: job_1454487534358_0024
16/02/03 11:43:13 INFO mapreduce.Job: Job job_1454487534358_0024 running in uber mode : false
16/02/03 11:43:13 INFO mapreduce.Job:  map 0% reduce 0%
16/02/03 11:43:26 INFO mapreduce.Job:  map 100% reduce 0%
16/02/03 11:43:34 INFO mapreduce.Job:  map 100% reduce 100%
16/02/03 11:43:35 INFO mapreduce.Job: Job job_1454487534358_0024 completed successfully
16/02/03 11:43:35 INFO mapreduce.Job: Counters: 49
        File System Counters
                FILE: Number of bytes read=429907
                FILE: Number of bytes written=1213837
                FILE: Number of read operations=0
                FILE: Number of large read operations=0
                FILE: Number of write operations=0
                HDFS: Number of bytes read=404945
                HDFS: Number of bytes written=1689
                HDFS: Number of read operations=9
                HDFS: Number of large read operations=0
                HDFS: Number of write operations=2
        Job Counters
                Launched map tasks=2
                Launched reduce tasks=1
                Data-local map tasks=2
                Total time spent by all maps in occupied slots (ms)=20841
                Total time spent by all reduces in occupied slots (ms)=4986
                Total time spent by all map tasks (ms)=20841
                Total time spent by all reduce tasks (ms)=4986
                Total vcore-seconds taken by all map tasks=20841
                Total vcore-seconds taken by all reduce tasks=4986
                Total megabyte-seconds taken by all map tasks=21341184
                Total megabyte-seconds taken by all reduce tasks=5105664
        Map-Reduce Framework
                Map input records=12592
                Map output records=12592
                Map output bytes=404717
                Map output materialized bytes=429913
                Input split bytes=228
                Combine input records=0
                Combine output records=0
                Reduce input groups=12592
                Reduce shuffle bytes=429913
                Reduce input records=12592
                Reduce output records=50
                Spilled Records=25184
                Shuffled Maps =2
                Failed Shuffles=0
                Merged Map outputs=2
                GC time elapsed (ms)=462
                CPU time spent (ms)=0
                Physical memory (bytes) snapshot=0
                Virtual memory (bytes) snapshot=0
                Total committed heap usage (bytes)=497025024
        Shuffle Errors
                BAD_ID=0
                CONNECTION=0
                IO_ERROR=0
                WRONG_LENGTH=0
                WRONG_MAP=0
```

```
                WRONG_REDUCE=0
        File Input Format Counters
                Bytes Read=404717
        File Output Format Counters
                Bytes Written=1689
16/02/03 11:43:35 INFO streaming.StreamJob: Output directory: /user/konniam/week_03/hw_3_3_1_sorted_count
```

3.3.1 Top 50 Purchased Items Results:

Result format:
(Item, Count, Relative Frequency, Largest Basket in Which Item was Included)

In [2]:
```
!hdfs dfs -cat /user/konniam/week_03/hw_3_3_1_sorted_count/part-*
```

```
16/02/03 11:43:41 WARN util.NativeCodeLoader: Unable to load native-hadoop library for your platform... using buil
tin-java classes where applicable
DAI62779        6667    0.0175067747831 36
FRO40251        3881    0.010191059387  37
ELE17451        3875    0.0101753040775 37
GRO73461        3602    0.00945843749344        37
SNA80324        3044    0.00799319370628        36
ELE32164        2851    0.0074863979161 36
DAI75645        2736    0.00718442114993        37
SNA45677        2455    0.0064465474865 36
FRO31317        2330    0.0061183118711 37
DAI85309        2293    0.00602115412894        36
ELE26917        2292    0.00601852824402        33
FRO80039        2233    0.00586360103355        34
GRO21487        2115    0.00555374661261        37
SNA99873        2083    0.00546971829507        35
GRO59710        2004    0.00526227338613        37
GRO71621        1920    0.00504169905258        36
FRO85978        1918    0.00503644728273        37
GRO30386        1840    0.00483162825872        36
ELE74009        1816    0.00476860702057        35
GRO56726        1784    0.00468457870302        36
DAI63921        1773    0.00465569396887        35
GRO46854        1756    0.00461105392517        37
ELE66600        1713    0.00449814087347        37
DAI83733        1712    0.00449551498855        36
FRO32293        1702    0.00446925613932        36
ELE66810        1697    0.0044561267147 36
SNA55762        1646    0.00432220658362        37
DAI22177        1627    0.00427231477008        36
FRO78087        1531    0.00402022981745        37
ELE99737        1516    0.0039808415436 33
ELE34057        1489    0.00390994265067        35
GRO94758        1489    0.00390994265067        36
FRO35904        1436    0.00377077074974        36
FRO53271        1420    0.00372875659097        36
SNA93860        1407    0.00369462008697        36
SNA90094        1390    0.00364998004327        36
GRO38814        1352    0.00355019641619        37
ELE56788        1345    0.00353181522173        36
GRO61133        1321    0.00346879398357        37
DAI88807        1316    0.00345566455896        35
ELE74482        1316    0.00345566455896        35
ELE59935        1311    0.00344253513434        36
SNA96271        1295    0.00340052097557        36
DAI43223        1290    0.00338739155095        37
ELE91337        1289    0.00338476566603        33
GRO15017        1275    0.0033480032771 37
DAI31081        1261    0.00331124088818        35
GRO81087        1220    0.00320357960633        36
DAI22896        1219    0.0032009537214 36
GRO85051        1214    0.00318782429679        34
```

3.3.1 Largest Basket MR

In [3]:
```
# Sort results by basketsize from 1st MR stage
!hdfs dfs -rm -r /user/konniam/week_03/hw_3_3_1_sorted_basket
# Use 2 mappers and 1 reducer
!hadoop jar $HADOOP_HOME/share/hadoop/tools/lib/hadoop-streaming-*.jar \
-D mapreduce.job.maps=2 \
-D mapreduce.job.reduces=1 \
-D mapreduce.job.output.key.comparator.class=org.apache.hadoop.mapreduce.lib.partition.KeyFieldBasedComparator \
```

```
-D stream.num.map.output.key.fields=4 \
-D mapreduce.partition.keycomparator.options='-k4,4nr -k1,1' \
-mapper /bin/cat \
-reducer $PWD/reducer_top1.py \
-input /user/konniam/week_03/hw_3_3_1/part* \
-output /user/konniam/week_03/hw_3_3_1_sorted_basket
```

```
16/02/03 11:43:56 WARN util.NativeCodeLoader: Unable to load native-hadoop library for your platform... using buil
tin-java classes where applicable
16/02/03 11:43:57 INFO fs.TrashPolicyDefault: Namenode trash configuration: Deletion interval = 0 minutes, Emptier
 interval = 0 minutes.
Deleted /user/konniam/week_03/hw_3_3_1_sorted_basket
16/02/03 11:43:59 WARN util.NativeCodeLoader: Unable to load native-hadoop library for your platform... using buil
tin-java classes where applicable
packageJobJar: [/var/folders/l8/h51_59852qscq403fs6q0xlh0000gn/T/hadoop-unjar4460119617717925651/] [] /var/folders
/l8/h51_59852qscq403fs6q0xlh0000gn/T/streamjob3572732194774922216.jar tmpDir=null
16/02/03 11:44:00 INFO client.RMProxy: Connecting to ResourceManager at /0.0.0.0:8032
16/02/03 11:44:00 INFO client.RMProxy: Connecting to ResourceManager at /0.0.0.0:8032
16/02/03 11:44:01 INFO mapred.FileInputFormat: Total input paths to process : 2
16/02/03 11:44:01 INFO mapreduce.JobSubmitter: number of splits:2
16/02/03 11:44:02 INFO mapreduce.JobSubmitter: Submitting tokens for job: job_1454487534358_0025
16/02/03 11:44:02 INFO impl.YarnClientImpl: Submitted application application_1454487534358_0025
16/02/03 11:44:02 INFO mapreduce.Job: The url to track the job: http://Konniams-MacBook-Air.local:8088/proxy/appli
cation_1454487534358_0025/
16/02/03 11:44:02 INFO mapreduce.Job: Running job: job_1454487534358_0025
16/02/03 11:44:11 INFO mapreduce.Job: Job job_1454487534358_0025 running in uber mode : false
16/02/03 11:44:11 INFO mapreduce.Job:  map 0% reduce 0%
16/02/03 11:44:23 INFO mapreduce.Job:  map 100% reduce 0%
16/02/03 11:44:30 INFO mapreduce.Job:  map 100% reduce 100%
16/02/03 11:44:31 INFO mapreduce.Job: Job job_1454487534358_0025 completed successfully
16/02/03 11:44:31 INFO mapreduce.Job: Counters: 49
        File System Counters
                FILE: Number of bytes read=442499
                FILE: Number of bytes written=1239021
                FILE: Number of read operations=0
                FILE: Number of large read operations=0
                FILE: Number of write operations=0
                HDFS: Number of bytes read=404945
                HDFS: Number of bytes written=34
                HDFS: Number of read operations=9
                HDFS: Number of large read operations=0
                HDFS: Number of write operations=2
        Job Counters
                Launched map tasks=2
                Launched reduce tasks=1
                Data-local map tasks=2
                Total time spent by all maps in occupied slots (ms)=18463
                Total time spent by all reduces in occupied slots (ms)=4643
                Total time spent by all map tasks (ms)=18463
                Total time spent by all reduce tasks (ms)=4643
                Total vcore-seconds taken by all map tasks=18463
                Total vcore-seconds taken by all reduce tasks=4643
                Total megabyte-seconds taken by all map tasks=18906112
                Total megabyte-seconds taken by all reduce tasks=4754432
        Map-Reduce Framework
                Map input records=12592
                Map output records=12592
                Map output bytes=417309
                Map output materialized bytes=442505
                Input split bytes=228
                Combine input records=0
                Combine output records=0
                Reduce input groups=12592
                Reduce shuffle bytes=442505
                Reduce input records=12592
                Reduce output records=1
                Spilled Records=25184
                Shuffled Maps =2
                Failed Shuffles=0
                Merged Map outputs=2
                GC time elapsed (ms)=380
                CPU time spent (ms)=0
                Physical memory (bytes) snapshot=0
                Virtual memory (bytes) snapshot=0
                Total committed heap usage (bytes)=480247808
        Shuffle Errors
                BAD_ID=0
                CONNECTION=0
                IO_ERROR=0
                WRONG_LENGTH=0
                WRONG_MAP=0
```

```
                WRONG_REDUCE=0
        File Input Format Counters
                Bytes Read=404717
        File Output Format Counters
                Bytes Written=34
16/02/03 11:44:31 INFO streaming.StreamJob: Output directory: /user/konniam/week_03/hw_3_3_1_sorted_basket
```

3.3.1 Largest Basket: 37
Note: the largest basket of 37 occurred for many items, and not specific to the one item shown (it is simply the one that came out in the item name sorting)

In [4]:
```
!hdfs dfs -cat /user/konniam/week_03/hw_3_3_1_sorted_basket/part-* | head -n 1
```

