MIDS - w261 Machine Learning At Scale

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

Assignment - HW5

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Week: 5

Due Time: 2 Phases.

- **HW5 Phase 1** This can be done on a local machine (with a unit test on the cloud such as AltaScale's PaaS or on AWS) and is due Tuesday, Week 6 by 8AM (West coast time). It will primarily focus on building a unit/systems and for pairwise similarity calculations pipeline (for stripe documents)
- **HW5 Phase 2** This will require the AltaScale cluster and will be due Tuesday, Week 7 by 8AM (West coast time). The focus of HW5 Phase 2 will be to scale up the unit/systems tests to the Google 5 gram corpus. This will be a group exercise

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1 Instructions

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MIDS UC Berkeley, Machine Learning at Scale
DATSCIW261 ASSIGNMENT #5

Version 2017-9-2

IMPORTANT

This homework must be completed in the cloud

=== INSTRUCTIONS for SUBMISSIONS ===

Follow the instructions for submissions carefully.

Each student has a `HW-<user>` repository for all assignments.

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

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

- Your local HW5 directory. Your repo file structure should look like this:

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

2 Useful References

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- See async and live lectures for this week

3 HW Problems

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PHASE 2

HW 5.4

Full-scale experiment on Google N-gram data on the CLOUD

Once you are happy with your test results proceed to generating your results on the Google n-grams dataset.

3. HW5.4.0 Run systems tests on the CLOUD (PHASE 2)

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Repeat HW5.3.0 (using the same small data sources that were used in HW5.3.0) on **the cloud** (e.g., AltaScale / AWS/ SoftLayer/ Azure). Make sure all tests give correct results! Good luck out there!

In [1]:
```
%load_ext autoreload
%autoreload 2
```

In [2]:
```
import sys
sys.executable
```

Out[2]:
```
'/home/nileshbhoyar/.conda/envs/py27/bin/python'
```

In [5]:
```
%%writefile buildStripes.py
#!~/anaconda2/bin/python
# -*- coding: utf-8 -*-

from __future__ import division
import re
import mrjob
import json
from mrjob.protocol import RawProtocol
from mrjob.job import MRJob
from mrjob.step import MRStep
from itertools import  combinations
class MRbuildStripes(MRJob):

  #START SUDENT CODE531_STRIPES
    SORT_VALUES = True

    #def __init__(self, *args, **kwargs):
    #    super(MRjoins, self).__init__(*args, **kwargs)




    def mapper(self, _, recs):
        self.increment_counter('Execution Counts', 'mapper calls', 1)
        fields = recs.split("\t")

        products = fields[0].lower().replace('\n','').split()
        for i, term in enumerate(products):
                # Create a new stripe for each term
                stripe = {}

                for j, token in enumerate(products):
                    # Don't count the term's co-occurrence with itself
                    if i != j:
                        x = stripe.get(token,None)
                        if x == None:
                            stripe[token] = int( fields[1])
                        else:
                            stripe[token] += int(fields[1])

                # Emit the term and the stripe
                yield term, stripe

    def combiner(self, word, stripes):
        yield word, self.combine_stripes(stripes)

    def combine_stripes(self, stripes):
        combined_stripe = {}

        for stripe in stripes:
            for key, value in stripe.iteritems():
                if key in combined_stripe:
                    combined_stripe[key] += int(value)
                else:
                    combined_stripe[key] = int(value)

        return combined_stripe
    def reducer(self,key, records):
        yield key, self.combine_stripes(records)

    def steps(self):  #pipeline of Map-Reduce jobs
        step = MRStep(
                    mapper=self.mapper,       # STEP 1: word count step
                    combiner = self.combiner,
                    reducer=self.reducer
                    )
        return [step]
```

```
Overwriting buildStripes.py
```

In [7]:
```
%%writefile invertedIndex.py
#!~/anaconda2/bin/python
# -*- coding: utf-8 -*-


from __future__ import division
import collections
import re
import json
import math
import numpy as np
import itertools
import mrjob
from mrjob.protocol import RawProtocol
from mrjob.job import MRJob
from mrjob.step import MRStep
from mrjob.protocol import JSONProtocol
class MRinvertedIndex(MRJob):
    INPUT_PROTOCOL = JSONProtocol
    SORT_VALUES = True
#START SUDENT CODE531_INV_INDEX
    def mapper_normalize_transpose(self, word, rate_stripe):

        # First compute the magnitude for the vector.

        #magnitude = math.sqrt(sum([value ** 2 for value in rate_stripe.interval
ues()]))

        # Divide each value in the vector by the magnitude to normalize.
        length = len(rate_stripe)
        for key, value in rate_stripe.iteritems():
            #normalized_value = value / magnitude
            yield key, { word: length}
    def combiner_normalize_transpose(self, word, transpose_stripes):
        yield word, self.combine_stripes(transpose_stripes)
    def reducer_normalize_transpose(self, word, transpose_stripes):
        yield word, self.combine_stripes(transpose_stripes)
    def combine_stripes(self, stripes):
        combined_stripe = {}

        for stripe in stripes:
            for key, value in stripe.iteritems():
                if key in combined_stripe:
                    combined_stripe[key] += value
                else:
                    combined_stripe[key] = value

        return combined_stripe


    def steps(self):

        transpose_step = MRStep(
            mapper = self.mapper_normalize_transpose,
            combiner = self.combiner_normalize_transpose,
            reducer = self.reducer_normalize_transpose)
        return [transpose_step]

#END SUDENT CODE531_INV_INDEX

if __name__ == '__main__':
    MRinvertedIndex.run()
```

```
Overwriting invertedIndex.py
```

In [9]:
```
%%writefile similarity.py
#!~/anaconda2/bin/python
# -*- coding: utf-8 -*-

from __future__ import division
import collections
import re
import json
import math
import numpy as np
import itertools
import mrjob
from mrjob.protocol import RawProtocol
from mrjob.job import MRJob
from mrjob.step import MRStep
from mrjob.protocol import JSONProtocol

class MRsimilarity(MRJob):
    INPUT_PROTOCOL = JSONProtocol
    SORT_VALUES = True

#START SUDENT CODE531_SIMILARITY
    def mapper_jaccard(self, word, rate_stripe):
        #get all words and lengths
#We will emit stripes for each word vector here.  These stripes will
#be used in combiner to find the common length i.e. words occuring together
        nonzero_keys = [key for key, value in rate_stripe.iteritems() if value
!= 0]



        sorted_keys = sorted(nonzero_keys)
        # N * N  complexity matrix calculation
        #We are going over each record to find out the common occureances
        for i in range(0, len(sorted_keys)):
            left_label = sorted_keys[i]

            stripe = {}

            for j in range(i + 1, len(sorted_keys)):
                right_label = sorted_keys[j]
                stripe[right_label] = 1

            yield left_label, stripe



        for key in sorted_keys:
            yield '*',{key:1}
            #{u'DocC': 1}
        #yield '*', { key: 1 for key in sorted_keys }
    def combiner_jaccard(self, left_label, partial_stripes):
        yield left_label, self.combine_stripes(partial_stripes)

#find out the jaccard values.
    def reducer_jaccard(self, left_label, partial_stripes):
        total_stripe = self.combine_stripes(partial_stripes)
        #this stores the total length of each word Vector
        if left_label == '*':
            self.total_counts = total_stripe
            return

        for right_label, intersection_size in total_stripe.iteritems():
            coordinate = (left_label, right_label)
            union_size = self.total_counts[left_label] + self.total_counts[righ
t_label]


            jaccard_distance = float(intersection_size)/float(union_size - inte
```

```
Overwriting similarity.py
```

In [12]:
```
%%writefile googlebooks-eng-all-5gram-20090715-0-filtered-first-10-lines.txt
A BILL FOR ESTABLISHING RELIGIOUS       59      59      54
A Biography of General George   92      90      74
A Case Study in Government      102     102     78
A Case Study of Female  447     447     327
A Case Study of Limited 55      55      43
A Child's Christmas in Wales    1099    1061    866
A Circumstantial Narrative of the       62      62      50
A City by the Sea       62      60      49
A Collection of Fairy Tales     123     117     80
A Collection of Forms of        116     103     82
```

```
Overwriting googlebooks-eng-all-5gram-20090715-0-filtered-first-10-lines.txt
```

In [13]:
```
%%writefile atlas-boon-systems-test.txt
atlas boon      50      50      50
boon cava dipped        10      10      10
atlas dipped    15      15      15
```

```
Overwriting atlas-boon-systems-test.txt
```

In [13]:
```
#copy all files on local folder

!rm -r /home/nileshbhoyar/data
!hdfs dfs -copyToLocal hdfs:///user/cendylin/filtered-5Grams/ /home/nileshbhoya
r/data
```

In [14]:
```
#!hdfs dfs rm --recursive systems_test_stripes_1
!python buildStripes.py -r local googlebooks-eng-all-5gram-20090715-0-filtered-first-10-lines.txt > systems_test_stripes_1
!cat systems_test_stripes_1
```

```
No configs found; falling back on auto-configuration
ignoring partitioner keyword arg (requires real Hadoop): 'org.apache.hadoop.mapred.lib.KeyFieldBasedPartitioner'
Creating temp directory /tmp/buildStripes.nileshbhoyar.20170622.134335.594889
Running step 1 of 1...
Counters: 1
        Execution Counts
                mapper calls=10
Counters: 1
        Execution Counts
                mapper calls=10
Streaming final output from /tmp/buildStripes.nileshbhoyar.20170622.134335.594889/output...
Removing temp directory /tmp/buildStripes.nileshbhoyar.20170622.134335.594889...
"forms" {"a":116,"of":232,"collection":116}
"general"       {"a":92,"of":92,"george":92,"biography":92}
"george"        {"a":92,"of":92,"biography":92,"general":92}
"government"    {"a":102,"case":102,"study":102,"in":102}
"in"    {"a":1201,"case":102,"government":102,"study":102,"child's":1099,"wales":1099,"christmas":1099}
"limited"       {"a":55,"case":55,"study":55,"of":55}
"narrative"     {"a":62,"of":62,"the":62,"circumstantial":62}
"of"    {"a":1011,"case":502,"circumstantial":62,"george":92,"limited":55,"of":232,"tales":123,"collection":355,"general":92,"forms":232,"female":447,"narrative":62,"study":502,"fairy":123,"the":62,"biography":92}
"religious"     {"a":59,"bill":59,"for":59,"establishing":59}
"sea"   {"a":62,"city":62,"the":62,"by":62}
"study" {"a":604,"case":604,"limited":55,"government":102,"of":502,"female":447,"in":102}
"tales" {"a":123,"of":123,"fairy":123,"collection":123}
"the"   {"a":124,"city":62,"circumstantial":62,"of":62,"sea":62,"narrative":62,"by":62}
"wales" {"a":1099,"in":1099,"christmas":1099,"child's":1099}
"a"     {"limited":55,"sea":62,"general":92,"female":447,"in":1201,"religious":59,"george":92,"biography":92,"city":62,"for":59,"tales":123,"child's":1099,"forms":116,"wales":1099,"christmas":1099,"government":102,"collection":239,"by":62,"case":604,"circumstantial":62,"fairy":123,"of":1011,"study":604,"bill":59,"establishing":59,"narrative":62,"the":124}
"bill"  {"a":59,"religious":59,"for":59,"establishing":59}
"biography"     {"a":92,"of":92,"george":92,"general":92}
"by"    {"a":62,"city":62,"the":62,"sea":62}
"case"  {"a":604,"limited":55,"government":102,"of":502,"study":604,"female":447,"in":102}
"child's"       {"a":1099,"wales":1099,"christmas":1099,"in":1099}
"christmas"     {"a":1099,"wales":1099,"in":1099,"child's":1099}
"circumstantial"        {"a":62,"of":62,"the":62,"narrative":62}
"city"  {"a":62,"the":62,"by":62,"sea":62}
"collection"    {"a":239,"of":355,"fairy":123,"tales":123,"forms":116}
"establishing"  {"a":59,"bill":59,"religious":59,"for":59}
"fairy" {"a":123,"of":123,"tales":123,"collection":123}
"female"        {"a":447,"case":447,"study":447,"of":447}
"for"   {"a":59,"bill":59,"religious":59,"establishing":59}
```