```
16/02/03 11:44:37 WARN util.NativeCodeLoader: Unable to load native-hadoop library for your platform... using buil
tin-java classes where applicable
DAI35347        1060    0.00278343801861        37
```

3.3.1 Number of Unique Items: 12592

In [9]:
```
!hdfs dfs -cat /user/konniam/week_03/hw_3_3_1/part-* | wc -l
```

```
16/02/01 11:15:13 WARN util.NativeCodeLoader: Unable to load native-hadoop library for your platform... using buil
tin-java classes where applicable
   12592
```

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.

Strategy

- 1st stage:
  Mapper: basket -> (Item1, Item2, 1)
  Reducer: (Item1, Item2, 1) -> (Item1, Item2, count, relative frequency)
  (Use 2 mappers and 2 reducers)
- 2nd stage: Sort (Item1, Item2, count, relative frequency) by count

Mapper 3.4

In [60]:
```
%%writefile mapper_3_4.py
#!/usr/bin/env python
# Mapper for 3.4
# Author: Konniam Chan
# Pairs analysis
import sys
from itertools import combinations

for line in sys.stdin:
    # Count how many mappers called
    sys.stderr.write("reporter:counter:MR-Counter,Num_mapper_calls,1\n")
    record = line.strip().split()
    # Assume all items in basket co-occur, get all combinations of items
    # Sort by alphanumerical order first and eliminate potential duplicates
    record = sorted(set(record))
    for combo in combinations(record, 2):
        # Emit each co-occurrence pair
        print '%s.%s\t%s' % (combo[0], combo[1], 1)
    # Assume 1 reducer in the next step
    # Emit total with key (*0 and *1) for order inversion (keep track of total number of baskets)
    # Assume output goes to 2 reducers
    print '%s\t%s' % ('*0' , 1)
    print '%s\t%s' % ('*1' , 1)
```

```
Overwriting mapper_3_4.py
```

Combiner 3.4

In [61]:
```
%%writefile combiner_3_4.py
#!/usr/bin/env python
## Combiner for 3.4
# Author: Konniam Chan
# Pairs analysis
import sys
current_pair = None
current_count = 0

for line in sys.stdin:
    # Count how many combiners called
    sys.stderr.write("reporter:counter:MR-Counter,Num_combiner_calls,1\n")
    # Obtain pair and intermediate counts
    line = line.strip()
    pair, count = line.split('\t')
    count = int(count)
    # Rely on sorting to increment pair counts
    if current_pair == pair:
        current_count += count
    else:
        if current_pair:
            print '%s\t%s' % (current_pair, current_count)
        current_count = count
        current_pair = pair

# Output last pair
if current_pair == pair:
    print '%s\t%s' % (current_pair, current_count)
```

```
Overwriting combiner_3_4.py
```

Reducer 3.4

In [62]:
```
%%writefile reducer_3_4.py
#!/usr/bin/env python
## Reducer for 3.4
# Author: Konniam Chan
# Pairs analysis
from __future__ import division
import sys
current_pair = None
current_count = 0
s = 100

for line in sys.stdin:
    # Count how many reducers called
    sys.stderr.write("reporter:counter:MR-Counter,Num_reducer_calls,1\n")
    # Obtain pair and intermediate counts
    line = line.strip()
    pair, count = line.split('\t')
    count = int(count)
    # Rely on sorting to increment pair counts
    if current_pair == pair:
        current_count += count
    else:
        # Obtain total count and save to memory
        if current_pair in ['*0', '*1']:
            total = current_count
        elif current_pair:
            # Emit only if count is above s (100)
            if current_count >= s:
                item_1, item_2 = current_pair.split('.')
                print '%s\t%s\t%s\t%s' % (item_1, item_2, current_count, current_count / total)
        current_count = count
        current_pair = pair

# Output last pair
if current_pair == pair:
    # Emit only if count is above s (100)
    if current_count >= s:
        item_1, item_2 = current_pair.split('.')
        print '%s\t%s\t%s\t%s' % (item_1, item_2, current_count, current_count / total)
```

```
Overwriting reducer_3_4.py
```

In [63]:
```
!chmod a+x *_3_4.py
```

3.4 MR 1st Stage

In [64]:
```
# Shopping cart analysis with pairs, with counters for number of mappers, combiners, and reducers
!hdfs dfs -rm -r /user/konniam/week_03/hw_3_4
# Use 2 mappers and 2 reducers
!hadoop jar $HADOOP_HOME/share/hadoop/tools/lib/hadoop-streaming-*.jar \
-D mapreduce.job.maps=2 \
-D mapreduce.job.reduces=2 \
-mapper $PWD/mapper_3_4.py \
-combiner $PWD/combiner_3_4.py \
-reducer $PWD/reducer_3_4.py \
-input /user/konniam/week_03/ProductPurchaseData.txt \
-output /user/konniam/week_03/hw_3_4
```

```
16/01/31 18:05:56 WARN util.NativeCodeLoader: Unable to load native-hadoop library for your platform... using buil
tin-java classes where applicable
16/01/31 18:05:57 INFO fs.TrashPolicyDefault: Namenode trash configuration: Deletion interval = 0 minutes, Emptier
 interval = 0 minutes.
Deleted /user/konniam/week_03/hw_3_4
16/01/31 18:05:59 WARN util.NativeCodeLoader: Unable to load native-hadoop library for your platform... using buil
tin-java classes where applicable
packageJobJar: [/var/folders/l8/h51_59852qscq403fs6q0xlh0000gn/T/hadoop-unjar7093338702810948 59/] [] /var/folders/
l8/h51_59852qscq403fs6q0xlh0000gn/T/streamjob7289565244085294957.jar tmpDir=null
16/01/31 18:06:00 INFO client.RMProxy: Connecting to ResourceManager at /0.0.0.0:8032
16/01/31 18:06:01 INFO client.RMProxy: Connecting to ResourceManager at /0.0.0.0:8032
16/01/31 18:06:02 INFO mapred.FileInputFormat: Total input paths to process : 1
16/01/31 18:06:02 INFO mapreduce.JobSubmitter: number of splits:2
16/01/31 18:06:02 INFO mapreduce.JobSubmitter: Submitting tokens for job: job_1454277284610_0016
16/01/31 18:06:02 INFO impl.YarnClientImpl: Submitted application application_1454277284610_0016
16/01/31 18:06:02 INFO mapreduce.Job: The url to track the job: http://Konniams-MacBook-Air.local:8088/proxy/appli
cation_1454277284610_0016/
16/01/31 18:06:02 INFO mapreduce.Job: Running job: job_1454277284610_0016
16/01/31 18:06:11 INFO mapreduce.Job: Job job_1454277284610_0016 running in uber mode : false

16/01/31 18:06:11 INFO mapreduce.Job:  map 0% reduce 0%
```

```
16/01/31 18:06:26 INFO mapreduce.Job:  map 58% reduce 0%
16/01/31 18:06:28 INFO mapreduce.Job:  map 67% reduce 0%
16/01/31 18:06:48 INFO mapreduce.Job:  map 83% reduce 0%
16/01/31 18:06:49 INFO mapreduce.Job:  map 100% reduce 0%
16/01/31 18:07:02 INFO mapreduce.Job:  map 100% reduce 39%
16/01/31 18:07:04 INFO mapreduce.Job:  map 100% reduce 81%
16/01/31 18:07:05 INFO mapreduce.Job:  map 100% reduce 89%
16/01/31 18:07:06 INFO mapreduce.Job:  map 100% reduce 92%
16/01/31 18:07:07 INFO mapreduce.Job:  map 100% reduce 100%
16/01/31 18:07:08 INFO mapreduce.Job: Job job_1454277284610_0016 completed successfully
16/01/31 18:07:08 INFO mapreduce.Job: Counters: 52
        File System Counters
                FILE: Number of bytes read=22624207
                FILE: Number of bytes written=45720068
                FILE: Number of read operations=0
                FILE: Number of large read operations=0
                FILE: Number of write operations=0
                HDFS: Number of bytes read=3462103
                HDFS: Number of bytes written=51765
                HDFS: Number of read operations=12
                HDFS: Number of large read operations=0
                HDFS: Number of write operations=4
        Job Counters
                Launched map tasks=2
                Launched reduce tasks=2
                Data-local map tasks=2
                Total time spent by all maps in occupied slots (ms)=70318
                Total time spent by all reduces in occupied slots (ms)=32606
                Total time spent by all map tasks (ms)=70318
                Total time spent by all reduce tasks (ms)=32606
                Total vcore-seconds taken by all map tasks=70318
                Total vcore-seconds taken by all reduce tasks=32606
                Total megabyte-seconds taken by all map tasks=72005632
                Total megabyte-seconds taken by all reduce tasks=33388544
        Map-Reduce Framework
                Map input records=31101
                Map output records=2596216
                Map output bytes=50991290
                Map output materialized bytes=22624219
                Input split bytes=236
                Combine input records=2596216
                Combine output records=1026711
                Reduce input groups=877097
                Reduce shuffle bytes=22624219
                Reduce input records=1026711
                Reduce output records=1334
                Spilled Records=2053422
                Shuffled Maps =4
                Failed Shuffles=0
                Merged Map outputs=4
                GC time elapsed (ms)=932
                CPU time spent (ms)=0
                Physical memory (bytes) snapshot=0
                Virtual memory (bytes) snapshot=0
                Total committed heap usage (bytes)=599785472
        MR-Counter
                Num_combiner_calls=2596216
                Num_mapper_calls=31101
                Num_reducer_calls=1026711
        Shuffle Errors
                BAD_ID=0
                CONNECTION=0
                IO_ERROR=0
                WRONG_LENGTH=0
                WRONG_MAP=0
                WRONG_REDUCE=0
        File Input Format Counters
                Bytes Read=3461867
        File Output Format Counters
                Bytes Written=51765
16/01/31 18:07:08 INFO streaming.StreamJob: Output directory: /user/konniam/week_03/hw_3_4
```

In [65]:
```
!hdfs dfs -cat /user/konniam/week_03/hw_3_4/part* | wc -l
```

```
16/01/31 18:07:15 WARN util.NativeCodeLoader: Unable to load native-hadoop library for your platform... using buil
tin-java classes where applicable
    1334
```

3.4 MR 2nd Stage (sort by count)

In [5]:
```
# Shopping cart analysis with pairs, with counters for number of mappers, combiners, and reducers
# Sort output of 1st stage MR to get top support counts
!hdfs dfs -rm -r /user/konniam/week_03/hw_3_4_sorted
# Use 2 mappers and 1 reducer
!hadoop jar $HADOOP_HOME/share/hadoop/tools/lib/hadoop-streaming-*.jar \
-D mapreduce.job.maps=2 \
-D mapreduce.job.reduces=1 \
-D mapreduce.job.output.key.comparator.class=org.apache.hadoop.mapreduce.lib.partition.KeyFieldBasedComparator \
-D stream.num.map.output.key.fields=3 \
-D mapreduce.partition.keycomparator.options='-k3,3nr -k1,2' \
-mapper /bin/cat \
-reducer $PWD/reducer_top50.py \
-input /user/konniam/week_03/hw_3_4/part* \
-output /user/konniam/week_03/hw_3_4_sorted
```

```
16/02/03 11:45:23 WARN util.NativeCodeLoader: Unable to load native-hadoop library for your platform... using buil
tin-java classes where applicable
16/02/03 11:45:24 INFO fs.TrashPolicyDefault: Namenode trash configuration: Deletion interval = 0 minutes, Emptier
 interval = 0 minutes.
Deleted /user/konniam/week_03/hw_3_4_sorted
16/02/03 11:45:25 WARN util.NativeCodeLoader: Unable to load native-hadoop library for your platform... using buil
tin-java classes where applicable
packageJobJar: [/var/folders/l8/h51_59852qscq403fs6q0xlh0000gn/T/hadoop-unjar3029703903248871676/] [] /var/folders
/l8/h51_59852qscq403fs6q0xlh0000gn/T/streamjob9846253315494068 97.jar tmpDir=null
16/02/03 11:45:27 INFO client.RMProxy: Connecting to ResourceManager at /0.0.0.0:8032
16/02/03 11:45:27 INFO client.RMProxy: Connecting to ResourceManager at /0.0.0.0:8032
16/02/03 11:45:28 INFO mapred.FileInputFormat: Total input paths to process : 2
16/02/03 11:45:29 INFO mapreduce.JobSubmitter: number of splits:2
16/02/03 11:45:29 INFO mapreduce.JobSubmitter: Submitting tokens for job: job_1454487534358_0026
16/02/03 11:45:29 INFO impl.YarnClientImpl: Submitted application application_1454487534358_0026
16/02/03 11:45:29 INFO mapreduce.Job: The url to track the job: http://Konniams-MacBook-Air.local:8088/proxy/appli
cation_1454487534358_0026/
16/02/03 11:45:29 INFO mapreduce.Job: Running job: job_1454487534358_0026
16/02/03 11:45:38 INFO mapreduce.Job: Job job_1454487534358_0026 running in uber mode : false
16/02/03 11:45:38 INFO mapreduce.Job:  map 0% reduce 0%
16/02/03 11:45:50 INFO mapreduce.Job:  map 100% reduce 0%
16/02/03 11:45:57 INFO mapreduce.Job:  map 100% reduce 100%
16/02/03 11:45:58 INFO mapreduce.Job: Job job_1454487534358_0026 completed successfully
16/02/03 11:45:58 INFO mapreduce.Job: Counters: 49
        File System Counters
                FILE: Number of bytes read=54439
                FILE: Number of bytes written=462868
                FILE: Number of read operations=0
                FILE: Number of large read operations=0
                FILE: Number of write operations=0
                HDFS: Number of bytes read=51989
                HDFS: Number of bytes written=1898
                HDFS: Number of read operations=9
                HDFS: Number of large read operations=0
                HDFS: Number of write operations=2
        Job Counters
                Launched map tasks=2
                Launched reduce tasks=1
                Data-local map tasks=2
                Total time spent by all maps in occupied slots (ms)=17244
                Total time spent by all reduces in occupied slots (ms)=5255
                Total time spent by all map tasks (ms)=17244
                Total time spent by all reduce tasks (ms)=5255
                Total vcore-seconds taken by all map tasks=17244
                Total vcore-seconds taken by all reduce tasks=5255
                Total megabyte-seconds taken by all map tasks=17657856
                Total megabyte-seconds taken by all reduce tasks=5381120
        Map-Reduce Framework
                Map input records=1334
                Map output records=1334
                Map output bytes=51765
                Map output materialized bytes=54445
                Input split bytes=224
                Combine input records=0
                Combine output records=0
                Reduce input groups=1334
                Reduce shuffle bytes=54445
                Reduce input records=1334
                Reduce output records=50
                Spilled Records=2668
                Shuffled Maps =2
                Failed Shuffles=0
                Merged Map outputs=2
                GC time elapsed (ms)=360
```

```
                CPU time spent (ms)=0
                Physical memory (bytes) snapshot=0
                Virtual memory (bytes) snapshot=0
                Total committed heap usage (bytes)=493355008
        Shuffle Errors
                BAD_ID=0
                CONNECTION=0
                IO_ERROR=0
                WRONG_LENGTH=0
                WRONG_MAP=0
                WRONG_REDUCE=0
        File Input Format Counters
                Bytes Read=51765
        File Output Format Counters
                Bytes Written=1898
16/02/03 11:45:58 INFO streaming.StreamJob: Output directory: /user/konniam/week_03/hw_3_4_sorted
```

3.4 Results

Top 50 product pairs by support counts

In [6]:
```
!hdfs dfs -cat /user/konniam/week_03/hw_3_4_sorted/part*
```

```
16/02/03 11:46:03 WARN util.NativeCodeLoader: Unable to load native-hadoop library for your platform... using buil
tin-java classes where applicable
DAI62779        ELE17451        1592    0.0511880646925
FRO40251        SNA80324        1412    0.0454004694383
DAI75645        FRO40251        1254    0.0403202469374
FRO40251        GRO85051        1213    0.0390019613517
DAI62779        GRO73461        1139    0.0366226166361
DAI75645        SNA80324        1130    0.0363332368734
DAI62779        FRO40251        1070    0.0344040384554
DAI62779        SNA80324        923     0.0296775023311
DAI62779        DAI85309        918     0.0295167357963
ELE32164        GRO59710        911     0.0292916626475
DAI62779        DAI75645        882     0.0283592167454
FRO40251        GRO73461        882     0.0283592167454
DAI62779        ELE92920        877     0.0281984502106
FRO40251        FRO92469        835     0.026848011318
DAI62779        ELE32164        832     0.0267515513971
DAI75645        GRO73461        712     0.0228931545609
DAI43223        ELE32164        711     0.022861001254
DAI62779        GRO30386        709     0.02279669464
ELE17451        FRO40251        697     0.0224108549564
DAI85309        ELE99737        659     0.0211890292917
DAI62779        ELE26917        650     0.020899649529
GRO21487        GRO73461        631     0.0202887366966
DAI62779        SNA45677        604     0.0194205974084
ELE17451        SNA80324        597     0.0191955242597
DAI62779        GRO71621        595     0.0191312176457
DAI62779        SNA55762        593     0.0190669110318
DAI62779        DAI83733        586     0.018841837883
ELE17451        GRO73461        580     0.0186489180412
GRO73461        SNA80324        562     0.0180701585158
DAI62779        GRO59710        561     0.0180380052088
DAI62779        FRO80039        550     0.0176843188322
DAI75645        ELE17451        547     0.0175878589113
DAI62779        SNA93860        537     0.0172663258416
DAI55148        DAI62779        526     0.016912639465
DAI43223        GRO59710        512     0.0164624931674
ELE17451        ELE32164        511     0.0164303398605
DAI62779        SNA18336        506     0.0162695733256
ELE32164        GRO73461        486     0.0156265071863
DAI62779        FRO78087        482     0.0154978939584
DAI85309        ELE17451        482     0.0154978939584
DAI62779        GRO94758        479     0.0154014340375
DAI62779        GRO21487        471     0.0151442075817
GRO85051        SNA80324        471     0.0151442075817
ELE17451        GRO30386        468     0.0150477476608
FRO85978        SNA95666        463     0.014886981126
DAI62779        FRO19221        462     0.014854827819
DAI62779        GRO46854        461     0.0148226745121
DAI43223        DAI62779        459     0.0147583678981
ELE92920        SNA18336        455     0.0146297546703
DAI88079        FRO40251        446     0.0143403749076
```

3.4 Pairs Statistics

Property	Configuration
Operating System	Mac
Cores	2
Memory	4GB
Number of Tuples Processed	
- Mappers	31,101
- Combiners	2,596,216
- Reducers	1,026,711

Stage	Elapsed Time (s)
1st Stage MapReduce (2 mappers, 2 reducers, with combiners)	56
2nd Stage MapReduce (2 mappers, 1 reducer)	19
Total	75

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

Strategy

- 1st stage:
  Mapper: basket -> (Item_i, Stripe_i) [where Stripe_i is a json formatted string]
  Reducer: (Item_i, Stripe_i) -> (Item1, Item2, count, relative frequency)
  (Use 2 mappers and 2 reducers)
- 2nd stage: Sort (Item1, Item2, count, relative frequency) by count

3.5 Mapper

In [8]:
```
%%writefile mapper_3_5.py
#!/usr/bin/env python
# Mapper for 3.5
# Author: Konniam Chan
# Stripes shopping cart analysis
import sys
import json
from itertools import combinations

for line in sys.stdin:
    # Count how many mappers called
    sys.stderr.write("reporter:counter:MR-Counter,Num_mapper_calls,1\n")
    # Read record
    record = line.strip().split()
    # Assume all items in basket co-occur, get all combinations of items
    # Sort by alphanumerical order first and eliminate potential duplicates
    record = sorted(set(record))
    # Skip last item because it will always be part of another item's row
    stripes = {item:{} for item in record[:-1]}
    # Create stripes
    for pair in combinations(record, 2):
        stripes[pair[0]][pair[1]] = 1
    # Emit each stripe
    for k,v in stripes.items():
        print '%s\t%s' % (k, json.dumps(v))
    # Emit basket count for order inversion
    # Assume 2 reducers
    print '%s\t%s' % ('*0', json.dumps({"*0": 1}))
    print '%s\t%s' % ('*1', json.dumps({"*1": 1}))
```

```
Overwriting mapper_3_5.py
```

3.5 Combiner

In [7]:
```
%%writefile combiner_3_5.py
#!/usr/bin/env python
# Combiner for 3.5
# Author: Konniam Chan
# Stripes shopping cart analysis
import sys
import json

current_item = None
current_stripe = {}

# Function to add stripes
def add_stripes(current_stripe, stripe):
    for key in stripe:
        if key in current_stripe:
            current_stripe[key] += stripe[key]
        else:
            current_stripe[key] = stripe[key]
    return current_stripe

for line in sys.stdin:
    # Count how many combiners called
    sys.stderr.write("reporter:counter:MR-Counter,Num_combiner_calls,1\n")
    # Obtain stripe
    line = line.strip()
    item, stripe = line.split('\t')
    # Read json string, then convert to Counter dictionary
    stripe = json.loads(stripe)
    # Rely on sorting to collect stripes
    if current_item == item:
        current_stripe = add_stripes(current_stripe, stripe)
    else:
        if current_item:
            print '%s\t%s' % (current_item, json.dumps(current_stripe))
        current_stripe = stripe
        current_item = item