In [15]:
```
##############################################################################
# Make Stripes from ngrams for systems test 2
##############################################################################

!hdfs dfs rm --recursive systems_test_stripes_2
!python buildStripes.py -r local atlas-boon-systems-test.txt > systems_test_str
ipes_2
```

```
rm: Unknown command
Did you mean -rm?  This command begins with a dash.
No configs found; falling back on auto-configuration
ignoring partitioner keyword arg (requires real Hadoop): 'org.apache.hadoop.ma
pred.lib.KeyFieldBasedPartitioner'
Creating temp directory /tmp/buildStripes.nileshbhoyar.20170622.134337.535810
Running step 1 of 1...
Counters: 1
        Execution Counts
                mapper calls=3
Counters: 1
        Execution Counts
                mapper calls=3
Streaming final output from /tmp/buildStripes.nileshbhoyar.20170622.134337.535
810/output...
Removing temp directory /tmp/buildStripes.nileshbhoyar.20170622.134337.535810.
..
```

In [16]:
```
with open("systems_test_stripes_3", "w") as f:
    f.writelines([
        '"DocA"\t{"X":20, "Y":30, "Z":5}\n',
        '"DocB"\t{"X":100, "Y":20}\n',
        '"DocC"\t{"M":5, "N":20, "Z":5, "Y":1}\n'
    ])
!cat systems_test_stripes_3
```

```
"DocA"  {"X":20, "Y":30, "Z":5}
"DocB"  {"X":100, "Y":20}
"DocC"  {"M":5, "N":20, "Z":5, "Y":1}
```

In [17]:
```
!python invertedIndex.py -r local systems_test_stripes_1 > systems_test_index_1
!python invertedIndex.py -r local systems_test_stripes_2 > systems_test_index_2
!python invertedIndex.py -r local systems_test_stripes_3 > systems_test_index_3
```

```
No configs found; falling back on auto-configuration
ignoring partitioner keyword arg (requires real Hadoop): 'org.apache.hadoop.ma
pred.lib.KeyFieldBasedPartitioner'
Creating temp directory /tmp/invertedIndex.nileshbhoyar.20170622.134439.961757
Running step 1 of 1...
Streaming final output from /tmp/invertedIndex.nileshbhoyar.20170622.134439.96
1757/output...
Removing temp directory /tmp/invertedIndex.nileshbhoyar.20170622.134439.961757
...
No configs found; falling back on auto-configuration
ignoring partitioner keyword arg (requires real Hadoop): 'org.apache.hadoop.ma
pred.lib.KeyFieldBasedPartitioner'
Creating temp directory /tmp/invertedIndex.nileshbhoyar.20170622.134441.181151
Running step 1 of 1...
Streaming final output from /tmp/invertedIndex.nileshbhoyar.20170622.134441.18
1151/output...
Removing temp directory /tmp/invertedIndex.nileshbhoyar.20170622.134441.181151
...
No configs found; falling back on auto-configuration
ignoring partitioner keyword arg (requires real Hadoop): 'org.apache.hadoop.ma
pred.lib.KeyFieldBasedPartitioner'
Creating temp directory /tmp/invertedIndex.nileshbhoyar.20170622.134442.393751
Running step 1 of 1...
Streaming final output from /tmp/invertedIndex.nileshbhoyar.20170622.134442.39
3751/output...
Removing temp directory /tmp/invertedIndex.nileshbhoyar.20170622.134442.393751
...
```

In [18]:
```
##############################################################
# Pretty print systems tests for generating Inverted Index
##############################################################

import json

for i in range(1,4):
    print "-"*100
    print "Systems test ",i," - Inverted Index"
    print "-"*100
    with open("systems_test_index_"+str(i),"r") as f:
        lines = sorted(f.readlines())
        for line in lines:
            line = line.strip()
            word, doc_list = line.split("\t")
            doc_dict = json.loads(doc_list)
            stripe=[]
            for doc in doc_dict:
                stripe.append([doc, doc_dict[doc]])
            stripe=sorted(stripe)
            stripe.extend([["",""] for _ in xrange(3 - len(stripe))])

            print "{0:>16} |{1:>16} |{2:>16} |{3:>16}".format(
              (word), stripe[0][0]+" "+str(stripe[0][1]), stripe[1][0]+" "+str(
stripe[1][1]), stripe[2][0]+" "+str(stripe[2][1]))
```

```
Systems test  1  - Inverted Index
```

"a"	bill 4	biography 4	by 4
"bill"	a 27	establishing 4	for 4
"biography"	a 27	general 4	george 4
"by"	a 27	city 4	sea 4
"case"	a 27	female 4	government 4
"child's"	a 27	christmas 4	in 7
"christmas"	a 27	child's 4	in 7
"circumstantial"	a 27	narrative 4	of 16
"city"	a 27	by 4	sea 4
"collection"	a 27	fairy 4	forms 3
"establishing"	a 27	bill 4	for 4
"fairy"	a 27	collection 5	of 16
"female"	a 27	case 7	of 16
"for"	a 27	bill 4	establishing 4
"forms"	a 27	collection 5	of 16
"general"	a 27	biography 4	george 4
"george"	a 27	biography 4	general 4
"government"	a 27	case 7	in 7
"in"	a 27	case 7	child's 4
"limited"	a 27	case 7	of 16
"narrative"	a 27	circumstantial 4	of 16
"of"	a 27	biography 4	case 7
"religious"	a 27	bill 4	establishing 4
"sea"	a 27	by 4	city 4
"study"	a 27	case 7	female 4
"tales"	a 27	collection 5	fairy 4
"the"	a 27	by 4	circumstantial 4
"wales"	a 27	child's 4	christmas 4

```
Systems test  2  - Inverted Index
```

"atlas"	boon 3	dipped 3	
"boon"	atlas 2	cava 2	dipped 3
"cava"	boon 3	dipped 3	
"dipped"	atlas 2	boon 3	cava 2

```
Systems test  3  - Inverted Index
```

"M"	DocC 4		
"N"	DocC 4		
"X"	DocA 3	DocB 2	
"Y"	DocA 3	DocB 2	DocC 4
"Z"	DocA 3	DocC 4	

In [19]:
```
!python similarity.py -r hadoop systems_test_index_1 --cmdenv PATH=/opt/anacond
a/bin:$PATH  > systems_test_similarities_1
```

```
No configs found; falling back on auto-configuration
Creating temp directory /tmp/similarity.nileshbhoyar.20170622.134515.421078
Looking for hadoop binary in /opt/hadoop/bin...
Found hadoop binary: /opt/hadoop/bin/hadoop
Using Hadoop version 2.7.3
Copying local files to hdfs:///user/nileshbhoyar/tmp/mrjob/similarity.nileshbh
oyar.20170622.134515.421078/files/...
Looking for Hadoop streaming jar in /opt/hadoop...
Found Hadoop streaming jar: /opt/hadoop/share/hadoop/tools/lib/hadoop-streamin
g-2.7.3.jar
Detected hadoop configuration property names that do not match hadoop version
2.7.3:
The have been translated as follows
 mapred.output.key.comparator.class: mapreduce.job.output.key.comparator.class
mapred.text.key.comparator.options: mapreduce.partition.keycomparator.options
mapred.text.key.partitioner.options: mapreduce.partition.keypartitioner.option
s
Running step 1 of 1...
  packageJobJar: [] [/opt/hadoop-2.7.3/share/hadoop/tools/lib/hadoop-streaming
-2.7.3.jar] /tmp/streamjob6051991845423607969.jar tmpDir=null
  Timeline service address: http://rm-ia.s3s.altiscale.com:8188/ws/v1/timeline
/
  Connecting to ResourceManager at rm-ia.s3s.altiscale.com/10.251.255.108:8032
  Connecting to Application History server at rm-ia.s3s.altiscale.com/10.251.2
55.108:10200
  Timeline service address: http://rm-ia.s3s.altiscale.com:8188/ws/v1/timeline
/
  Connecting to ResourceManager at rm-ia.s3s.altiscale.com/10.251.255.108:8032
  Connecting to Application History server at rm-ia.s3s.altiscale.com/10.251.2
55.108:10200
  Loaded native gpl library from the embedded binaries
  Successfully loaded & initialized native-lzo library [hadoop-lzo rev d62701d
4d05dfa6115bbaf8d9dff002df142e62d]
  Total input paths to process : 1
  number of splits:2
  Submitting tokens for job: job_1497906899862_1898
  Submitted application application_1497906899862_1898
  The url to track the job: http://rm-ia.s3s.altiscale.com:8088/proxy/applicat
ion_1497906899862_1898/
  Running job: job_1497906899862_1898
  Job job_1497906899862_1898 running in uber mode : false
   map 0% reduce 0%
   map 100% reduce 0%
   map 100% reduce 100%
  Job job_1497906899862_1898 completed successfully
  Output directory: hdfs:///user/nileshbhoyar/tmp/mrjob/similarity.nileshbhoya
r.20170622.134515.421078/output
Counters: 49
        File Input Format Counters
                Bytes Read=2868
        File Output Format Counters
                Bytes Written=27736
        File System Counters
                FILE: Number of bytes read=2211
                FILE: Number of bytes written=405587
                FILE: Number of large read operations=0
                FILE: Number of read operations=0
                FILE: Number of write operations=0
                HDFS: Number of bytes read=3248
                HDFS: Number of bytes written=27736
                HDFS: Number of large read operations=0
                HDFS: Number of read operations=9
                HDFS: Number of write operations=2
        Job Counters
                Launched map tasks=2
                Launched reduce tasks=1
                Rack-local map tasks=2
                Total megabyte-milliseconds taken by all map tasks=19418112
                Total megabyte-milliseconds taken by all reduce tasks=10606080
                Total time spent by all map tasks (ms)=12642
```

In [20]:
```
!python similarity.py -r hadoop systems_test_index_3 --cmdenv PATH=/opt/anacond
a/bin:$PATH > systems_test_similarities_3
```

```
No configs found; falling back on auto-configuration
Creating temp directory /tmp/similarity.nileshbhoyar.20170622.134735.588689
Looking for hadoop binary in /opt/hadoop/bin...
Found hadoop binary: /opt/hadoop/bin/hadoop
Using Hadoop version 2.7.3
Copying local files to hdfs:///user/nileshbhoyar/tmp/mrjob/similarity.nileshbh
oyar.20170622.134735.588689/files/...
Looking for Hadoop streaming jar in /opt/hadoop...
Found Hadoop streaming jar: /opt/hadoop/share/hadoop/tools/lib/hadoop-streamin
g-2.7.3.jar
Detected hadoop configuration property names that do not match hadoop version
2.7.3:
The have been translated as follows
 mapred.output.key.comparator.class: mapreduce.job.output.key.comparator.class
mapred.text.key.comparator.options: mapreduce.partition.keycomparator.options
mapred.text.key.partitioner.options: mapreduce.partition.keypartitioner.option
s
Running step 1 of 1...
  packageJobJar: [] [/opt/hadoop-2.7.3/share/hadoop/tools/lib/hadoop-streaming
-2.7.3.jar] /tmp/streamjob8666199577463701867.jar tmpDir=null
  Timeline service address: http://rm-ia.s3s.altiscale.com:8188/ws/v1/timeline
/
  Connecting to ResourceManager at rm-ia.s3s.altiscale.com/10.251.255.108:8032
  Connecting to Application History server at rm-ia.s3s.altiscale.com/10.251.2
55.108:10200
  Timeline service address: http://rm-ia.s3s.altiscale.com:8188/ws/v1/timeline
/
  Connecting to ResourceManager at rm-ia.s3s.altiscale.com/10.251.255.108:8032
  Connecting to Application History server at rm-ia.s3s.altiscale.com/10.251.2
55.108:10200
  Loaded native gpl library from the embedded binaries
  Successfully loaded & initialized native-lzo library [hadoop-lzo rev d62701d
4d05dfa6115bbaf8d9dff002df142e62d]
  Total input paths to process : 1
  number of splits:2
  Submitting tokens for job: job_1497906899862_1900
  Submitted application application_1497906899862_1900
  The url to track the job: http://rm-ia.s3s.altiscale.com:8088/proxy/applicat
ion_1497906899862_1900/
  Running job: job_1497906899862_1900
  Job job_1497906899862_1900 running in uber mode : false
   map 0% reduce 0%
   map 100% reduce 0%
   map 100% reduce 100%
  Job job_1497906899862_1900 completed successfully
  Output directory: hdfs:///user/nileshbhoyar/tmp/mrjob/similarity.nileshbhoya
r.20170622.134735.588689/output
Counters: 49
        File Input Format Counters
                Bytes Read=167
        File Output Format Counters
                Bytes Written=236
        File System Counters
                FILE: Number of bytes read=123
                FILE: Number of bytes written=401284
                FILE: Number of large read operations=0
                FILE: Number of read operations=0
                FILE: Number of write operations=0
                HDFS: Number of bytes read=547
                HDFS: Number of bytes written=236
                HDFS: Number of large read operations=0
                HDFS: Number of read operations=9
                HDFS: Number of write operations=2
        Job Counters
                Launched map tasks=2
                Launched reduce tasks=1
                Rack-local map tasks=2
                Total megabyte-milliseconds taken by all map tasks=12518400
                Total megabyte-milliseconds taken by all reduce tasks=10247680
                Total time spent by all map tasks (ms)=8150
```