# Output last stripe
if current_item == item:
    print '%s\t%s' % (current_item, json.dumps(current_stripe))
```

```
Overwriting combiner_3_5.py
```

3.5 Reducer

In [19]:
```
%%writefile reducer_3_5.py
#!/usr/bin/env python
## Reducer for 3.5
# Author: Konniam Chan
# Stripes shopping cart analysis
from __future__ import division
import sys
import json

current_item = None
current_stripe = {}
s = 100

# Function to add stripes
def add_stripes(current_stripe, stripe):
    for key in stripe:
        if key in current_stripe:
            current_stripe[key] += stripe[key]
        else:
            current_stripe[key] = stripe[key]
    return current_stripe

for line in sys.stdin:
    # Count how many reducers called
    sys.stderr.write("reporter:counter:MR-Counter,Num_reducer_calls,1\n")
    # Obtain stripe
    line = line.strip()
    item, stripe = line.split('\t')
    # Read json string, then convert to Counter dictionary
    stripe = json.loads(stripe)
    # Rely on sorting to collect stripes
    if current_item == item:
        current_stripe = add_stripes(current_stripe, stripe)
    else:
        # Obtain total count and save to memory
        if current_item == '*0':
            total = current_stripe['*0']
        elif current_item == '*1':
            total = current_stripe['*1']
        elif current_item:
            # Output all neighbor pairs in the stripe
            for neighbor, current_count in current_stripe.items():
                # Output in support is at least 100
                if current_count >= s:
                    print '%s\t%s\t%s\t%s' % (current_item, neighbor, current_count, current_count/total)
        current_stripe = stripe
        current_item = item

# Output last stripe
if current_item == item:
    for neighbor, current_count in current_stripe.items():
        if current_count >= s:
            print '%s\t%s\t%s\t%s' % (current_item, neighbor, current_count, current_count/total)
```

```
Overwriting reducer_3_5.py
```

In [79]:
```
!chmod a+x *_3_5.py
```

3.5 MR 1st Stage

In [20]:
```
# Shopping cart analysis with stripes, with counters for number of mappers, combiners, and reducers
!hdfs dfs -rm -r /user/konniam/week_03/hw_3_5
# Use 2 mappers and 2 reducers
!hadoop jar $HADOOP_HOME/share/hadoop/tools/lib/hadoop-streaming-*.jar \
-D mapreduce.job.maps=2 \
-D mapreduce.job.reduces=2 \
-mapper $PWD/mapper_3_5.py \
-reducer $PWD/reducer_3_5.py \
-combiner $PWD/combiner_3_5.py \
-input /user/konniam/week_03/ProductPurchaseData.txt \
-output /user/konniam/week_03/hw_3_5
```

```
16/02/03 11:58:50 WARN util.NativeCodeLoader: Unable to load native-hadoop library for your platform... using buil
tin-java classes where applicable
16/02/03 11:58:51 INFO fs.TrashPolicyDefault: Namenode trash configuration: Deletion interval = 0 minutes, Emptier
 interval = 0 minutes.
Deleted /user/konniam/week_03/hw_3_5
```

```
16/02/03 11:58:52 WARN util.NativeCodeLoader: Unable to load native-hadoop library for your platform... using buil
tin-java classes where applicable
packageJobJar: [/var/folders/l8/h51_59852qscq403fs6q0xlh0000gn/T/hadoop-unjar5986202487866547422/] [] /var/folders
/l8/h51_59852qscq403fs6q0xlh0000gn/T/streamjob1043533591408109191.jar tmpDir=null
16/02/03 11:58:54 INFO client.RMProxy: Connecting to ResourceManager at /0.0.0.0:8032
16/02/03 11:58:54 INFO client.RMProxy: Connecting to ResourceManager at /0.0.0.0:8032
16/02/03 11:58:55 INFO mapred.FileInputFormat: Total input paths to process : 1
16/02/03 11:58:55 INFO mapreduce.JobSubmitter: number of splits:2
16/02/03 11:58:56 INFO mapreduce.JobSubmitter: Submitting tokens for job: job_1454487534358_0027
16/02/03 11:58:56 INFO impl.YarnClientImpl: Submitted application application_1454487534358_0027
16/02/03 11:58:56 INFO mapreduce.Job: The url to track the job: http://Konniams-MacBook-Air.local:8088/proxy/appli
cation_1454487534358_0027/
16/02/03 11:58:56 INFO mapreduce.Job: Running job: job_1454487534358_0027
16/02/03 11:59:04 INFO mapreduce.Job: Job job_1454487534358_0027 running in uber mode : false
16/02/03 11:59:04 INFO mapreduce.Job:  map 0% reduce 0%
16/02/03 11:59:21 INFO mapreduce.Job:  map 53% reduce 0%
16/02/03 11:59:24 INFO mapreduce.Job:  map 67% reduce 0%
16/02/03 11:59:34 INFO mapreduce.Job:  map 100% reduce 0%
16/02/03 11:59:45 INFO mapreduce.Job:  map 100% reduce 50%
16/02/03 11:59:46 INFO mapreduce.Job:  map 100% reduce 100%
16/02/03 11:59:47 INFO mapreduce.Job: Job job_1454487534358_0027 completed successfully
16/02/03 11:59:47 INFO mapreduce.Job: Counters: 52
        File System Counters
                FILE: Number of bytes read=15677786
                FILE: Number of bytes written=31827226
                FILE: Number of read operations=0
                FILE: Number of large read operations=0
                FILE: Number of write operations=0
                HDFS: Number of bytes read=3462103
                HDFS: Number of bytes written=51765
                HDFS: Number of read operations=12
                HDFS: Number of large read operations=0
                HDFS: Number of write operations=4
        Job Counters
                Launched map tasks=2
                Launched reduce tasks=2
                Data-local map tasks=2
                Total time spent by all maps in occupied slots (ms)=54133
                Total time spent by all reduces in occupied slots (ms)=18186
                Total time spent by all map tasks (ms)=54133
                Total time spent by all reduce tasks (ms)=18186
                Total vcore-seconds taken by all map tasks=54133
                Total vcore-seconds taken by all reduce tasks=18186
                Total megabyte-seconds taken by all map tasks=55432192
                Total megabyte-seconds taken by all reduce tasks=18622464
        Map-Reduce Framework
                Map input records=31101
                Map output records=411922
                Map output bytes=42450230
                Map output materialized bytes=15677798
                Input split bytes=236
                Combine input records=411922
                Combine output records=16944
                Reduce input groups=12013
                Reduce shuffle bytes=15677798
                Reduce input records=16944
                Reduce output records=1334
                Spilled Records=33888
                Shuffled Maps =4
                Failed Shuffles=0
                Merged Map outputs=4
                GC time elapsed (ms)=662
                CPU time spent (ms)=0
                Physical memory (bytes) snapshot=0
                Virtual memory (bytes) snapshot=0
                Total committed heap usage (bytes)=586153984
        MR-Counter
                Num_combiner_calls=411922
                Num_mapper_calls=31101
                Num_reducer_calls=16944
        Shuffle Errors
                BAD_ID=0
                CONNECTION=0
                IO_ERROR=0
                WRONG_LENGTH=0
                WRONG_MAP=0
                WRONG_REDUCE=0
        File Input Format Counters
                Bytes Read=3461867
        File Output Format Counters
```

```
                Bytes Written=51765
16/02/03 11:59:47 INFO streaming.StreamJob: Output directory: /user/konniam/week_03/hw_3_5
```

In [21]:
```
!hdfs dfs -cat /user/konniam/week_03/hw_3_5/part* | wc -l
```

```
16/02/03 12:05:17 WARN util.NativeCodeLoader: Unable to load native-hadoop library for your platform... using buil
tin-java classes where applicable
    1334
```

3.5 MR 2nd Stage (sort by count)

In [22]:
```
# Shopping cart analysis with pairs, with counters for number of mappers, combiners, and reducers
# Sort output of 1st stage MR to get top support counts
!hdfs dfs -rm -r /user/konniam/week_03/hw_3_5_sorted
# Use 2 mappers and 1 reducer
!hadoop jar $HADOOP_HOME/share/hadoop/tools/lib/hadoop-streaming-*.jar \
-D mapreduce.job.maps=2 \
-D mapreduce.job.reduces=1 \
-D mapreduce.job.output.key.comparator.class=org.apache.hadoop.mapreduce.lib.partition.KeyFieldBasedComparator \
-D stream.num.map.output.key.fields=3 \
-D mapreduce.partition.keycomparator.options='-k3,3nr -k1,2' \
-mapper /bin/cat \
-reducer $PWD/reducer_top50.py \
-input /user/konniam/week_03/hw_3_5/part* \
-output /user/konniam/week_03/hw_3_5_sorted
```

```
16/02/03 12:05:42 WARN util.NativeCodeLoader: Unable to load native-hadoop library for your platform... using buil
tin-java classes where applicable
16/02/03 12:05:43 INFO fs.TrashPolicyDefault: Namenode trash configuration: Deletion interval = 0 minutes, Emptier
 interval = 0 minutes.
Deleted /user/konniam/week_03/hw_3_5_sorted
16/02/03 12:05:45 WARN util.NativeCodeLoader: Unable to load native-hadoop library for your platform... using buil
tin-java classes where applicable
packageJobJar: [/var/folders/l8/h51_59852qscq403fs6q0xlh0000gn/T/hadoop-unjar784545658839887956/] [] /var/folders/
l8/h51_59852qscq403fs6q0xlh0000gn/T/streamjob7683328440605710148.jar tmpDir=null
16/02/03 12:05:47 INFO client.RMProxy: Connecting to ResourceManager at /0.0.0.0:8032
16/02/03 12:05:47 INFO client.RMProxy: Connecting to ResourceManager at /0.0.0.0:8032
16/02/03 12:05:48 INFO mapred.FileInputFormat: Total input paths to process : 2
16/02/03 12:05:48 INFO mapreduce.JobSubmitter: number of splits:3
16/02/03 12:05:49 INFO mapreduce.JobSubmitter: Submitting tokens for job: job_1454487534358_0028
16/02/03 12:05:49 INFO impl.YarnClientImpl: Submitted application application_1454487534358_0028
16/02/03 12:05:50 INFO mapreduce.Job: The url to track the job: http://Konniams-MacBook-Air.local:8088/proxy/appli
cation_1454487534358_0028/
16/02/03 12:05:50 INFO mapreduce.Job: Running job: job_1454487534358_0028
16/02/03 12:05:59 INFO mapreduce.Job: Job job_1454487534358_0028 running in uber mode : false
16/02/03 12:05:59 INFO mapreduce.Job:  map 0% reduce 0%
16/02/03 12:06:13 INFO mapreduce.Job:  map 100% reduce 0%
16/02/03 12:06:21 INFO mapreduce.Job:  map 100% reduce 100%
16/02/03 12:06:22 INFO mapreduce.Job: Job job_1454487534358_0028 completed successfully
16/02/03 12:06:23 INFO mapreduce.Job: Counters: 49
        File System Counters
                FILE: Number of bytes read=54439
                FILE: Number of bytes written=580891
                FILE: Number of read operations=0
                FILE: Number of large read operations=0
                FILE: Number of write operations=0
                HDFS: Number of bytes read=54891
                HDFS: Number of bytes written=1898
                HDFS: Number of read operations=12
                HDFS: Number of large read operations=0
                HDFS: Number of write operations=2
        Job Counters
                Launched map tasks=3
                Launched reduce tasks=1
                Data-local map tasks=3
                Total time spent by all maps in occupied slots (ms)=35198
                Total time spent by all reduces in occupied slots (ms)=5756
                Total time spent by all map tasks (ms)=35198
                Total time spent by all reduce tasks (ms)=5756
                Total vcore-seconds taken by all map tasks=35198
                Total vcore-seconds taken by all reduce tasks=5756
                Total megabyte-seconds taken by all map tasks=36042752
                Total megabyte-seconds taken by all reduce tasks=5894144
        Map-Reduce Framework
                Map input records=1334
                Map output records=1334
                Map output bytes=51765
                Map output materialized bytes=54451
                Input split bytes=336
```

```
                Combine input records=0
                Combine output records=0
                Reduce input groups=1334
                Reduce shuffle bytes=54451
                Reduce input records=1334
                Reduce output records=50
                Spilled Records=2668
                Shuffled Maps =3
                Failed Shuffles=0
                Merged Map outputs=3
                GC time elapsed (ms)=517
                CPU time spent (ms)=0
                Physical memory (bytes) snapshot=0
                Virtual memory (bytes) snapshot=0
                Total committed heap usage (bytes)=685244416
        Shuffle Errors
                BAD_ID=0
                CONNECTION=0
                IO_ERROR=0
                WRONG_LENGTH=0
                WRONG_MAP=0
                WRONG_REDUCE=0
        File Input Format Counters
                Bytes Read=54555
        File Output Format Counters
                Bytes Written=1898
16/02/03 12:06:23 INFO streaming.StreamJob: Output directory: /user/konniam/week_03/hw_3_5_sorted
```

3.5 Results

Top 50 product pairs by support counts

In [23]:
```
!hdfs dfs -cat /user/konniam/week_03/hw_3_5_sorted/part*
```

```
16/02/03 12:06:30 WARN util.NativeCodeLoader: Unable to load native-hadoop library for your platform... using buil
tin-java classes where applicable
DAI62779        ELE17451        1592    0.0511880646925
FRO40251        SNA80324        1412    0.0454004694383
DAI75645        FRO40251        1254    0.0403202469374
FRO40251        GRO85051        1213    0.0390019613517
DAI62779        GRO73461        1139    0.0366226166361
DAI75645        SNA80324        1130    0.0363332368734
DAI62779        FRO40251        1070    0.0344040384554
DAI62779        SNA80324        923     0.0296775023311
DAI62779        DAI85309        918     0.0295167357963
ELE32164        GRO59710        911     0.0292916626475
DAI62779        DAI75645        882     0.0283592167454
FRO40251        GRO73461        882     0.0283592167454
DAI62779        ELE92920        877     0.0281984502106
FRO40251        FRO92469        835     0.026848011318
DAI62779        ELE32164        832     0.0267515513971
DAI75645        GRO73461        712     0.0228931545609
DAI43223        ELE32164        711     0.022861001254
DAI62779        GRO30386        709     0.02279669464
ELE17451        FRO40251        697     0.0224108549564
DAI85309        ELE99737        659     0.0211890292917
DAI62779        ELE26917        650     0.020899649529
GRO21487        GRO73461        631     0.0202887366966
DAI62779        SNA45677        604     0.0194205974084
ELE17451        SNA80324        597     0.0191955242597
DAI62779        GRO71621        595     0.0191312176457
DAI62779        SNA55762        593     0.0190669110318
DAI62779        DAI83733        586     0.018841837883
ELE17451        GRO73461        580     0.0186489180412
GRO73461        SNA80324        562     0.0180701585158
DAI62779        GRO59710        561     0.0180380052088
DAI62779        FRO80039        550     0.0176843188322
DAI75645        ELE17451        547     0.0175878589113
DAI62779        SNA93860        537     0.0172663258416
DAI55148        DAI62779        526     0.016912639465
DAI43223        GRO59710        512     0.0164624931674
ELE17451        ELE32164        511     0.0164303398605
DAI62779        SNA18336        506     0.0162695733256
ELE32164        GRO73461        486     0.0156265071863
DAI62779        FRO78087        482     0.0154978939584
DAI85309        ELE17451        482     0.0154978939584
DAI62779        GRO94758        479     0.0154014340375
DAI62779        GRO21487        471     0.0151442075817
GRO85051        SNA80324        471     0.0151442075817
ELE17451        GRO30386        468     0.0150477476608
FRO85978        SNA95666        463     0.014886981126
DAI62779        FRO19221        462     0.014854827819
DAI62779        GRO46854        461     0.0148226745121
DAI43223        DAI62779        459     0.0147583678981
ELE92920        SNA18336        455     0.0146297546703
DAI88079        FRO40251        446     0.0143403749076
```

3.5 Stripes Statistics

Property	Configuration
Operating System	Mac
Cores	2
Memory	4GB
Number of Tuples Processed	
- Mappers	31,101
- Combiners	411,922
- Reducers	16,944

Stage	Elapsed Time (s)
1st Stage MapReduce (2 mappers, 2 reducers, with combiners)	41
2nd Stage MapReduce (2 mappers, 1 reducer)	22

Total	63

3.5 Response

In the pairs formulation, there are many records transmitted between the mappers and the reducers. In this particular problem, the reducer received over 1,000,000 records. In the stripes formulation, due to the more condensed structure of the stripe, there are only about 17,000 records. In jobs where there are a large number of mappers and reducers on different networks, the number of tuples sent in the pairs approach could be prohibitive. In our pseudo-distributed environment, both mappers and reducers live on the same network and we didn't incur any network costs. The stripes approach is faster by 12 seconds. If the network costs were more significant, we would see stripes performing significantly better.

HW3.6

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

Apriori

The Apriori algorithm is used to find frequent item sets. These sets are useful in generating assocation rules, which are widely used in recommendations. The central idea is that if a set of items A is frequent, so is any subset of A. Thus, if any subset of A is not frequent, then A cannot be frequent. This idea is used to limit the large space of higher-number item sets.

The algorithm works in stages. In the first pass, we look at all baskets of transactions and generates a list of counts for each item (C1). We filter it based on a specified minimmum support count and obtain a set of frequent items of size 1 (L1). In the second pass, we look at all baskets, filtered out all items NOT in L1, then use the rest to generate candidate paris (C2). We filter this list to generate frequent items of size 2 (L2). In the third pass, we look at all baskets and filtered out all items not in L1. We form pairs, then filter out items not in L2. We then form triplet candidates (C3), filter to get L3. Repeat until we get to the size of frequent items that we want.

Confidence and Lift

For an association rule A -> b, **confidence** measures how "likely" b would occur, in the baskets that contain A. High confidence means that if A is in the basket, b is likley to be in the same basket. The formula is: $\frac{support(A\ U\ b)}{support(A)}$.

Lift measures the ratio between confidence and how likley is b to occur unconditionally. It can be calculated as $\frac{Confidence(A->b)}{Confidence(null->b)}$ where $Confidence(null-> b) = support(b)$

Applications

One could use Apriori algorithm to create marketing campaigns in retail stores, let's say at Starbucks. If an association rule shows that two food items are often purchased together, we can advertise both items in some fashion to increase revenue per transaction.

HW3.7. 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

Strategy

We will do 3 passes over the data, to get the set of triples with support of at least 100 (L3). Then we can easily do another MR job to calculate confidence by dividing L3 counts with the corresponding L2 counts. Thus, in total we will run 4 MR jobs.

1st pass of Apriori Algorithm

In [2]:
```
%%writefile mapper_3_7_pass1.py
#!/usr/bin/env python
# Mapper for 3.7
# Author: Konniam Chan
# Apriori Algorithm
import sys

for line in sys.stdin:
    record = line.strip().split()
    # Emit count of item
    for item in record:
        print '%s\t%s' % (item, 1)
```

```
Writing mapper_3_7_pass1.py
```

In [25]:
```
%%writefile combiner_3_7_pass1.py
#!/usr/bin/env python
## Combiner for 3.7
# Author: Konniam Chan
# Apriori
import sys
current_item = None
current_count = 0
item = None

for line in sys.stdin:
    # Obtain item and intermediate counts
    line = line.strip()
    item, count = line.split('\t')
    count = int(count)
    # Rely on sorting to increment item counts
    if current_item == item:
        current_count += count
    else:
        if current_item:
            print '%s\t%s' % (current_item, current_count)
        current_count = count
        current_item = item

# Output last item
if current_item == item:
    print '%s\t%s' % (current_item, current_count)
```

```
Writing combiner_3_7_pass1.py
```

In [4]:
```
%%writefile reducer_3_7_pass1.py
#!/usr/bin/env python
## Reducer for 3.7
# Author: Konniam Chan
# Apriori
import sys
current_item = None
current_count = 0
item = None
SUPPORT = 100

for line in sys.stdin:
    # Obtain item and intermediate counts
    line = line.strip()
    item, count = line.split('\t')
    count = int(count)
    # Rely on sorting to increment item counts
    if current_item == item:
        current_count += count
    else:
        if current_item and current_count >= SUPPORT:
            print '%s\t%s' % (current_item, current_count)
        current_count = count
        current_item = item

# Output last item
if current_item == item and current_count >= SUPPORT:
    print '%s\t%s' % (current_item, current_count)
```

```
Writing reducer_3_7_pass1.py
```

In [5]:
```
!chmod a+x *_3_7_pass1.py
```

Obtain L1

In [6]:
```
# Apriori
!hdfs dfs -rm -r /user/konniam/week_03/hw_3_7_pass1
# Use 2 mappers and 2 reducers
!hadoop jar $HADOOP_HOME/share/hadoop/tools/lib/hadoop-streaming-*.jar \
-D mapreduce.job.maps=2 \
-D mapreduce.job.reduces=1 \
-mapper $PWD/mapper_3_7_pass1.py \
-combiner $PWD/combiner_3_7_pass1.py \
-reducer $PWD/reducer_3_7_pass1.py \
-input /user/konniam/week_03/ProductPurchaseData.txt \
-output /user/konniam/week_03/hw_3_7_pass1
```