In [21]:
```
##########################################
# Pretty print systems tests
##########################################

import json
for i in range(3,0,-1):
  print '—'*110
  print "Systems test ",i," - Similarity measures"
  print '—'*110
  print "{0:>15} |{1:>15}|{2:>15}".format(
            "pair",  "jaccard","Dice")
  print '-'*110

  with open("systems_test_similarities_"+str(i),"r") as f:
      lines = f.readlines()
      for line in lines:
          line = line.strip()
          pair,stripe = line.split("\t")
          stripe = json.loads(stripe)

          print "{0:>15} |{1:>15f}|{2:>15f}".format(
              pair,float(stripe['jaccard']),float(stripe['dice'] ))
#          print "{0:>15f} |{1:>15} |{2:>15f} |{3:>15f} |{4:>15f} |{5:>15f}".fo
rmat(
#                float(avg), stripe[0], float(stripe[1]), float(stripe[2]), floa
t(stripe[3]), float(stripe[4]))
          #print
```

```
_____________________________________________________________________________________
_____________________________
Systems test  3  - Similarity measures
_____________________________________________________________________________________
_____________________________
           pair |        jaccard|           Dice
-------------------------------------------------------------------------------------
--------------------------------
["DocA", "DocB"] |       0.666667|       0.800000
["DocA", "DocC"] |       0.400000|       0.571429
["DocB", "DocC"] |       0.200000|       0.333333
_____________________________________________________________________________________
_____________________________
Systems test  2  - Similarity measures
_____________________________________________________________________________________
_____________________________
           pair |        jaccard|           Dice
-------------------------------------------------------------------------------------
--------------------------------
["atlas","dipped"] |       0.250000|       0.400000
["atlas","boon"] |       0.250000|       0.400000
["atlas","cava"] |       1.000000|       1.000000
["boon","dipped"] |       0.500000|       0.666667
["boon","cava"] |       0.250000|       0.400000
["cava","dipped"] |       0.250000|       0.400000
_____________________________________________________________________________________
_____________________________
Systems test  1  - Similarity measures
_____________________________________________________________________________________
_____________________________
           pair |        jaccard|           Dice
-------------------------------------------------------------------------------------
--------------------------------
["a", "limited"] |       0.107143|       0.193548
   ["a", "sea"] |       0.107143|       0.193548
["a", "general"] |       0.107143|       0.193548
["a", "female"] |       0.107143|       0.193548
    ["a", "in"] |       0.214286|       0.352941
["a", "religious"] |       0.107143|       0.193548
["a", "george"] |       0.107143|       0.193548
["a", "biography"] |       0.107143|       0.193548
  ["a", "city"] |       0.107143|       0.193548
   ["a", "for"] |       0.107143|       0.193548
 ["a", "tales"] |       0.107143|       0.193548
["a", "government"] |       0.107143|       0.193548
   ["a", "the"] |       0.214286|       0.352941
 ["a", "forms"] |       0.071429|       0.133333
 ["a", "wales"] |       0.107143|       0.193548
["a", "christmas"] |       0.107143|       0.193548
["a", "child's"] |       0.107143|       0.193548
["a", "collection"] |       0.142857|       0.250000
    ["a", "by"] |       0.107143|       0.193548
  ["a", "case"] |       0.214286|       0.352941
["a", "circumstantial"] |       0.107143|       0.193548
    ["a", "of"] |       0.535714|       0.697674
 ["a", "study"] |       0.214286|       0.352941
  ["a", "bill"] |       0.107143|       0.193548
["a", "establishing"] |       0.107143|       0.193548
["a", "narrative"] |       0.107143|       0.193548
 ["a", "fairy"] |       0.107143|       0.193548
["bill", "limited"] |       0.142857|       0.250000
["bill", "sea"] |       0.142857|       0.250000
["bill", "general"] |       0.142857|       0.250000
["bill", "female"] |       0.142857|       0.250000
 ["bill", "in"] |       0.100000|       0.181818
["bill", "religious"] |       0.600000|       0.750000
["bill", "george"] |       0.142857|       0.250000
["bill", "biography"] |       0.142857|       0.250000
["bill", "city"] |       0.142857|       0.250000
["bill", "for"] |       0.600000|       0.750000
```

3. HW5.4.1 Full-scale experiment: EDA of Google n-grams dataset (PHASE 2)

Back to Table of Contents

Do some EDA on this dataset using mrjob, e.g.,

- A. Longest 5-gram (number of characters)
- B. Top 10 most frequent words (please use the count information), i.e., unigrams
- C. 20 Most/Least densely appearing words (count/pages_count) sorted in decreasing order of relative frequency
- D. Distribution of 5-gram sizes (character length). E.g., count (using the count field) up how many times a 5-gram of 50 characters shows up. Plot the data graphically using a histogram.

HW5.4.1 - A. Longest 5-gram (number of characters)

In [50]:
```
%%writefile longest5gram.py
#!~/anaconda2/bin/python
# -*- coding: utf-8 -*-

import re

import mrjob
from mrjob.protocol import RawProtocol
from mrjob.job import MRJob
from mrjob.step import MRStep
import sys
class longest5gram(MRJob):

    # START STUDENT CODE 5.4.1.A


    def mapper(self, _,recs):
        fields = recs.split("\t")
        ngram_length = len(fields[0])
        yield None, (ngram_length, fields[0])


    def combiner(self, _, pairs):
        yield None, self.get_longest_ngram(pairs)


    def reducer(self, _, pairs):
        ngram_length, ngram = self.get_longest_ngram(pairs)
        yield None,(ngram_length, ngram)
    def reducer_second(self, _,pairs):
        ngram_length, ngram = self.get_longest_ngram(pairs)
        yield ngram_length, ngram
        #yield None,pairs

    def get_longest_ngram(self, pairs):
        longest_ngram = None
        longest_ngram_length = 0

        for ngram_length, ngram in pairs:
            if ngram_length > longest_ngram_length:
                longest_ngram = ngram
                longest_ngram_length = ngram_length
            elif ngram_length == longest_ngram_length and ngram < longest_ngram
:
                longest_ngram = ngram

        return longest_ngram_length, longest_ngram
    def steps(self):  #pipeline of Map-Reduce jobs

        return [
            MRStep(
                    mapper=self.mapper,
                    combiner=self.combiner,
                    reducer=self.reducer,
                    jobconf = {
                    'mapreduce.job.reduces': 5,
                    'mapreduce.reduce.cpu.vcores':8
                }

            ),
            MRStep(reducer=self.reducer_second,
                  jobconf = {
                    'mapreduce.job.reduces': 1,
                    'mapreduce.reduce.cpu.vcores':8
                }
                  ) # Step 2: most frequent word
        ]
```

```
Overwriting longest5gram.py
```

On test data set:

In [51]:
```
#!python longest5gram.py -r hadoop "hdfs:///user/cendylin/filtered-5Grams/*.txt
" > outputlongest.txt
%time !python longest5gram.py -r local "googlebooks-eng-all-5gram-20090715-0-fi
ltered-first-10-lines.txt"
```

```
No configs found; falling back on auto-configuration
Creating temp directory /tmp/longest5gram.nileshbhoyar.20170622.142918.800894
Running step 1 of 2...
Running step 2 of 2...
Streaming final output from /tmp/longest5gram.nileshbhoyar.20170622.142918.800
894/output...
33      "A BILL FOR ESTABLISHING RELIGIOUS"
Removing temp directory /tmp/longest5gram.nileshbhoyar.20170622.142918.800894.
..
CPU times: user 26 ms, sys: 13 ms, total: 39 ms
Wall time: 1.25 s
```

On full data set:

In [52]:
```
#!python longest5gram.py -r hadoop "hdfs:///user/cendylin/filtered-5Grams/*.txt
" > outputlongest.txt
%time !python longest5gram.py -r hadoop "hdfs:///user/cendylin/filtered-5Grams/
" > outputlongest.txt
```

```
No configs found; falling back on auto-configuration
Looking for hadoop binary in /opt/hadoop/bin...
Found hadoop binary: /opt/hadoop/bin/hadoop
Creating temp directory /tmp/longest5gram.nileshbhoyar.20170622.142922.541791
Using Hadoop version 2.7.3
Copying local files to hdfs:///user/nileshbhoyar/tmp/mrjob/longest5gram.nilesh
bhoyar.20170622.142922.541791/files/...
Looking for Hadoop streaming jar in /opt/hadoop...
Found Hadoop streaming jar: /opt/hadoop/share/hadoop/tools/lib/hadoop-streamin
g-2.7.3.jar
Running step 1 of 2...
  packageJobJar: [] [/opt/hadoop-2.7.3/share/hadoop/tools/lib/hadoop-streaming
-2.7.3.jar] /tmp/streamjob6208803200533625506.jar tmpDir=null
  Timeline service address: http://rm-ia.s3s.altiscale.com:8188/ws/v1/timeline
/
  Connecting to ResourceManager at rm-ia.s3s.altiscale.com/10.251.255.108:8032
  Connecting to Application History server at rm-ia.s3s.altiscale.com/10.251.2
55.108:10200
  Timeline service address: http://rm-ia.s3s.altiscale.com:8188/ws/v1/timeline
/
  Connecting to ResourceManager at rm-ia.s3s.altiscale.com/10.251.255.108:8032
  Connecting to Application History server at rm-ia.s3s.altiscale.com/10.251.2
55.108:10200
  Loaded native gpl library from the embedded binaries
  Successfully loaded & initialized native-lzo library [hadoop-lzo rev d62701d
4d05dfa6115bbaf8d9dff002df142e62d]
  Total input paths to process : 190
  number of splits:190
  Submitting tokens for job: job_1497906899862_1917
  Submitted application application_1497906899862_1917
  The url to track the job: http://rm-ia.s3s.altiscale.com:8088/proxy/applicat
ion_1497906899862_1917/
  Running job: job_1497906899862_1917
  Job job_1497906899862_1917 running in uber mode : false
   map 0% reduce 0%
   map 1% reduce 0%
   map 2% reduce 0%
   map 4% reduce 0%
   map 5% reduce 0%
   map 6% reduce 0%
   map 7% reduce 0%
   map 8% reduce 0%
   map 9% reduce 0%
   map 11% reduce 0%
   map 13% reduce 0%
   map 14% reduce 0%
   map 16% reduce 0%
   map 18% reduce 0%
   map 19% reduce 0%
   map 21% reduce 0%
   map 23% reduce 0%
   map 24% reduce 0%
   map 26% reduce 0%
   map 27% reduce 0%
   map 29% reduce 0%
   map 31% reduce 0%
   map 33% reduce 0%
   map 35% reduce 0%
   map 37% reduce 0%
   map 38% reduce 0%
   map 40% reduce 0%
   map 41% reduce 0%
   map 43% reduce 0%
   map 44% reduce 0%
   map 46% reduce 0%
   map 47% reduce 0%
   map 48% reduce 0%
   map 50% reduce 0%
   map 52% reduce 0%
   map 54% reduce 0%
```

Report Stats:

Step1

No of maps 190

No of Reducers 10

Total time for haddop jobs 1mins, 19sec

Step 2

No of reducers 1

No of maps 2

Total time 17 sec

Step 1 http://rm-ia.s3s.altiscale.com:19888/jobhistory/job/job_1497906899862_1907 (http://rm-ia.s3s.altiscale.com:19888/jobhistory/job/job_1497906899862_1907)

Step 2 http://rm-ia.s3s.altiscale.com:19888/jobhistory/job/job_1497906899862_1909 (http://rm-ia.s3s.altiscale.com:19888/jobhistory/job/job_1497906899862_1909)