```
16/02/03 23:28:15 WARN util.NativeCodeLoader: Unable to load native-hadoop library for your platform... using buil
tin-java classes where applicable
16/02/03 23:28:16 INFO fs.TrashPolicyDefault: Namenode trash configuration: Deletion interval = 0 minutes, Emptier
 interval = 0 minutes.
Deleted /user/konniam/week_03/hw_3_7_pass1
16/02/03 23:28:18 WARN util.NativeCodeLoader: Unable to load native-hadoop library for your platform... using buil
tin-java classes where applicable
packageJobJar: [/var/folders/l8/h51_59852qscq403fs6q0xlh0000gn/T/hadoop-unjar4403250698977015195/] [] /var/folders
/l8/h51_59852qscq403fs6q0xlh0000gn/T/streamjob7955926000752034618.jar tmpDir=null
16/02/03 23:28:20 INFO client.RMProxy: Connecting to ResourceManager at /0.0.0.0:8032
16/02/03 23:28:21 INFO client.RMProxy: Connecting to ResourceManager at /0.0.0.0:8032
16/02/03 23:28:23 INFO mapred.FileInputFormat: Total input paths to process : 1
16/02/03 23:28:23 INFO mapreduce.JobSubmitter: number of splits:2
16/02/03 23:28:23 INFO mapreduce.JobSubmitter: Submitting tokens for job: job_1454487534358_0031
16/02/03 23:28:24 INFO impl.YarnClientImpl: Submitted application application_1454487534358_0031
16/02/03 23:28:24 INFO mapreduce.Job: The url to track the job: http://Konniams-MacBook-Air.local:8088/proxy/appli
cation_1454487534358_0031/
16/02/03 23:28:24 INFO mapreduce.Job: Running job: job_1454487534358_0031
16/02/03 23:28:38 INFO mapreduce.Job: Job job_1454487534358_0031 running in uber mode : false
16/02/03 23:28:38 INFO mapreduce.Job:  map 0% reduce 0%
16/02/03 23:28:54 INFO mapreduce.Job:  map 100% reduce 0%
16/02/03 23:29:04 INFO mapreduce.Job:  map 100% reduce 100%
16/02/03 23:29:06 INFO mapreduce.Job: Job job_1454487534358_0031 completed successfully
16/02/03 23:29:06 INFO mapreduce.Job: Counters: 49
        File System Counters
                FILE: Number of bytes read=235933
                FILE: Number of bytes written=825667
                FILE: Number of read operations=0
                FILE: Number of large read operations=0
                FILE: Number of write operations=0
                HDFS: Number of bytes read=3462103
                HDFS: Number of bytes written=8471
                HDFS: Number of read operations=9
                HDFS: Number of large read operations=0
                HDFS: Number of write operations=2
        Job Counters
                Launched map tasks=2
                Launched reduce tasks=1
                Data-local map tasks=2
                Total time spent by all maps in occupied slots (ms)=27969
                Total time spent by all reduces in occupied slots (ms)=6184
                Total time spent by all map tasks (ms)=27969
                Total time spent by all reduce tasks (ms)=6184
                Total vcore-seconds taken by all map tasks=27969
                Total vcore-seconds taken by all reduce tasks=6184
                Total megabyte-seconds taken by all map tasks=28640256
                Total megabyte-seconds taken by all reduce tasks=6332416
        Map-Reduce Framework
                Map input records=31101
                Map output records=380824
                Map output bytes=4189064
                Map output materialized bytes=235939
                Input split bytes=236
                Combine input records=380824
                Combine output records=17745
                Reduce input groups=12592
                Reduce shuffle bytes=235939
                Reduce input records=17745
                Reduce output records=647
                Spilled Records=35490
                Shuffled Maps =2
                Failed Shuffles=0
```

```
                Merged Map outputs=2
                GC time elapsed (ms)=423
                CPU time spent (ms)=0
                Physical memory (bytes) snapshot=0
                Virtual memory (bytes) snapshot=0
                Total committed heap usage (bytes)=487063552
        Shuffle Errors
                BAD_ID=0
                CONNECTION=0
                IO_ERROR=0
                WRONG_LENGTH=0
                WRONG_MAP=0
                WRONG_REDUCE=0
        File Input Format Counters
                Bytes Read=3461867
        File Output Format Counters
                Bytes Written=8471
16/02/03 23:29:06 INFO streaming.StreamJob: Output directory: /user/konniam/week_03/hw_3_7_pass1
```

In [7]:
```
!hdfs dfs -cat /user/konniam/week_03/hw_3_7_pass1/part* | wc -l
```

```
16/02/03 23:30:17 WARN util.NativeCodeLoader: Unable to load native-hadoop library for your platform... using buil
tin-java classes where applicable
     647
```

In [8]:
```
!hdfs dfs -cat /user/konniam/week_03/hw_3_7_pass1/part* | sort -k2,2nr | head
```

```
16/02/03 23:30:20 WARN util.NativeCodeLoader: Unable to load native-hadoop library for your platform... using buil
tin-java classes where applicable
DAI62779        6667
FRO40251        3881
ELE17451        3875
GRO73461        3602
SNA80324        3044
ELE32164        2851
DAI75645        2736
SNA45677        2455
FRO31317        2330
DAI85309        2293
```

In [9]:
```
!hdfs dfs -getmerge /user/konniam/week_03/hw_3_7_pass1 L1_counts.txt
```

```
16/02/03 23:30:24 WARN util.NativeCodeLoader: Unable to load native-hadoop library for your platform... using buil
tin-java classes where applicable
```

2nd Pass to Obtain L2

In [10]:
```
%%writefile mapper_3_7_pass2.py
#!/usr/bin/env python
# Mapper for 3.7
# Author: Konniam Chan
# Apriori Algorithm
import sys
from itertools import combinations

# Array to hold frequent items
freq_items_L1 = []
with open("L1_counts.txt", "r") as f:
    for line in f:
        item, _ = line.strip().split()
        freq_items_L1.append(item)

# Accept input from Hadoop streaming
for line in sys.stdin:
    items = line.strip().split()
    # Filter to only include items in frequent list
    items = filter(lambda x: x in freq_items_L1, items)
    # Sort items
    items = sorted(set(items))
    # Create candidate pairs (C2)
    for pair in combinations(items, 2):
        print '%s.%s\t%s' % (pair[0], pair[1], 1)
```

```
Writing mapper_3_7_pass2.py
```

In [11]:
```
!cp combiner_3_7_pass1.py combiner_3_7_pass2.py
!cp reducer_3_7_pass1.py reducer_3_7_pass2.py
```

In [12]:
```
!chmod a+x *_3_7_pass2.py
```

Obtain L2

In [13]:
```
# Apriori
!hdfs dfs -rm -r /user/konniam/week_03/hw_3_7_pass2
# Use 2 mappers and 2 reducers
!hadoop jar $HADOOP_HOME/share/hadoop/tools/lib/hadoop-streaming-*.jar \
-D mapreduce.job.maps=2 \
-D mapreduce.job.reduces=2 \
-mapper $PWD/mapper_3_7_pass2.py \
-combiner $PWD/combiner_3_7_pass2.py \
-reducer $PWD/reducer_3_7_pass2.py \
-input /user/konniam/week_03/ProductPurchaseData.txt \
-output /user/konniam/week_03/hw_3_7_pass2 \
-file L1_counts.txt
```

```
16/02/03 23:30:58 WARN util.NativeCodeLoader: Unable to load native-hadoop library for your platform... using buil
tin-java classes where applicable
16/02/03 23:30:59 INFO fs.TrashPolicyDefault: Namenode trash configuration: Deletion interval = 0 minutes, Emptier
 interval = 0 minutes.
Deleted /user/konniam/week_03/hw_3_7_pass2
16/02/03 23:31:01 WARN streaming.StreamJob: -file option is deprecated, please use generic option -files instead.
16/02/03 23:31:01 WARN util.NativeCodeLoader: Unable to load native-hadoop library for your platform... using buil
tin-java classes where applicable
packageJobJar: [L1_counts.txt, /var/folders/l8/h51_59852qscq403fs6q0xlh0000gn/T/hadoop-unjar721548109007871352/] [
] /var/folders/l8/h51_59852qscq403fs6q0xlh0000gn/T/streamjob6445342460718776132.jar tmpDir=null
16/02/03 23:31:03 INFO client.RMProxy: Connecting to ResourceManager at /0.0.0.0:8032
16/02/03 23:31:03 INFO client.RMProxy: Connecting to ResourceManager at /0.0.0.0:8032
16/02/03 23:31:05 INFO mapred.FileInputFormat: Total input paths to process : 1
16/02/03 23:31:05 INFO mapreduce.JobSubmitter: number of splits:2
16/02/03 23:31:05 INFO mapreduce.JobSubmitter: Submitting tokens for job: job_1454487534358_0032
16/02/03 23:31:06 INFO impl.YarnClientImpl: Submitted application application_1454487534358_0032
16/02/03 23:31:06 INFO mapreduce.Job: The url to track the job: http://Konniams-MacBook-Air.local:8088/proxy/appli
cation_1454487534358_0032/
16/02/03 23:31:06 INFO mapreduce.Job: Running job: job_1454487534358_0032
16/02/03 23:31:17 INFO mapreduce.Job: Job job_1454487534358_0032 running in uber mode : false
16/02/03 23:31:17 INFO mapreduce.Job:  map 0% reduce 0%
16/02/03 23:31:34 INFO mapreduce.Job:  map 51% reduce 0%
16/02/03 23:31:37 INFO mapreduce.Job:  map 67% reduce 0%
16/02/03 23:31:45 INFO mapreduce.Job:  map 83% reduce 0%
16/02/03 23:31:46 INFO mapreduce.Job:  map 100% reduce 0%
16/02/03 23:32:00 INFO mapreduce.Job:  map 100% reduce 50%
16/02/03 23:32:02 INFO mapreduce.Job:  map 100% reduce 100%
16/02/03 23:32:02 INFO mapreduce.Job: Job job_1454487534358_0032 completed successfully
16/02/03 23:32:02 INFO mapreduce.Job: Counters: 49
        File System Counters
                FILE: Number of bytes read=5030492
                FILE: Number of bytes written=10537330
                FILE: Number of read operations=0
                FILE: Number of large read operations=0
                FILE: Number of write operations=0
                HDFS: Number of bytes read=3462103
                HDFS: Number of bytes written=29355
                HDFS: Number of read operations=12
                HDFS: Number of large read operations=0
                HDFS: Number of write operations=4
        Job Counters
                Launched map tasks=2
                Launched reduce tasks=2
                Data-local map tasks=2
                Total time spent by all maps in occupied slots (ms)=49972
                Total time spent by all reduces in occupied slots (ms)=26931
                Total time spent by all map tasks (ms)=49972
                Total time spent by all reduce tasks (ms)=26931
                Total vcore-seconds taken by all map tasks=49972
                Total vcore-seconds taken by all reduce tasks=26931
                Total megabyte-seconds taken by all map tasks=51171328
                Total megabyte-seconds taken by all reduce tasks=27577344
        Map-Reduce Framework
                Map input records=31101
                Map output records=1358592
                Map output bytes=27171840
                Map output materialized bytes=5030504
                Input split bytes=236
                Combine input records=1358592
                Combine output records=227163
                Reduce input groups=149097
```

```
                Reduce shuffle bytes=5030504
                Reduce input records=227163
                Reduce output records=1334
                Spilled Records=454326
                Shuffled Maps =4
                Failed Shuffles=0
                Merged Map outputs=4
                GC time elapsed (ms)=569
                CPU time spent (ms)=0
                Physical memory (bytes) snapshot=0
                Virtual memory (bytes) snapshot=0
                Total committed heap usage (bytes)=581959680
        Shuffle Errors
                BAD_ID=0
                CONNECTION=0
                IO_ERROR=0
                WRONG_LENGTH=0
                WRONG_MAP=0
                WRONG_REDUCE=0
        File Input Format Counters
                Bytes Read=3461867
        File Output Format Counters
                Bytes Written=29355
16/02/03 23:32:02 INFO streaming.StreamJob: Output directory: /user/konniam/week_03/hw_3_7_pass2
```

In [14]:
```
!hdfs dfs -cat /user/konniam/week_03/hw_3_7_pass2/part* | wc -l
```

```
16/02/03 23:32:08 WARN util.NativeCodeLoader: Unable to load native-hadoop library for your platform... using buil
tin-java classes where applicable
    1334
```

In [15]:
```
!hdfs dfs -cat /user/konniam/week_03/hw_3_7_pass2/part* | sort -k2,2nr | head
```

```
16/02/03 23:32:12 WARN util.NativeCodeLoader: Unable to load native-hadoop library for your platform... using buil
tin-java classes where applicable
DAI62779.ELE17451       1592
FRO40251.SNA80324       1412
DAI75645.FRO40251       1254
FRO40251.GRO85051       1213
DAI62779.GRO73461       1139
DAI75645.SNA80324       1130
DAI62779.FRO40251       1070
DAI62779.SNA80324       923
DAI62779.DAI85309       918
ELE32164.GRO59710       911
```

In [16]:
```
!hdfs dfs -getmerge /user/konniam/week_03/hw_3_7_pass2 L2_counts.txt
```

```
16/02/03 23:32:16 WARN util.NativeCodeLoader: Unable to load native-hadoop library for your platform... using buil
tin-java classes where applicable
```

Third pass to obtain L3

In [29]:
```
%%writefile mapper_3_7_pass3.py
#!/usr/bin/env python
# Mapper for 3.7
# Author: Konniam Chan
# Apriori Algorithm
import sys
from itertools import combinations

# Arrays to hold frequent items
freq_items_L1 = []
with open("L1_counts.txt", "r") as f:
    for line in f:
        item, _ = line.strip().split()
        freq_items_L1.append(item)

freq_items_L2 = []
with open("L2_counts.txt", "r") as f:
    for line in f:
        item, _ = line.strip().split()
        freq_items_L2.append(item)
# Function to yield a pair for evalution
def generate_pairs(items):
    '''
    Input: list of items filtered by L1
    Output: pairs of items, filtered by L2
    '''
    for pair in combinations(items, 2):
        if '.'.join([pair[0], pair[1]]) in freq_items_L2:
            yield pair

# Accept input from Hadoop streaming
for line in sys.stdin:
    items = line.strip().split()
    # Filter using L1 and sort
    items = filter(lambda x: x in freq_items_L1, items)
    items = sorted(set(items))
    # Form C3 from filtered L2 pairs
    for pair in generate_pairs(items):
        first, second = pair[0], pair[1]
        second_index = items.index(second)
        # Only look at items after the pair to find match (avoid double counting)
        for third in items[second_index+1:]:
            # Check if triple is a viable candidate
            if '.'.join([second, third]) in freq_items_L2 and '.'.join([first, third]) in freq_items_L2:

                # Triple is possible
                print '%s.%s.%s\t%s' % (first, second, third, 1)
    # Emit total for order inversion
    print '%s\t%s' % ('*0', 1)
    print '%s\t%s' % ('*1', 1)
```

```
Overwriting mapper_3_7_pass3.py
```

In [26]:
```
# Use same combiner as pass 1
!mv combiner_3_7_pass1.py combiner_3_7_pass3.py
```

In [37]:
```
%%writefile reducer_3_7_pass3.py
#!/usr/bin/env python
## Reducer for 3.7
# Author: Konniam Chan
# Apriori
from __future__ import division
import sys
current_triple = None
current_count = 0
triple = None
SUPPORT = 100

for line in sys.stdin:
    # Obtain triple and intermediate counts
    line = line.strip()
    triple, count = line.split('\t')
    count = int(count)
    # Rely on sorting to increment triple counts
    if current_triple == triple:
        current_count += count
    else:
        if current_triple in ['*0', '*1']:
            total = current_count
        elif current_triple:
            if current_count >= SUPPORT:
                print '%s\t%s\t%s' % (current_triple, current_count, current_count / total)
        current_count = count
        current_triple = triple

# Output last triple
if current_triple == triple and current_count >= SUPPORT:
    print '%s\t%s\t%s' % (current_triple, current_count, current_count / total)
```

```
Overwriting reducer_3_7_pass3.py
```

In [33]:
```
!chmod a+x *_3_7_pass3.py
```

Obtain L3

In [39]:
```
# Apriori
!hdfs dfs -rm -r /user/konniam/week_03/hw_3_7_pass3
# Use 2 mappers and 2 reducers
!hadoop jar $HADOOP_HOME/share/hadoop/tools/lib/hadoop-streaming-*.jar \
-D mapreduce.job.maps=2 \
-D mapreduce.job.reduces=2 \
-mapper $PWD/mapper_3_7_pass3.py \
-combiner $PWD/combiner_3_7_pass3.py \
-reducer $PWD/reducer_3_7_pass3.py \
-input /user/konniam/week_03/ProductPurchaseData.txt \
-output /user/konniam/week_03/hw_3_7_pass3 \
-file L1_counts.txt \
-file L2_counts.txt
```

```
16/02/03 23:58:38 WARN util.NativeCodeLoader: Unable to load native-hadoop library for your platform... using buil
tin-java classes where applicable
16/02/03 23:58:39 INFO fs.TrashPolicyDefault: Namenode trash configuration: Deletion interval = 0 minutes, Emptier
 interval = 0 minutes.
Deleted /user/konniam/week_03/hw_3_7_pass3
16/02/03 23:58:41 WARN streaming.StreamJob: -file option is deprecated, please use generic option -files instead.
16/02/03 23:58:41 WARN util.NativeCodeLoader: Unable to load native-hadoop library for your platform... using buil
tin-java classes where applicable
packageJobJar: [L1_counts.txt, L2_counts.txt, /var/folders/l8/h51_59852qscq403fs6q0xlh0000gn/T/hadoop-unjar2932304
002032762554/] [] /var/folders/l8/h51_59852qscq403fs6q0xlh0000gn/T/streamjob3434050542611831197.jar tmpDir=null
16/02/03 23:58:43 INFO client.RMProxy: Connecting to ResourceManager at /0.0.0.0:8032
16/02/03 23:58:43 INFO client.RMProxy: Connecting to ResourceManager at /0.0.0.0:8032
16/02/03 23:58:44 INFO mapred.FileInputFormat: Total input paths to process : 1
16/02/03 23:58:45 INFO mapreduce.JobSubmitter: number of splits:2
16/02/03 23:58:45 INFO mapreduce.JobSubmitter: Submitting tokens for job: job_1454487534358_0034
16/02/03 23:58:45 INFO impl.YarnClientImpl: Submitted application application_1454487534358_0034
16/02/03 23:58:45 INFO mapreduce.Job: The url to track the job: http://Konniams-MacBook-Air.local:8088/proxy/appli
cation_1454487534358_0034/
16/02/03 23:58:45 INFO mapreduce.Job: Running job: job_1454487534358_0034
16/02/03 23:58:55 INFO mapreduce.Job: Job job_1454487534358_0034 running in uber mode : false
16/02/03 23:58:55 INFO mapreduce.Job:  map 0% reduce 0%
16/02/03 23:59:11 INFO mapreduce.Job:  map 18% reduce 0%
16/02/03 23:59:17 INFO mapreduce.Job:  map 23% reduce 0%
16/02/03 23:59:20 INFO mapreduce.Job:  map 25% reduce 0%
16/02/03 23:59:23 INFO mapreduce.Job:  map 30% reduce 0%
```

```
16/02/03 23:59:26 INFO mapreduce.Job:  map 33% reduce 0%
16/02/03 23:59:29 INFO mapreduce.Job:  map 38% reduce 0%
16/02/03 23:59:35 INFO mapreduce.Job:  map 43% reduce 0%
16/02/03 23:59:38 INFO mapreduce.Job:  map 48% reduce 0%
16/02/03 23:59:41 INFO mapreduce.Job:  map 51% reduce 0%
16/02/03 23:59:44 INFO mapreduce.Job:  map 56% reduce 0%
16/02/03 23:59:47 INFO mapreduce.Job:  map 59% reduce 0%
16/02/03 23:59:50 INFO mapreduce.Job:  map 61% reduce 0%
16/02/03 23:59:51 INFO mapreduce.Job:  map 78% reduce 0%
16/02/03 23:59:53 INFO mapreduce.Job:  map 80% reduce 0%
16/02/04 00:00:02 INFO mapreduce.Job:  map 83% reduce 0%
16/02/04 00:00:09 INFO mapreduce.Job:  map 83% reduce 8%
16/02/04 00:00:10 INFO mapreduce.Job:  map 100% reduce 8%
16/02/04 00:00:11 INFO mapreduce.Job:  map 100% reduce 17%
16/02/04 00:00:12 INFO mapreduce.Job:  map 100% reduce 100%
16/02/04 00:00:13 INFO mapreduce.Job: Job job_1454487534358_0034 completed successfully
16/02/04 00:00:13 INFO mapreduce.Job: Counters: 49
        File System Counters
                FILE: Number of bytes read=437184
                FILE: Number of bytes written=1352182
                FILE: Number of read operations=0
                FILE: Number of large read operations=0
                FILE: Number of write operations=0
                HDFS: Number of bytes read=3462103
                HDFS: Number of bytes written=11138
                HDFS: Number of read operations=12
                HDFS: Number of large read operations=0
                HDFS: Number of write operations=4
        Job Counters
                Launched map tasks=2
                Launched reduce tasks=2
                Data-local map tasks=2
                Total time spent by all maps in occupied slots (ms)=126742
                Total time spent by all reduces in occupied slots (ms)=33242
                Total time spent by all map tasks (ms)=126742
                Total time spent by all reduce tasks (ms)=33242
                Total vcore-seconds taken by all map tasks=126742
                Total vcore-seconds taken by all reduce tasks=33242
                Total megabyte-seconds taken by all map tasks=129783808
                Total megabyte-seconds taken by all reduce tasks=34039808
        Map-Reduce Framework
                Map input records=31101
                Map output records=279049
                Map output bytes=6599573
                Map output materialized bytes=437196
                Input split bytes=236
                Combine input records=279049
                Combine output records=13871
                Reduce input groups=7070
                Reduce shuffle bytes=437196
                Reduce input records=13871
                Reduce output records=233
                Spilled Records=27742
                Shuffled Maps =4
                Failed Shuffles=0
                Merged Map outputs=4
                GC time elapsed (ms)=657
                CPU time spent (ms)=0
                Physical memory (bytes) snapshot=0
                Virtual memory (bytes) snapshot=0
                Total committed heap usage (bytes)=570949632
        Shuffle Errors
                BAD_ID=0
                CONNECTION=0
                IO_ERROR=0
                WRONG_LENGTH=0
                WRONG_MAP=0
                WRONG_REDUCE=0
        File Input Format Counters
                Bytes Read=3461867
        File Output Format Counters
                Bytes Written=11138
16/02/04 00:00:13 INFO streaming.StreamJob: Output directory: /user/konniam/week_03/hw_3_7_pass3
```

In [40]:
```
!hdfs dfs -cat /user/konniam/week_03/hw_3_7_pass3/part* | sort -k2,2nr | head
```