In [53]:
```
!cat outputlongest.txt
```

```
159     "AIOPJUMRXUYVASLYHYPSIBEMAPODIKR UFRYDIUUOLBIGASUAURUSREXLISNAYE RNOON
DQSRUNSUBUNOUGRABBERYAIRTC UTAHRAPTOREDILEIPMILBDUMMYUVERI SYEVRAHVELOCYALLOSA
URUSLINROTSR"
```

In [31]:
```
import nltk
nltk.download('punkt')
```

```
[nltk_data] Downloading package punkt to
[nltk_data]     /home/nileshbhoyar/nltk_data...
[nltk_data]   Package punkt is already up-to-date!
```

Out[31]: True

HW5.4.1 - B. Top 10 most frequent words

In [39]:
```
%%writefile mostFrequentWords.py
#!~/anaconda2/bin/python
# -*- coding: utf-8 -*-

import re

import mrjob
from mrjob.protocol import RawProtocol

#from mrjob.protocol import  RawValueProtocol
from mrjob.job import MRJob
from mrjob.step import MRStep

from collections import defaultdict

class mostFrequentWords(MRJob):
    INPUT_PROTOCOL = RawProtocol



    # START STUDENT CODE 5.4.1.B
    INPUT_PROTOCOL = RawProtocol
    MRJob.SORT_VALUES = True

    def mapper(self, key, value):
        words = re.findall("\w+", key.lower())
        #words =word_tokenize(key.lower())

        for word in words:
            yield word,1


    def combiner(self, word, counts):

         yield word, sum(counts)

    def reducer(self, word, counts):

         yield word, sum(counts)
    def steps(self):
        return [
            MRStep(
                    mapper=self.mapper,
                    combiner=self.combiner,
                    reducer=self.reducer,
                    jobconf = {
                    'mapreduce.job.reduces': 40,
                    'mapreduce.reduce.cpu.vcores':8
                    }
                  ),]



if __name__ == '__main__':
    mostFrequentWords.run()
```

```
Overwriting mostFrequentWords.py
```

On the test data set:

In [42]:
```
!python mostFrequentWords.py -r local "googlebooks-eng-all-5gram-20090715-0-fil
tered-first-10-lines.txt" > mostfrequent.txt
!cat mostfrequent.txt
```

```
No configs found; falling back on auto-configuration
ignoring partitioner keyword arg (requires real Hadoop): 'org.apache.hadoop.ma
pred.lib.KeyFieldBasedPartitioner'
Creating temp directory /tmp/mostFrequentWords.nileshbhoyar.20170622.141238.43
6925
Running step 1 of 1...
Streaming final output from /tmp/mostFrequentWords.nileshbhoyar.20170622.14123
8.436925/output...
Removing temp directory /tmp/mostFrequentWords.nileshbhoyar.20170622.141238.43
6925...
"collection"    2
"in"    2
"forms" 1
"bill"  1
"s"     1
"sea"   1
"george"        1
"limited"       1
"the"   2
"for"   1
"circumstantial"        1
"by"    1
"case"  3
"establishing"  1
"child" 1
"biography"     1
"a"     10
"wales" 1
"of"    7
"narrative"     1
"city"  1
"government"    1
"christmas"     1
"general"       1
"female"        1
"religious"     1
"tales" 1
"fairy" 1
"study" 3
```

On the full data set:

In [43]:
```
!hdfs dfs -mkdir hdfs:///user/nileshbhoyar/output/
!hdfs dfs -rm -r hdfs:///user/nileshbhoyar/output/HW541/
%time !python mostFrequentWords.py \
        -r hadoop \
        --output-dir="hdfs:///user/nileshbhoyar/output/HW541/"\
        --no-output \
        "hdfs:///user/cendylin/filtered-5Grams/"
```

```
mkdir: `hdfs:/user/nileshbhoyar/output': File exists
17/06/22 14:13:03 INFO fs.TrashPolicyDefault: Namenode trash configuration: De
letion interval = 5760 minutes, Emptier interval = 360 minutes.
Moved: 'hdfs://nn-ia.s3s.altiscale.com:8020/user/nileshbhoyar/output/HW541' to
trash at: hdfs://nn-ia.s3s.altiscale.com:8020/user/nileshbhoyar/.Trash/Current
No configs found; falling back on auto-configuration
Looking for hadoop binary in /opt/hadoop/bin...
Found hadoop binary: /opt/hadoop/bin/hadoop
Creating temp directory /tmp/mostFrequentWords.nileshbhoyar.20170622.141304.13
6799
Using Hadoop version 2.7.3
Copying local files to hdfs:///user/nileshbhoyar/tmp/mrjob/mostFrequentWords.n
ileshbhoyar.20170622.141304.136799/files/...
Looking for Hadoop streaming jar in /opt/hadoop...
Found Hadoop streaming jar: /opt/hadoop/share/hadoop/tools/lib/hadoop-streamin
g-2.7.3.jar
Detected hadoop configuration property names that do not match hadoop version
2.7.3:
The have been translated as follows
 mapred.output.key.comparator.class: mapreduce.job.output.key.comparator.class
mapred.text.key.comparator.options: mapreduce.partition.keycomparator.options
mapred.text.key.partitioner.options: mapreduce.partition.keypartitioner.option
s
Running step 1 of 1...
  packageJobJar: [] [/opt/hadoop-2.7.3/share/hadoop/tools/lib/hadoop-streaming
-2.7.3.jar] /tmp/streamjob8293326753705703331.jar tmpDir=null
  Timeline service address: http://rm-ia.s3s.altiscale.com:8188/ws/v1/timeline
/
  Connecting to ResourceManager at rm-ia.s3s.altiscale.com/10.251.255.108:8032
  Connecting to Application History server at rm-ia.s3s.altiscale.com/10.251.2
55.108:10200
  Timeline service address: http://rm-ia.s3s.altiscale.com:8188/ws/v1/timeline
/
  Connecting to ResourceManager at rm-ia.s3s.altiscale.com/10.251.255.108:8032
  Connecting to Application History server at rm-ia.s3s.altiscale.com/10.251.2
55.108:10200
  Loaded native gpl library from the embedded binaries
  Successfully loaded & initialized native-lzo library [hadoop-lzo rev d62701d
4d05dfa6115bbaf8d9dff002df142e62d]
  Total input paths to process : 190
  number of splits:190
  Submitting tokens for job: job_1497906899862_1912
  Submitted application application_1497906899862_1912
  The url to track the job: http://rm-ia.s3s.altiscale.com:8088/proxy/applicat
ion_1497906899862_1912/
  Running job: job_1497906899862_1912
  Job job_1497906899862_1912 running in uber mode : false
   map 0% reduce 0%
   map 1% reduce 0%
   map 2% reduce 0%
   map 3% reduce 0%
   map 4% reduce 0%
   map 5% reduce 0%
   map 6% reduce 0%
   map 7% reduce 0%
   map 8% reduce 0%
   map 9% reduce 0%
   map 10% reduce 0%
   map 11% reduce 0%
   map 12% reduce 0%
   map 13% reduce 0%
   map 14% reduce 0%
   map 15% reduce 0%
   map 16% reduce 0%
   map 17% reduce 0%
   map 18% reduce 0%
   map 19% reduce 0%
   map 20% reduce 0%
   map 21% reduce 0%
   map 22% reduce 0%
```

In [44]:
```
!rm frequentwords.txt
!hdfs dfs -cat hdfs:///user/nileshbhoyar/output/HW541/* > /home/nileshbhoyar/hw
-nileshbhoyar/HW5/frequentwords.txt
```

In [45]:
```
!sort -k2nr -k1 frequentwords.txt > frequentwords.txt_sorted.txt
```

In [46]:
```
!head -10 frequentwords.txt_sorted.txt
```

```
"the"   27502442
"of"    18191779
"to"    12075972
"in"    7881254
"a"     7853623
"and"   7767901
"that"  4327887
"is"    3847383
"be"    3288734
"for"   2763614
```

In [47]:
```
!head -10000 frequentwords.txt_sorted.txt > vocabulary.txt
!head -10000 frequentwords.txt_sorted.txt | tail -1000 > basis.txt
```

Most frequent words MR stats

Step 1:

```
RUNNING for 2mins, 51sec
Launched map tasks=190
Launched reduce tasks=3 sec

Job Name:   streamjob8293326753705703331.jar
User Name:  nileshbhoyar
Queue:  berkeley
State:  SUCCEEDED
Uberized:   false
Submitted:  Thu Jun 22 14:13:24 UTC 2017
Started:    Thu Jun 22 14:16:05 UTC 2017
Finished:   Thu Jun 22 14:25:40 UTC 2017
Elapsed:    9mins, 35sec
Diagnostics:
Average Map Time    2mins, 51sec
Average Shuffle Time    3sec
Average Merge Time  0sec
Average Reduce Time 3sec
```

http://rm-ia.s3s.altiscale.com:19888/jobhistory/job/job_1497906899862_1912/mapreduce/job/job_1497906899862_1912 (http://rm-ia.s3s.altiscale.com:19888/jobhistory/job/job_1497906899862_1912/mapreduce/job/job_1497906899862_1912)

HW5.4.1 - C. 20 Most/Least densely appearing words

In [202]:
```
%%writefile mostLeastDenseWords.py
#!~/anaconda2/bin/python
# -*- coding: utf-8 -*-
from __future__ import division
import re
import numpy as np
import mrjob
from mrjob.protocol import RawProtocol
from mrjob.job import MRJob
from mrjob.step import MRStep

import time
import logging

class mostLeastDenseWords(MRJob):

    # START STUDENT CODE 5.4.1.C
    def mapper1(self, _, line):
        line = line.strip()
        tabs = line.split('\t')
        words = tabs[0].split(' ')
        for word1 in words:
            yield ''.join(words),word1

    def reducer1(self, key , values):
        word2list={}
        for value in values:
            if value not in word2list:
                word2list[value]=1
            else:
                word2list[value]+=1
        yield key,word2list

    def mapper2(self, key , values):
        for v in values:
            yield v,(values[v],1)

    def combiner2(self, key , values):
        tf=0
        idf=0
        for pair in values:
            tf+=pair[0]
            idf+=pair[1]
        yield key,(tf,idf)

    def reducer2(self, key , values):
        tf=0
        idf=0
        for pair in values:
            tf+=pair[0]
            idf+=pair[1]
        yield key,(tf/idf)

    def steps(self):
        JOBCONF_STEP1 = {
            'mapreduce.job.output.key.comparator.class': 'org.apache.hadoop.map
red.lib.KeyFieldBasedComparator',
            'mapreduce.partition.keypartitioner.options':'-nrk2',
            'mapreduce.partition.keycomparator.options':'-nrk2',
            'mapred.map.tasks': 190,
            'mapred.reduce.tasks': 30,
            'mapreduce.reduce.cpu.vcores':4,
            'partitioner':'org.apache.hadoop.mapred.lib.KeyFieldBasedPartitione
r'
        }
        return [MRStep(jobconf=JOBCONF_STEP1,mapper=self.mapper1,reducer=self.r
educer1
                       ),
                MRStep(mapper=self.mapper2,combiner=self.combiner2,reducer=self
```

```
Overwriting mostLeastDenseWords.py
```

On the test data set:

In [203]:
```
!rm mostLeastDenseWords.txt
!python mostLeastDenseWords.py -r local "googlebooks-eng-all-5gram-20090715-0-filtered-first-10-lines.txt" > mostLeastDenseWords.txt
```

```
No configs found; falling back on auto-configuration
Creating temp directory /tmp/mostLeastDenseWords.nileshbhoyar.20170622.174709.434922
Running step 1 of 2...
Running step 2 of 2...
Streaming final output from /tmp/mostLeastDenseWords.nileshbhoyar.20170622.174709.434922/output...
Removing temp directory /tmp/mostLeastDenseWords.nileshbhoyar.20170622.174709.434922...
WARNING:root:('time elapsed:', '2.62731385231')
```

In [204]:
```
!cat mostLeastDenseWords.txt | sort -nrk2 | head -20
!cat mostLeastDenseWords.txt | sort -nrk2 | head -20
```

```
"of"    1.1666666667
"the"   1.0
"in"    1.0
"by"    1.0
"Wales" 1.0
"Tales" 1.0
"Study" 1.0
"Sea"   1.0
"RELIGIOUS"     1.0
"Narrative"     1.0
"Limited"       1.0
"Government"    1.0
"George"        1.0
"General"       1.0
"Forms" 1.0
"Female"        1.0
"Fairy" 1.0
"FOR"   1.0
"ESTABLISHING"  1.0
"Collection"    1.0
"of"    1.1666666667
"the"   1.0
"in"    1.0
"by"    1.0
"Wales" 1.0
"Tales" 1.0
"Study" 1.0
"Sea"   1.0
"RELIGIOUS"     1.0
"Narrative"     1.0
"Limited"       1.0
"Government"    1.0
"George"        1.0
"General"       1.0
"Forms" 1.0
"Female"        1.0
"Fairy" 1.0
"FOR"   1.0
"ESTABLISHING"  1.0
"Collection"    1.0
```

On the full data set:

In [205]:
```
!hdfs dfs -mkdir hdfs:///user/nileshbhoyar/output/
!hdfs dfs -rm -r hdfs:///user/nileshbhoyar/output/HW541C/
%time !python mostLeastDenseWords.py \
        -r hadoop \
        --output-dir="hdfs:///user/nileshbhoyar/output/HW541C/"\
        --no-output \
        "hdfs:///user/cendylin/filtered-5Grams/"
```

```
mkdir: `hdfs:/user/nileshbhoyar/output': File exists
17/06/22 17:47:21 INFO fs.TrashPolicyDefault: Namenode trash configuration: De
letion interval = 5760 minutes, Emptier interval = 360 minutes.
Moved: 'hdfs://nn-ia.s3s.altiscale.com:8020/user/nileshbhoyar/output/HW541C' t
o trash at: hdfs://nn-ia.s3s.altiscale.com:8020/user/nileshbhoyar/.Trash/Curre
nt
No configs found; falling back on auto-configuration
Looking for hadoop binary in /opt/hadoop/bin...
Found hadoop binary: /opt/hadoop/bin/hadoop
Creating temp directory /tmp/mostLeastDenseWords.nileshbhoyar.20170622.174722.
371042
Using Hadoop version 2.7.3
Copying local files to hdfs:///user/nileshbhoyar/tmp/mrjob/mostLeastDenseWords
.nileshbhoyar.20170622.174722.371042/files/...
Looking for Hadoop streaming jar in /opt/hadoop...
Found Hadoop streaming jar: /opt/hadoop/share/hadoop/tools/lib/hadoop-streamin
g-2.7.3.jar
Detected hadoop configuration property names that do not match hadoop version
2.7.3:
The have been translated as follows
 mapred.map.tasks: mapreduce.job.maps
mapred.reduce.tasks: mapreduce.job.reduces
Running step 1 of 2...
  packageJobJar: [] [/opt/hadoop-2.7.3/share/hadoop/tools/lib/hadoop-streaming
-2.7.3.jar] /tmp/streamjob3040269206354443932.jar tmpDir=null
  Timeline service address: http://rm-ia.s3s.altiscale.com:8188/ws/v1/timeline
/
  Connecting to ResourceManager at rm-ia.s3s.altiscale.com/10.251.255.108:8032
  Connecting to Application History server at rm-ia.s3s.altiscale.com/10.251.2
55.108:10200
  Timeline service address: http://rm-ia.s3s.altiscale.com:8188/ws/v1/timeline
/
  Connecting to ResourceManager at rm-ia.s3s.altiscale.com/10.251.255.108:8032
  Connecting to Application History server at rm-ia.s3s.altiscale.com/10.251.2
55.108:10200
  Loaded native gpl library from the embedded binaries
  Successfully loaded & initialized native-lzo library [hadoop-lzo rev d62701d
4d05dfa6115bbaf8d9dff002df142e62d]
  Total input paths to process : 190
  number of splits:190
  Submitting tokens for job: job_1497906899862_2043
  Submitted application application_1497906899862_2043
  The url to track the job: http://rm-ia.s3s.altiscale.com:8088/proxy/applicat
ion_1497906899862_2043/
  Running job: job_1497906899862_2043
  Job job_1497906899862_2043 running in uber mode : false
   map 0% reduce 0%
   map 1% reduce 0%
   map 2% reduce 0%
   map 3% reduce 0%
   map 4% reduce 0%
   map 5% reduce 0%
   map 6% reduce 0%
   map 7% reduce 0%
   map 9% reduce 0%
   map 10% reduce 0%
   map 11% reduce 0%
   map 12% reduce 0%
   map 14% reduce 0%
   map 15% reduce 0%
   map 17% reduce 0%
   map 18% reduce 0%
   map 20% reduce 0%
   map 21% reduce 0%
   map 23% reduce 0%
   map 25% reduce 0%
   map 26% reduce 0%
   map 27% reduce 0%
   map 28% reduce 0%
   map 29% reduce 0%
```

In [206]:
```
!hdfs dfs -ls hdfs:///user/nileshbhoyar/output/HW541C/
!hdfs dfs -cat hdfs:/user/nileshbhoyar/output/HW541C/part-* > final_density.txt
```

```
Found 2 items
-rw-r--r--   3 nileshbhoyar users          0 2017-06-22 18:08 hdfs:/user/niles
hbhoyar/output/HW541C/_SUCCESS
-rw-r--r--   3 nileshbhoyar users    5412281 2017-06-22 18:08 hdfs:/user/niles
hbhoyar/output/HW541C/part-00000
```

In [207]:
```
!sort -k2nr final_density.txt > sorted_density.txt
```

In [208]:
```
!head  -20  sorted_density.txt
```

```
"IOOO"  5.0
"MeO"   5.0
"OMe"   5.0
"OOOOOO"        5.0
"PIC"   5.0
"Quintile"      5.0
"llll"  5.0
"nnn"   5.0
"oooooooooooooooo"      5.0
"xxxx"  5.0
"xxxxxxxx"      5.0
"OOOOO" 4.2857142857142856
"CHOH"  4.0
"oooooooo"      4.0
"ooooo" 3.875
"IIII"  3.6666666666666665
"oooooo"        3.5
"ARCHIE"        3.0
"Cosine"        3.0
"Crystalloid"   3.0
```

Word density MR stats

```
ec2_instance_type: m3.xlarge
num_ec2_instances: 15
```

Step 1:

```
Job Name:   streamjob3040269206354443932.jar
User Name:  nileshbhoyar
Queue:  berkeley
State:  SUCCEEDED
Uberized:   false
Submitted:  Thu Jun 22 17:47:41 UTC 2017
Started:    Thu Jun 22 17:47:49 UTC 2017
Finished:   Thu Jun 22 17:54:08 UTC 2017
Elapsed:    6mins, 19sec
Diagnostics:
Average Map Time    1mins, 10sec
Average Shuffle Time    4sec
Average Merge Time  7sec
Average Reduce Time 4mins, 9sec
```

http://rm-ia.s3s.altiscale.com:19888/jobhistory/job/job_1497906899862_2043/mapreduce/job/job_1497906899862_2043 (http://rm-ia.s3s.altiscale.com:19888/jobhistory/job/job_1497906899862_2043/mapreduce/job/job_1497906899862_2043)

step 2

```
Job Name:   streamjob810535679113074807.jar
User Name:  nileshbhoyar
Queue:  berkeley
State:  SUCCEEDED
Uberized:   false
Submitted:  Thu Jun 22 17:54:18 UTC 2017
Started:    Thu Jun 22 17:54:28 UTC 2017
Finished:   Thu Jun 22 18:08:51 UTC 2017
Elapsed:    14mins, 22sec
Diagnostics:
Average Map Time    5mins, 25sec
Average Shuffle Time    3sec
Average Merge Time  5sec
Average Reduce Time 5mins, 36sec
```

http://rm-ia.s3s.altiscale.com:19888/jobhistory/job/job_1497906899862_2049/mapreduce/job/job_1497906899862_2049 (http://rm-ia.s3s.altiscale.com:19888/jobhistory/job/job_1497906899862_2049/mapreduce/job/job_1497906899862_2049)

HW5.4.1 - D. Distribution of 5-gram sizes (character length)

In [209]:
```
%%writefile distribution.py
#!~/anaconda2/bin/python
# -*- coding: utf-8 -*-

import mrjob
from mrjob.protocol import RawProtocol
from mrjob.job import MRJob
from mrjob.step import MRStep

class distribution(MRJob):
    counter=0
    # START STUDENT CODE 5.4.1.D
    def mapper(self, _, line):
        line = line.strip()
        tabs = line.split('\t')
        words = tabs[0]
        yield len(words),1
    def combiner(self,key,value):
        yield key,sum(value)
    def reducer(self, key , value):
        yield key,sum(value)

    def steps(self):
        return [MRStep(mapper=self.mapper,combiner=self.combiner,reducer=self.r
educer,jobconf={
            'mapred.map.tasks': 190,
                    'mapreduce.reduce.cpu.vcores':8
        })]
    # END STUDENT CODE 5.4.1.D

if __name__ == '__main__':
    distribution.run()
```

```
Overwriting distribution.py
```

On the test data set:

In [210]:
```
!hdfs dfs rm --recursive systems_test_distribution
!python distribution.py -r hadoop googlebooks-eng-all-5gram-20090715-0-filtered
-first-10-lines.txt > systems_test_distribution.txt
```

```
rm: Unknown command
Did you mean -rm?  This command begins with a dash.
No configs found; falling back on auto-configuration
Creating temp directory /tmp/distribution.nileshbhoyar.20170622.181032.772579
Looking for hadoop binary in /opt/hadoop/bin...
Found hadoop binary: /opt/hadoop/bin/hadoop
Using Hadoop version 2.7.3
Copying local files to hdfs:///user/nileshbhoyar/tmp/mrjob/distribution.nilesh
bhoyar.20170622.181032.772579/files/...
Looking for Hadoop streaming jar in /opt/hadoop...
Found Hadoop streaming jar: /opt/hadoop/share/hadoop/tools/lib/hadoop-streamin
g-2.7.3.jar
Detected hadoop configuration property names that do not match hadoop version
2.7.3:
The have been translated as follows
 mapred.map.tasks: mapreduce.job.maps
Running step 1 of 1...
  packageJobJar: [] [/opt/hadoop-2.7.3/share/hadoop/tools/lib/hadoop-streaming
-2.7.3.jar] /tmp/streamjob6829425982842152834.jar tmpDir=null
  Timeline service address: http://rm-ia.s3s.altiscale.com:8188/ws/v1/timeline
/
  Connecting to ResourceManager at rm-ia.s3s.altiscale.com/10.251.255.108:8032
  Connecting to Application History server at rm-ia.s3s.altiscale.com/10.251.2
55.108:10200
  Timeline service address: http://rm-ia.s3s.altiscale.com:8188/ws/v1/timeline
/
  Connecting to ResourceManager at rm-ia.s3s.altiscale.com/10.251.255.108:8032
  Connecting to Application History server at rm-ia.s3s.altiscale.com/10.251.2
55.108:10200
  Loaded native gpl library from the embedded binaries
  Successfully loaded & initialized native-lzo library [hadoop-lzo rev d62701d
4d05dfa6115bbaf8d9dff002df142e62d]
  Total input paths to process : 1
  number of splits:375
  Submitting tokens for job: job_1497906899862_2066
  Submitted application application_1497906899862_2066
  The url to track the job: http://rm-ia.s3s.altiscale.com:8088/proxy/applicat
ion_1497906899862_2066/
  Running job: job_1497906899862_2066
  Job job_1497906899862_2066 running in uber mode : false
   map 0% reduce 0%
   map 1% reduce 0%
   map 2% reduce 0%
   map 3% reduce 0%
   map 5% reduce 0%
   map 6% reduce 0%
   map 7% reduce 0%
   map 8% reduce 0%
   map 9% reduce 0%
   map 10% reduce 0%
   map 11% reduce 0%
   map 12% reduce 0%
   map 13% reduce 0%
   map 14% reduce 0%
   map 15% reduce 0%
   map 17% reduce 0%
   map 18% reduce 0%
   map 19% reduce 0%
   map 20% reduce 0%
   map 22% reduce 0%
   map 24% reduce 0%
   map 27% reduce 0%
   map 29% reduce 0%
   map 31% reduce 0%
   map 32% reduce 0%
   map 34% reduce 0%
   map 36% reduce 0%
   map 39% reduce 0%
   map 40% reduce 0%
   map 41% reduce 0%
```

In [196]:
```
!cat systems_test_distribution.txt | sort -nrk1,1
```

```
33      2
29      1
28      1
27      1
26      1
24      1
23      1
22      1
17      1
```

On the full data set:

In [197]:
```
!hdfs dfs -mkdir hdfs:///user/nileshbhoyar/output/
!hdfs dfs -rm -r hdfs:///user/nileshbhoyar/output/HW541D/
%time !python distribution.py \
        -r hadoop \
        --output-dir="hdfs:///user/nileshbhoyar/output/HW541D/"\
        --no-output \
        "hdfs:///user/cendylin/filtered-5Grams/"
```

```
mkdir: `hdfs:/user/nileshbhoyar/output': File exists
rm: `hdfs:///user/nileshbhoyar/output/HW541D/': No such file or directory
No configs found; falling back on auto-configuration
Looking for hadoop binary in /opt/hadoop/bin...
Found hadoop binary: /opt/hadoop/bin/hadoop
Creating temp directory /tmp/distribution.nileshbhoyar.20170622.173959.458053
Using Hadoop version 2.7.3
Copying local files to hdfs:///user/nileshbhoyar/tmp/mrjob/distribution.nilesh
bhoyar.20170622.173959.458053/files/...
Looking for Hadoop streaming jar in /opt/hadoop...
Found Hadoop streaming jar: /opt/hadoop/share/hadoop/tools/lib/hadoop-streamin
g-2.7.3.jar
Detected hadoop configuration property names that do not match hadoop version
2.7.3:
The have been translated as follows
 mapred.map.tasks: mapreduce.job.maps
Running step 1 of 1...
  packageJobJar: [] [/opt/hadoop-2.7.3/share/hadoop/tools/lib/hadoop-streaming
-2.7.3.jar] /tmp/streamjob1829799781120004028.jar tmpDir=null
  Timeline service address: http://rm-ia.s3s.altiscale.com:8188/ws/v1/timeline
/
  Connecting to ResourceManager at rm-ia.s3s.altiscale.com/10.251.255.108:8032
  Connecting to Application History server at rm-ia.s3s.altiscale.com/10.251.2
55.108:10200
  Timeline service address: http://rm-ia.s3s.altiscale.com:8188/ws/v1/timeline
/
  Connecting to ResourceManager at rm-ia.s3s.altiscale.com/10.251.255.108:8032
  Connecting to Application History server at rm-ia.s3s.altiscale.com/10.251.2
55.108:10200
  Loaded native gpl library from the embedded binaries
  Successfully loaded & initialized native-lzo library [hadoop-lzo rev d62701d
4d05dfa6115bbaf8d9dff002df142e62d]
  Total input paths to process : 190
  number of splits:190
  Submitting tokens for job: job_1497906899862_2038
  Submitted application application_1497906899862_2038
  The url to track the job: http://rm-ia.s3s.altiscale.com:8088/proxy/applicat
ion_1497906899862_2038/
  Running job: job_1497906899862_2038
  Job job_1497906899862_2038 running in uber mode : false
   map 0% reduce 0%
   map 1% reduce 0%
   map 3% reduce 0%
   map 4% reduce 0%
   map 6% reduce 0%
   map 7% reduce 0%
   map 8% reduce 0%
   map 10% reduce 0%
   map 11% reduce 0%
   map 13% reduce 0%
   map 15% reduce 0%
   map 16% reduce 0%
   map 17% reduce 0%
   map 19% reduce 0%
   map 20% reduce 0%
   map 22% reduce 0%
   map 24% reduce 0%
   map 26% reduce 0%
   map 28% reduce 0%
   map 32% reduce 0%
   map 35% reduce 0%
   map 38% reduce 0%
   map 41% reduce 0%
   map 43% reduce 0%
   map 44% reduce 0%
   map 46% reduce 0%
   map 48% reduce 0%
   map 50% reduce 0%
   map 52% reduce 0%
   map 53% reduce 0%
```

In [198]:
```
!rm full_distribution.txt
!hdfs dfs -cat hdfs:///user/nileshbhoyar/output/HW541D/part* |sort -nk1,1 > ful
l_distribution.txt
```

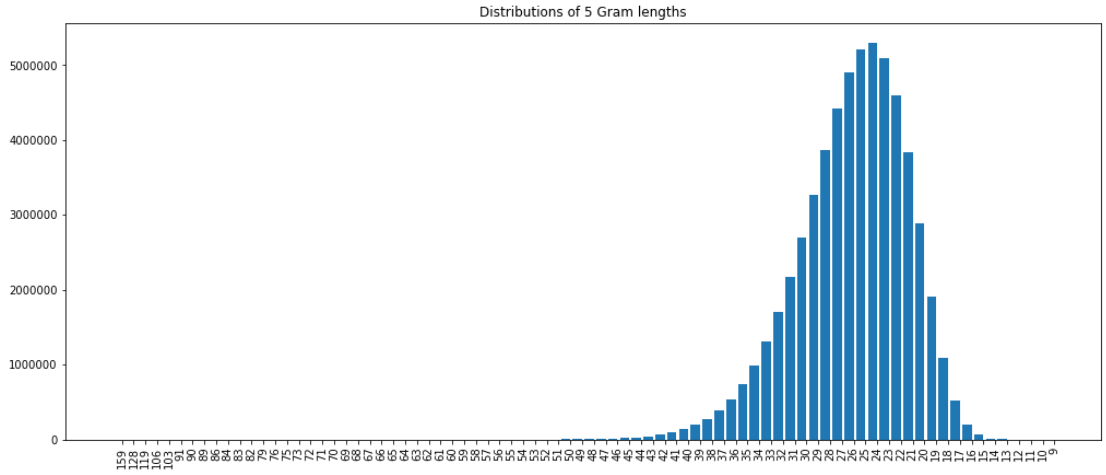
```
rm: cannot remove `full_distribution.txt': No such file or directory
```

In [199]:
```
%matplotlib inline
import numpy as np
import pylab as pl

results_A = []
for line in open("full_distribution.txt").readlines():
    line = line.strip()
    X,Y = line.split("\t")
    results_A.append([int(X),int(Y)])

items = (np.array(results_A)[::-1].T)
fig = pl.figure(figsize=(17,7))
ax = pl.subplot(111)
width=0.8
ax.bar(range(len(items[0])), items[1], width=width)
ax.set_xticks(np.arange(len(items[0])) + width/2)
ax.set_xticklabels(items[0], rotation=90)

pl.title("Distributions of 5 Gram lengths")
pl.show()
```



Distribution MRJob stats

```
Job Name:   streamjob1829799781120004028.jar
User Name:  nileshbhoyar
Queue:  berkeley
State:  SUCCEEDED
Uberized:   false
Submitted:  Thu Jun 22 17:40:18 UTC 2017
Started:    Thu Jun 22 17:40:26 UTC 2017
Finished:   Thu Jun 22 17:41:55 UTC 2017
Elapsed:    1mins, 28sec
Diagnostics:
Average Map Time    54sec
Average Shuffle Time    3sec
Average Merge Time  0sec
Average Reduce Time 1sec
http://rm-ia.s3s.altiscale.com:19888/jobhistory/job/job_1497906899862_2038/mapreduc
e/job/job_1497906899862_2038
```

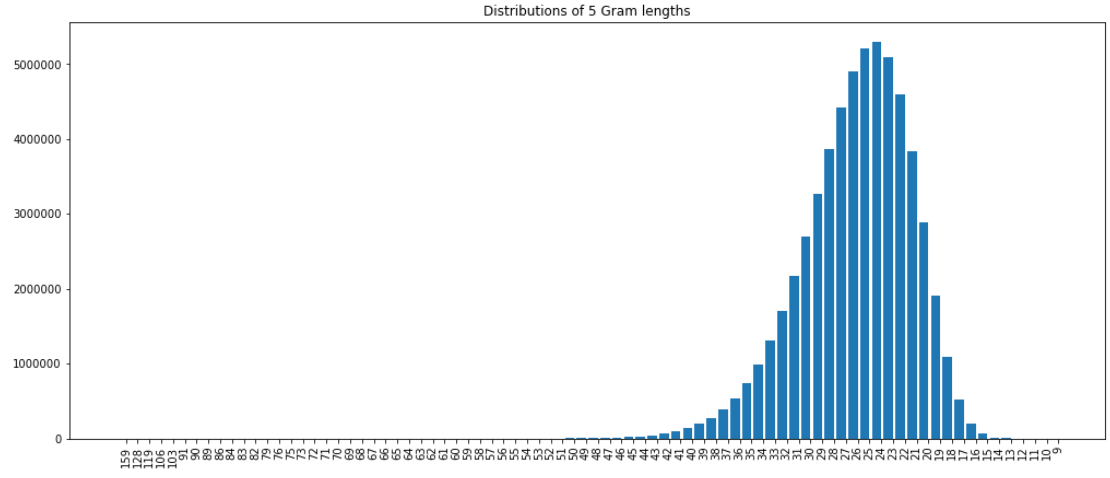
In [201]:
```
%matplotlib inline
import numpy as np
import pylab as pl

results_A = []
for line in open("full_distribution.txt").readlines():
    line = line.strip()
    X,Y = line.split("\t")
    results_A.append([int(X),int(Y)])

items = (np.array(results_A)[::-1].T)
fig = pl.figure(figsize=(17,7))
ax = pl.subplot(111)
width=0.8
ax.bar(range(len(items[0])), items[1], width=width)
ax.set_xticks(np.arange(len(items[0])) + width/2)
ax.set_xticklabels(items[0], rotation=90)



pl.title("Distributions of 5 Gram lengths")
pl.show()
```



Run times

```
Job Name:   streamjob1829799781120004028.jar
User Name:  nileshbhoyar
Queue:  berkeley
State:  SUCCEEDED
Uberized:   false
Submitted:  Thu Jun 22 17:40:18 UTC 2017
Started:    Thu Jun 22 17:40:26 UTC 2017
Finished:   Thu Jun 22 17:41:55 UTC 2017
Elapsed:    1mins, 28sec
Diagnostics:
Average Map Time    54sec
Average Shuffle Time    3sec
Average Merge Time  0sec
Average Reduce Time 1sec
http://rm-ia.s3s.altiscale.com:19888/jobhistory/job/job_1497906899862_2038/mapreduc
e/job/job_1497906899862_2038
```

In [ ]:

3. HW5.4.2 OPTIONAL Question: log-log plots (PHASE 2)

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Plot the log-log plot of the frequency distributuion of unigrams. Does it follow power law distribution?

For more background see:

- https://en.wikipedia.org/wiki/Log%E2%80%93log_plot (https://en.wikipedia.org/wiki/Log%E2%80%93log_plot)
- https://en.wikipedia.org/wiki/Power_law (https://en.wikipedia.org/wiki/Power_law)

3. HW5.5 Synonym detection over 2Gig of Data with extra Preprocessing steps (HW5.3 plus some preprocessing) (Phase 2)

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For the remainder of this assignment please feel free to eliminate stop words from your analysis

There is also a corpus of stopwords, that is, high-frequency words like "the", "to" and "also" that we sometimes want to filter out of a document before further processing. Stopwords usually have little lexical content, and their presence in a text fails to distinguish it from other texts. Python's nltk comes with a prebuilt list of stopwords (see below). Using this stopword list filter out these tokens from your analysis and rerun the experiments in 5.5 and disucuss the results of using a stopword list and without using a stopword list.

from nltk.corpus import stopwords stopwords.words('english') ['i', 'me', 'my', 'myself', 'we', 'our', 'ours', 'ourselves', 'you', 'your', 'yours', 'yourself', 'yourselves', 'he', 'him', 'his', 'himself', 'she', 'her', 'hers', 'herself', 'it', 'its', 'itself', 'they', 'them', 'their', 'theirs', 'themselves', 'what', 'which', 'who', 'whom', 'this', 'that', 'these', 'those', 'am', 'is', 'are', 'was', 'were', 'be', 'been', 'being', 'have', 'has', 'had', 'having', 'do', 'does', 'did', 'doing', 'a', 'an', 'the', 'and', 'but', 'if', 'or', 'because', 'as', 'until', 'while', 'of', 'at', 'by', 'for', 'with', 'about', 'against', 'between', 'into', 'through', 'during', 'before', 'after', 'above', 'below', 'to', 'from', 'up', 'down', 'in', 'out', 'on', 'off', 'over', 'under', 'again', 'further', 'then', 'once', 'here', 'there', 'when', 'where', 'why', 'how', 'all', 'any', 'both', 'each', 'few', 'more', 'most', 'other', 'some', 'such', 'no', 'nor', 'not', 'only', 'own', 'same', 'so', 'than', 'too', 'very', 's', 't', 'can', 'will', 'just', 'don', 'should', 'now']

2: A large subset of the Google n-grams dataset as was described above

For each HW 5.4 -5.5.1 Please unit test and system test your code with respect to SYSTEMS TEST DATASET and show the results. Please compute the expected answer by hand and show your hand calculations for the SYSTEMS TEST DATASET. Then show the results you get with your system.