```
16/02/04 00:00:20 WARN util.NativeCodeLoader: Unable to load native-hadoop library for your platform... using buil
tin-java classes where applicable
DAI75645.FRO40251.SNA80324      550     0.0176843188322
DAI62779.FRO40251.SNA80324      476     0.0153049741166
FRO40251.GRO85051.SNA80324      471     0.0151442075817
DAI62779.ELE92920.SNA18336      432     0.01389022861
DAI62779.DAI75645.SNA80324      421     0.0135365422334
DAI62779.ELE17451.SNA80324      417     0.0134079290055
DAI62779.DAI75645.FRO40251      412     0.0132471624707
DAI62779.ELE17451.FRO40251      406     0.0130542426289
DAI75645.FRO40251.GRO85051      395     0.0127005562522
DAI62779.FRO40251.GRO85051      381     0.0122504099547
```

4th MR job to obtain confidence

In [45]:
```
%%writefile mapper_3_7_pass4.py
#!/usr/bin/env python
# Mapper for 3.7
# Author: Konniam Chan
# Apriori Algorithm
from __future__ import division
from itertools import combinations
import sys

# Load L2 dictionary
L2_counts = {}
with open("L2_counts.txt", "r") as f:
    for line in f:
        pair, L2_support_count = line.strip().split()
        L2_counts[pair] = int(L2_support_count)

for line in sys.stdin:
    triple, L3_support_count, L3_support = line.strip().split()
    items = triple.split('.')
    # Obtain confidence
    for pair in combinations(items, 2):
        item_1, item_2 = pair[0], pair[1]
        item_3 = [x for x in items if x != item_1 and x != item_2][0]
        L2_support_count = L2_counts['.'.join([item_1, item_2])]
        confidence = int(L3_support_count) / L2_support_count

        print ('%s.%s\t-> %s, %s,\t%s,\t%s' %
               (item_1, item_2, item_3, L3_support_count, L3_support, confidence))
```

```
Overwriting mapper_3_7_pass4.py
```

In [46]:
```
%%writefile reducer_3_7_pass4.py
#!/usr/bin/env python
# Mapper for 3.7
# Author: Konniam Chan
# Apriori Algorithm
import sys

counter = 0
N = 10
for line in sys.stdin:
    # Output 10 lines only
    if counter >= N:
        continue
    print line.strip()
    counter += 1
```

```
Overwriting reducer_3_7_pass4.py
```

In [43]:
```
!chmod a+x *_3_7_pass4.py
```

In [49]:
```
# Apriori
!hdfs dfs -rm -r /user/konniam/week_03/hw_3_7_pass4
# Use 2 mappers and 1 reducer
!hadoop jar $HADOOP_HOME/share/hadoop/tools/lib/hadoop-streaming-*.jar \
-D mapreduce.job.output.key.comparator.class=org.apache.hadoop.mapreduce.lib.partition.KeyFieldBasedComparator \
-D stream.num.map.output.key.fields=4 \
-D mapreduce.partition.keycomparator.options="-k4,4nr -k3,3nr" \
-D mapreduce.job.maps=2 \
-D mapreduce.job.reduces=1 \
```

```
-mapper $PWD/mapper_3_7_pass4.py \
-reducer $PWD/reducer_3_7_pass4.py \
-input /user/konniam/week_03/hw_3_7_pass3/part* \
-output /user/konniam/week_03/hw_3_7_pass4 \
-file L2_counts.txt
```

```
16/02/04 00:06:34 WARN util.NativeCodeLoader: Unable to load native-hadoop library for your platform... using buil
tin-java classes where applicable
16/02/04 00:06:35 INFO fs.TrashPolicyDefault: Namenode trash configuration: Deletion interval = 0 minutes, Emptier
 interval = 0 minutes.
Deleted /user/konniam/week_03/hw_3_7_pass4
16/02/04 00:06:36 WARN streaming.StreamJob: -file option is deprecated, please use generic option -files instead.
16/02/04 00:06:36 WARN util.NativeCodeLoader: Unable to load native-hadoop library for your platform... using buil
tin-java classes where applicable
packageJobJar: [L2_counts.txt, /var/folders/l8/h51_59852qscq403fs6q0xlh0000gn/T/hadoop-unjar3104935187276488070/]
[] /var/folders/l8/h51_59852qscq403fs6q0xlh0000gn/T/streamjob102885312347332334.jar tmpDir=null
16/02/04 00:06:37 INFO client.RMProxy: Connecting to ResourceManager at /0.0.0.0:8032
16/02/04 00:06:38 INFO client.RMProxy: Connecting to ResourceManager at /0.0.0.0:8032
16/02/04 00:06:39 INFO mapred.FileInputFormat: Total input paths to process : 2
16/02/04 00:06:39 INFO mapreduce.JobSubmitter: number of splits:3
16/02/04 00:06:39 INFO mapreduce.JobSubmitter: Submitting tokens for job: job_1454487534358_0036
16/02/04 00:06:40 INFO impl.YarnClientImpl: Submitted application application_1454487534358_0036
16/02/04 00:06:40 INFO mapreduce.Job: The url to track the job: http://Konniams-MacBook-Air.local:8088/proxy/appli
cation_1454487534358_0036/
16/02/04 00:06:40 INFO mapreduce.Job: Running job: job_1454487534358_0036
16/02/04 00:06:49 INFO mapreduce.Job: Job job_1454487534358_0036 running in uber mode : false
16/02/04 00:06:49 INFO mapreduce.Job:  map 0% reduce 0%
16/02/04 00:07:03 INFO mapreduce.Job:  map 67% reduce 0%
16/02/04 00:07:04 INFO mapreduce.Job:  map 100% reduce 0%
16/02/04 00:07:12 INFO mapreduce.Job:  map 100% reduce 100%
16/02/04 00:07:12 INFO mapreduce.Job: Job job_1454487534358_0036 completed successfully
16/02/04 00:07:12 INFO mapreduce.Job: Counters: 49
        File System Counters
                FILE: Number of bytes read=49920
                FILE: Number of bytes written=576737
                FILE: Number of read operations=0
                FILE: Number of large read operations=0
                FILE: Number of write operations=0
                HDFS: Number of bytes read=12761
                HDFS: Number of bytes written=577
                HDFS: Number of read operations=12
                HDFS: Number of large read operations=0
                HDFS: Number of write operations=2
        Job Counters
                Launched map tasks=3
                Launched reduce tasks=1
                Data-local map tasks=3
                Total time spent by all maps in occupied slots (ms)=38243
                Total time spent by all reduces in occupied slots (ms)=4924
                Total time spent by all map tasks (ms)=38243
                Total time spent by all reduce tasks (ms)=4924
                Total vcore-seconds taken by all map tasks=38243
                Total vcore-seconds taken by all reduce tasks=4924
                Total megabyte-seconds taken by all map tasks=39160832
                Total megabyte-seconds taken by all reduce tasks=5042176
        Map-Reduce Framework
                Map input records=233
                Map output records=699
                Map output bytes=48516
                Map output materialized bytes=49932
                Input split bytes=354
                Combine input records=0
                Combine output records=0
                Reduce input groups=699
                Reduce shuffle bytes=49932
                Reduce input records=699
                Reduce output records=10
                Spilled Records=1398
                Shuffled Maps =3
                Failed Shuffles=0
                Merged Map outputs=3
                GC time elapsed (ms)=665
                CPU time spent (ms)=0
                Physical memory (bytes) snapshot=0
                Virtual memory (bytes) snapshot=0
                Total committed heap usage (bytes)=688914432
        Shuffle Errors
                BAD_ID=0
                CONNECTION=0
                IO_ERROR=0
                WRONG_LENGTH=0
```

```
                WRONG_MAP=0
                WRONG_REDUCE=0
        File Input Format Counters
                Bytes Read=12407
        File Output Format Counters
                Bytes Written=577
16/02/04 00:07:12 INFO streaming.StreamJob: Output directory: /user/konniam/week_03/hw_3_7_pass4
```

Top 10 Rules by Confidence

(sorted by support if tied)

Results Formuat
(item1, item2) -> item3, supportCount, support, confidence

In [50]:
```
!hdfs dfs -cat /user/konniam/week_03/hw_3_7_pass4/part*
```

```
16/02/04 00:07:17 WARN util.NativeCodeLoader: Unable to load native-hadoop library for your platform... using buil
tin-java classes where applicable
GRO85051.SNA80324       -> FRO40251, 471,       0.0151442075817,        1.0
DAI75645.GRO85051       -> FRO40251, 395,       0.0127005562522,        1.0
ELE17451.GRO85051       -> FRO40251, 217,       0.00697726761197,       1.0
GRO73461.GRO85051       -> FRO40251, 147,       0.00472653612424,       1.0
ELE26917.GRO85051       -> FRO40251, 146,       0.00469438281727,       1.0
DAI23334.ELE92920       -> DAI62779, 143,       0.00459792289637,       1.0
ELE20847.GRO85051       -> FRO40251, 139,       0.0044693096685,        1.0
DAI55911.GRO85051       -> FRO40251, 133,       0.00427638982669,       1.0
ELE20847.FRO92469       -> FRO40251, 122,       0.00392270345005,       1.0
GRO21487.GRO85051       -> FRO40251, 120,       0.00385839683611,       1.0
```

HW3.8

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.

In [51]:
```
from fim import apriori
```

In [57]:
```
def apriori_3_8():
    # Pre-process to create iterable
    transactions = []
    with open('ProductPurchaseData.txt', 'r') as f:
        for line in f:
            items = line.strip().split()
            transactions.append(items)
    # Apriori
    results = apriori(transactions, target='r', supp=-100, zmin=3, zmax=3, report='asc')
    # Sort by confidence, then by support
    results = sorted(results, key=lambda x: (-x[4], -x[3]))
    for row in results[:10]:
        print row[1], row[0], row[2], row[3], row[4]

apriori_3_8()
```

```
('GRO85051', 'SNA80324') FRO40251 471 0.0151442075817 1.0
('GRO85051', 'DAI75645') FRO40251 395 0.0127005562522 1.0
('GRO85051', 'ELE17451') FRO40251 217 0.00697726761197 1.0
('GRO85051', 'GRO73461') FRO40251 147 0.00472653612424 1.0
('GRO85051', 'ELE26917') FRO40251 146 0.00469438281727 1.0
('DAI23334', 'ELE92920') DAI62779 143 0.00459792289637 1.0
('ELE20847', 'GRO85051') FRO40251 139 0.0044693096685 1.0
('DAI55911', 'GRO85051') FRO40251 133 0.00427638982669 1.0
('ELE20847', 'FRO92469') FRO40251 122 0.00392270345005 1.0
('GRO85051', 'GRO21487') FRO40251 120 0.00385839683611 1.0
```

The results of Mapreduce and pyFIM implementatioans are identical. In terms of execution times, pyFIM took less than 1 second, while MR took about 3 mins in total. Because the data set is small in this case and could be held in memory effectively, the in-memory approach of pyFIM is much faster. However, if the data set wee 1TB, Mapreduce could still handle it with multiple machines, where as pyFIM will fail to work.