In this part of the assignment we will focus on developing methods for detecting synonyms, using the Google 5-grams dataset. At a high level:

1. remove stopwords
2. get 10,0000 most frequent
3. get 1000 (9001-10000) features
4. build stripes

To accomplish this you must script two main tasks using MRJob:

TASK (1) Build stripes for the most frequent 10,000 words using cooccurence information based on the words ranked from 9001,-10,000 as a basis/vocabulary (drop stopword-like terms), and output to a file in your bucket on s3 (bigram analysis, though the words are non-contiguous).

TASK (2) Using two (symmetric) comparison methods of your choice (e.g., correlations, distances, similarities), pairwise compare all stripes (vectors), and output to a file in your bucket on s3.

Design notes for TASK (1)

For this task you will be able to modify the pattern we used in HW 3.2 (feel free to use the solution as reference). To total the word counts across the 5-grams, output the support from the mappers using the total order inversion pattern:

<*word,count>

to ensure that the support arrives before the cooccurrences.

In addition to ensuring the determination of the total word counts, the mapper must also output co-occurrence counts for the pairs of words inside of each 5-gram. Treat these words as a basket, as we have in HW 3, but count all stripes or pairs in both orders, i.e., count both orderings: (word1,word2), and (word2,word1), to preserve symmetry in our output for TASK (2).

Design notes for *TASK (2)*

For this task you will have to determine a method of comparison. Here are a few that you might consider:

- Jaccard
- Cosine similarity
- Spearman correlation
- Euclidean distance
- Taxicab (Manhattan) distance
- Shortest path graph distance (a graph, because our data is symmetric!)
- Pearson correlation
- Kendall correlation

However, be cautioned that some comparison methods are more difficult to parallelize than others, and do not perform more associations than is necessary, since your choice of association will be symmetric.

Please use the inverted index (discussed in live session #5) based pattern to compute the pairwise (term-by-term) similarity matrix.

Please report the size of the cluster used and the amount of time it takes to run for the index construction task and for the synonym calculation task. How many pairs need to be processed (HINT: use the posting list length to calculate directly)? Report your Cluster configuration!

Example MR stats: (report times!)

```
took ~11 minutes on 5 m3.xlarge nodes
Data-local map tasks=188
Launched map tasks=190
Launched reduce tasks=15
Other local map tasks=2
```

STOP word removal MR job from output of HW5.4.1 - B.

In [211]:
```
%%writefile stopremoval.py
from mrjob.job import MRJob
from mrjob.step import MRStep
import re

STOP_WORDS =['i', 'me', 'my', 'myself', 'we', 'our', 'ours',
             'ourselves', 'you', 'your', 'yours', 'yourself', 'yourselves', 'he
',
             'him', 'his', 'himself', 'she', 'her', 'hers', 'herself', 'it', 'i
ts', 'itself',
             'they', 'them', 'their', 'theirs', 'themselves', 'what', 'which',
'who', 'whom', 'this', 'that',
             'these', 'those', 'am', 'is', 'are', 'was', 'were', 'be', 'been',
'being', 'have', 'has', 'had',
             'having', 'do', 'does', 'did', 'doing', 'a', 'an', 'the', 'and', '
but', 'if', 'or', 'because', 'as',
             'until', 'while', 'of', 'at', 'by', 'for', 'with', 'about', 'again
st', 'between', 'into', 'through',
             'during', 'before', 'after', 'above', 'below', 'to', 'from', 'up',
'down', 'in', 'out', 'on', 'off',
             'over', 'under', 'again', 'further', 'then', 'once', 'here', 'ther
e', 'when', 'where', 'why', 'how',
             'all', 'any', 'both', 'each', 'few', 'more', 'most', 'other', 'som
e', 'such', 'no', 'nor', 'not', 'only',
             'own', 'same', 'so', 'than', 'too', 'very', 's', 't', 'can', 'will
', 'just', 'don', 'should', 'now']

class MRSTOPRemoval(MRJob):
    def mapper(self, _, line):
         fields = line.split("\t")
         word = re.findall("\w+", fields[0])
         if word[0] not in STOP_WORDS:
                yield word[0] ,int(fields[1])

    def combiner(self, word, counts):
        yield word, sum(counts)

    def reducer(self, word, counts):
        yield word, sum(counts)

    def steps(self):
        return [
            MRStep(
                    mapper=self.mapper,

                ),]

if __name__ == '__main__':
    MRSTOPRemoval.run()
```

```
Overwriting stopremoval.py
```

In [212]:
```
%time !python stopremoval.py -r local frequentwords.txt_sorted.txt > frequentwo
rds_final.txt
```

```
No configs found; falling back on auto-configuration
Creating temp directory /tmp/stopremoval.nileshbhoyar.20170622.181415.454506
Running step 1 of 1...
Streaming final output from /tmp/stopremoval.nileshbhoyar.20170622.181415.4545
06/output...
Removing temp directory /tmp/stopremoval.nileshbhoyar.20170622.181415.454506..
.
CPU times: user 70 ms, sys: 25 ms, total: 95 ms
Wall time: 2.56 s
```

In [213]:
```
!sort  -k2nr -k1 frequentwords_final.txt > frequentwords_final_sorted.txt
```

In [214]:
```
!head -10000 frequentwords_final_sorted.txt > vocabulary.txt
!head -10000 frequentwords_final_sorted.txt | tail -1000 > features.txt
```

In [215]:
```
# START STUDENT CODE 5.5
# ADD OR REMOVE CELLS AS NEEDED
```

In [216]:
```
%%writefile buildStripes.py
#!~/anaconda2/bin/python
# -*- coding: utf-8 -*-

from __future__ import division
import re
import mrjob
import csv
import json
from mrjob.protocol import RawProtocol
from mrjob.job import MRJob
from mrjob.step import MRStep
from itertools import  combinations
class MRbuildStripes(MRJob):

  #START SUDENT CODE531_STRIPES
    SORT_VALUES = True

    #def __init__(self, *args, **kwargs):
    #    super(MRjoins, self).__init__(*args, **kwargs)


    def mapper_init(self):
        self.basis = set()
        self.vocabulary = set()

        with open('features.txt', 'r') as basis_file:
            self.features = set([row[0] for row in csv.reader(basis_file, delim
iter = '\t')])

        with open('vocabulary.txt', 'r') as vocabulary_file:
            self.vocabulary = set([row[0] for row in csv.reader(vocabulary_file
, delimiter = '\t')])



    def mapper(self, _, recs):
        self.increment_counter('Execution Counts', 'mapper calls', 1)
        fields = recs.split("\t")

        products = fields[0].lower().replace('\n','').split()
        for i, term in enumerate(products):
                # Create a new stripe for each term
                stripe = {}
                # check if term is in vocab
                if term not in self.vocabulary:
                        continue
                for j, token in enumerate(products):

                    if i != j:
                        if token not in self.features:
                            continue
                        x = stripe.get(token,None)

                        if x == None:
                            stripe[token] = int( fields[1])
                        else:
                            stripe[token] += int(fields[1])

                # Emit the term and the stripe
                if len(stripe) > 0:
                    yield term, stripe

    def combiner(self, word, stripes):
        yield word, self.combine_stripes(stripes)

    def combine_stripes(self, stripes):
        combined_stripe = {}
```

```
Overwriting buildStripes.py
```

In [217]:
```
#unit test
!hdfs dfs rm --recursive systems_test_stripes_2
!python buildStripes.py -r hadoop atlas-boon-systems-test.txt --file features.t
xt --file vocabulary.txt  > systems_test_stripes_2
```

```
rm: Unknown command
Did you mean -rm?  This command begins with a dash.
No configs found; falling back on auto-configuration
Creating temp directory /tmp/buildStripes.nileshbhoyar.20170622.181437.037975
Looking for hadoop binary in /opt/hadoop/bin...
Found hadoop binary: /opt/hadoop/bin/hadoop
Using Hadoop version 2.7.3
Copying local files to hdfs:///user/nileshbhoyar/tmp/mrjob/buildStripes.nilesh
bhoyar.20170622.181437.037975/files/...
Looking for Hadoop streaming jar in /opt/hadoop...
Found Hadoop streaming jar: /opt/hadoop/share/hadoop/tools/lib/hadoop-streamin
g-2.7.3.jar
Detected hadoop configuration property names that do not match hadoop version
2.7.3:
The have been translated as follows
 mapred.map.tasks: mapreduce.job.maps
mapred.output.key.comparator.class: mapreduce.job.output.key.comparator.class
mapred.text.key.comparator.options: mapreduce.partition.keycomparator.options
mapred.text.key.partitioner.options: mapreduce.partition.keypartitioner.option
s
Running step 1 of 1...
  packageJobJar: [] [/opt/hadoop-2.7.3/share/hadoop/tools/lib/hadoop-streaming
-2.7.3.jar] /tmp/streamjob2074687973942837904.jar tmpDir=null
  Timeline service address: http://rm-ia.s3s.altiscale.com:8188/ws/v1/timeline
/
  Connecting to ResourceManager at rm-ia.s3s.altiscale.com/10.251.255.108:8032
  Connecting to Application History server at rm-ia.s3s.altiscale.com/10.251.2
55.108:10200
  Timeline service address: http://rm-ia.s3s.altiscale.com:8188/ws/v1/timeline
/
  Connecting to ResourceManager at rm-ia.s3s.altiscale.com/10.251.255.108:8032
  Connecting to Application History server at rm-ia.s3s.altiscale.com/10.251.2
55.108:10200
  Loaded native gpl library from the embedded binaries
  Successfully loaded & initialized native-lzo library [hadoop-lzo rev d62701d
4d05dfa6115bbaf8d9dff002df142e62d]
  Total input paths to process : 1
  number of splits:67
  Submitting tokens for job: job_1497906899862_2067
  Submitted application application_1497906899862_2067
  The url to track the job: http://rm-ia.s3s.altiscale.com:8088/proxy/applicat
ion_1497906899862_2067/
  Running job: job_1497906899862_2067
  Job job_1497906899862_2067 running in uber mode : false
   map 0% reduce 0%
   map 6% reduce 0%
   map 30% reduce 0%
   map 36% reduce 0%
   map 42% reduce 0%
   map 48% reduce 0%
   map 63% reduce 0%
   map 100% reduce 0%
   map 100% reduce 10%
   map 100% reduce 30%
   map 100% reduce 45%
   map 100% reduce 60%
   map 100% reduce 100%
  Job job_1497906899862_2067 completed successfully
  Output directory: hdfs:///user/nileshbhoyar/tmp/mrjob/buildStripes.nileshbho
yar.20170622.181437.037975/output
Counters: 51
        Execution Counts
                mapper calls=3
        File Input Format Counters
                Bytes Read=2278
        File Output Format Counters
                Bytes Written=0
        File System Counters
                FILE: Number of bytes read=400
                FILE: Number of bytes written=11725889
```

In [218]:
```
%%writefile invertedIndex.py
#!~/anaconda2/bin/python
# -*- coding: utf-8 -*-


from __future__ import division
import collections
import re
import json
import math
import numpy as np
import itertools
import mrjob
from mrjob.protocol import RawProtocol
from mrjob.job import MRJob
from mrjob.step import MRStep
from mrjob.protocol import JSONProtocol
class MRinvertedIndex(MRJob):
    INPUT_PROTOCOL = JSONProtocol
    SORT_VALUES = True
#START SUDENT CODE531_INV_INDEX
    def mapper_normalize_transpose(self, word, rate_stripe):



        # Divide each value in the vector by the magnitude to normalize.
        length = len(rate_stripe)
        for key, value in rate_stripe.iteritems():
            #normalized_value = value / magnitude
            yield key, { word: length}
    def combiner_normalize_transpose(self, word, transpose_stripes):
        yield word, self.combine_stripes(transpose_stripes)
    def reducer_normalize_transpose(self, word, transpose_stripes):
        yield word, self.combine_stripes(transpose_stripes)
    def combine_stripes(self, stripes):
        combined_stripe = {}

        for stripe in stripes:
            for key, value in stripe.iteritems():
                if key in combined_stripe:
                    combined_stripe[key] += value
                else:
                    combined_stripe[key] = value

        return combined_stripe


    def steps(self):

        transpose_step = MRStep(
            mapper = self.mapper_normalize_transpose,
            combiner = self.combiner_normalize_transpose,
            reducer = self.reducer_normalize_transpose,
            jobconf = {
                    'mapreduce.job.reduces': 10
                })
        return [transpose_step]

#END SUDENT CODE531_INV_INDEX

if __name__ == '__main__':
    MRinvertedIndex.run()
```

```
Overwriting invertedIndex.py
```

In [219]:
```
%%writefile similarity.py
#!~/anaconda2/bin/python
# -*- coding: utf-8 -*-

from __future__ import division
import collections
import re
import json
import math
import numpy as np
import itertools
import mrjob
from mrjob.protocol import RawValueProtocol
from mrjob.job import MRJob
from mrjob.step import MRStep
from mrjob.protocol import JSONProtocol

class MRsimilarity(MRJob):
    INPUT_PROTOCOL = JSONProtocol

    SORT_VALUES = True
    def makeKeyn(self,key, num_reducers):
        byteof = lambda char: int(format(ord(char), 'b'), 2)
        current_hash = 0
        for c in key:
            current_hash = (current_hash * 31 + byteof(c))
        return current_hash % num_reducers


#START SUDENT CODE531_SIMILARITY
    def mapper_jaccard(self, word, rate_stripe):
        #get all words and lengths
#We will emit stripes for each word vector here.  These stripes will
#be used in combiner to find the common length i.e. words occuring together
        nonzero_keys = [key for key, value in rate_stripe.iteritems() if value
!= 0]



        sorted_keys = sorted(nonzero_keys)
        mydict = {}
        for key,value in rate_stripe.iteritems():
            mydict[key] = str(value)
        #yield None,mydict
        # N * N  complexity matrix calculation
        #We are going over each record to find out the common occureances
        for i in range(0, len(sorted_keys)):

            left_label = sorted_keys[i]

            stripe = {}

            for j in range(i + 1, len(sorted_keys)):
                right_label = sorted_keys[j]
                rkey = right_label+'-'+mydict[right_label]
                stripe[rkey] = 1
            nkey =  left_label+'-'+mydict[left_label]
            if len(stripe) > 0:
                yield self.makeKeyn(left_label,10),(nkey,stripe)



        for key in sorted_keys:
            break
            yield '*',{key:1}
            #{u'DocC': 1}
        #yield '*', { key: 1 for key in sorted_keys }
    def combiner_jaccard(self, left_label, partial_stripes):
         #yield left_label,partial_stripes
```

```
Overwriting similarity.py
```

Unit Test

In [220]:
```
########################################################################
# Stripes for systems test 3 (given, no need to build stripes)
########################################################################

with open("systems_test_stripes_3", "w") as f:
    f.writelines([
        '"DocA"\t{"X":20, "Y":30, "Z":5}\n',
        '"DocB"\t{"X":100, "Y":20}\n',
        '"DocC"\t{"M":5, "N":20, "Z":5, "Y":1}\n'
    ])
!cat systems_test_stripes_3
```

```
"DocA"  {"X":20, "Y":30, "Z":5}
"DocB"  {"X":100, "Y":20}
"DocC"  {"M":5, "N":20, "Z":5, "Y":1}
```

In [221]:
```
!python invertedIndex.py -r local systems_test_stripes_3 > systems_test_index_3
```

```
No configs found; falling back on auto-configuration
ignoring partitioner keyword arg (requires real Hadoop): 'org.apache.hadoop.ma
pred.lib.KeyFieldBasedPartitioner'
Creating temp directory /tmp/invertedIndex.nileshbhoyar.20170622.181654.617426
Running step 1 of 1...
Streaming final output from /tmp/invertedIndex.nileshbhoyar.20170622.181654.61
7426/output...
Removing temp directory /tmp/invertedIndex.nileshbhoyar.20170622.181654.617426
...
```

In [222]:
```
##############################################################
# Pretty print systems tests for generating Inverted Index
##############################################################

import json

for i in range(3,4):
    print "-"*100
    print "Systems test ",i," - Inverted Index"
    print "-"*100
    with open("systems_test_index_"+str(i),"r") as f:
        lines = sorted(f.readlines())
        for line in lines:
            line = line.strip()
            word, doc_list = line.split("\t")
            doc_dict = json.loads(doc_list)
            stripe=[]
            for doc in doc_dict:
                stripe.append([doc, doc_dict[doc]])
            stripe=sorted(stripe)
            stripe.extend([["",""] for _ in xrange(3 - len(stripe))])

            print "{0:>16} |{1:>16} |{2:>16} |{3:>16}".format(
              (word), stripe[0][0]+" "+str(stripe[0][1]), stripe[1][0]+" "+str(
stripe[1][1]), stripe[2][0]+" "+str(stripe[2][1]))
```

```
----------------------------------------------------------------------------------------------------
Systems test  3  - Inverted Index
----------------------------------------------------------------------------------------------------
             "M" |          DocC 4 |                 |
             "N" |          DocC 4 |                 |
             "X" |          DocA 3 |          DocB 2 |
             "Y" |          DocA 3 |          DocB 2 |          DocC 4
             "Z" |          DocA 3 |          DocC 4 |
```

In [223]:
```
!cat systems_test_similarities_3
```

```
["DocA", "DocB"]        {"dice": 0.80000000000000004, "jaccard": 0.66666666666
666663}
["DocA", "DocC"]        {"dice": 0.5714285714285714, "jaccard": 0.400000000000
00002}
["DocB", "DocC"]        {"dice": 0.33333333333333331, "jaccard": 0.20000000000
000001}
```

In [224]:
```
!python similarity.py -r local systems_test_index_3  > systems_test_similaritie
s_3
!cat systems_test_similarities_3|sort -k3nr
```

```
No configs found; falling back on auto-configuration
ignoring partitioner keyword arg (requires real Hadoop): 'org.apache.hadoop.ma
pred.lib.KeyFieldBasedPartitioner'
Creating temp directory /tmp/similarity.nileshbhoyar.20170622.181656.308650
Running step 1 of 1...
Counters: 1
        reducers_custom
                counter_name=2
Streaming final output from /tmp/similarity.nileshbhoyar.20170622.181656.30865
0/output...
Removing temp directory /tmp/similarity.nileshbhoyar.20170622.181656.308650...
["DocA","DocB"] [0.6666666667,0.8,0.7333333333]
["DocA","DocC"] [0.4,0.5714285714,0.4857142857]
["DocB","DocC"] [0.2,0.3333333333,0.2666666667]
```

In [225]:
```
import json

import random

for i in range(3,2,-1):
  print '—'*110
  print "Systems test ",i," - Similarity measures"
  print '—'*110
  print "{0:>15} |{1:>15}|{2:>15}|{3:>15}".format(
            "pair",  "jaccard","Dice","average")
  print '-'*110

  with open("systems_test_similarities_"+str(i),"r") as f:
      lines = f.readlines()
      for line in lines:
          line = line.strip()

          pair,stripe = line.split("\t")


          result = stripe[1:-1].split(',')

          print "{0:>15} |{1:>15f}|{2:>15f}|{3:>15}".format(
              pair,float(result[0]),float(result[1] ),float(result[2]))
```

```
——————————————————————————————————————————————————————————————————————————————————————————————————————————
Systems test  3  - Similarity measures
——————————————————————————————————————————————————————————————————————————————————————————————————————————
           pair |        jaccard|           Dice|        average
--------------------------------------------------------------------------------------------------------------
["DocB","DocC"] |       0.200000|       0.333333|   0.2666666667
["DocA","DocC"] |       0.400000|       0.571429|   0.4857142857
["DocA","DocB"] |       0.666667|       0.800000|   0.7333333333
```

Run for all Data

In [88]:
```
# !mkdir /home/nileshbhoyar/output/HW55
# !mkdir /home/nileshbhoyar/output/HW55/stripes
# %time !python buildStripes.py \
#          -r local \
#          --output-dir="/home/nileshbhoyar/output/HW55/stripes"\
#          --no-output \
#          --file features.txt\
#          --file vocabulary.txt\
#         "/home/nileshbhoyar/data/googlebooks-eng-all-5gram-20090715-88-filter
ed.txt"
```

In [226]:
```
!hdfs dfs -mkdir hdfs:///user/nileshbhoyar/output
!hdfs dfs -mkdir hdfs:///user/nileshbhoyar/output/HW55
!hdfs dfs -rm -r hdfs:///user/nileshbhoyar/output/HW55/stripes
%time !python buildStripes.py\
        -r hadoop \
        --output-dir="hdfs:///user/nileshbhoyar/output/HW55/stripes/"\
        --no-output \
        --file features.txt\
        --file vocabulary.txt\
        "hdfs:///user/cendylin/filtered-5Grams/"
```

```
mkdir: `hdfs:/user/nileshbhoyar/output': File exists
mkdir: `hdfs:/user/nileshbhoyar/output/HW55': File exists
17/06/22 18:17:04 INFO fs.TrashPolicyDefault: Namenode trash configuration: De
letion interval = 5760 minutes, Emptier interval = 360 minutes.
Moved: 'hdfs://nn-ia.s3s.altiscale.com:8020/user/nileshbhoyar/output/HW55/stri
pes' to trash at: hdfs://nn-ia.s3s.altiscale.com:8020/user/nileshbhoyar/.Trash
/Current
No configs found; falling back on auto-configuration
Looking for hadoop binary in /opt/hadoop/bin...
Found hadoop binary: /opt/hadoop/bin/hadoop
Creating temp directory /tmp/buildStripes.nileshbhoyar.20170622.181705.230152
Using Hadoop version 2.7.3
Copying local files to hdfs:///user/nileshbhoyar/tmp/mrjob/buildStripes.nilesh
bhoyar.20170622.181705.230152/files/...
Looking for Hadoop streaming jar in /opt/hadoop...
Found Hadoop streaming jar: /opt/hadoop/share/hadoop/tools/lib/hadoop-streamin
g-2.7.3.jar
Detected hadoop configuration property names that do not match hadoop version
2.7.3:
The have been translated as follows
 mapred.map.tasks: mapreduce.job.maps
mapred.output.key.comparator.class: mapreduce.job.output.key.comparator.class
mapred.text.key.comparator.options: mapreduce.partition.keycomparator.options
mapred.text.key.partitioner.options: mapreduce.partition.keypartitioner.option
s
Running step 1 of 1...
  packageJobJar: [] [/opt/hadoop-2.7.3/share/hadoop/tools/lib/hadoop-streaming
-2.7.3.jar] /tmp/streamjob7789550624839722782.jar tmpDir=null
  Timeline service address: http://rm-ia.s3s.altiscale.com:8188/ws/v1/timeline
/
  Connecting to ResourceManager at rm-ia.s3s.altiscale.com/10.251.255.108:8032
  Connecting to Application History server at rm-ia.s3s.altiscale.com/10.251.2
55.108:10200
  Timeline service address: http://rm-ia.s3s.altiscale.com:8188/ws/v1/timeline
/
  Connecting to ResourceManager at rm-ia.s3s.altiscale.com/10.251.255.108:8032
  Connecting to Application History server at rm-ia.s3s.altiscale.com/10.251.2
55.108:10200
  Loaded native gpl library from the embedded binaries
  Successfully loaded & initialized native-lzo library [hadoop-lzo rev d62701d
4d05dfa6115bbaf8d9dff002df142e62d]
  Total input paths to process : 190
  number of splits:190
  Submitting tokens for job: job_1497906899862_2070
  Submitted application application_1497906899862_2070
  The url to track the job: http://rm-ia.s3s.altiscale.com:8088/proxy/applicat
ion_1497906899862_2070/
  Running job: job_1497906899862_2070
  Job job_1497906899862_2070 running in uber mode : false
   map 0% reduce 0%
   map 1% reduce 0%
   map 2% reduce 0%
   map 3% reduce 0%
   map 4% reduce 0%
   map 5% reduce 0%
   map 6% reduce 0%
   map 8% reduce 0%
   map 10% reduce 0%
   map 12% reduce 0%
   map 13% reduce 0%
   map 14% reduce 0%
   map 16% reduce 0%
   map 17% reduce 0%
   map 18% reduce 0%
   map 20% reduce 0%
   map 21% reduce 0%
   map 23% reduce 0%
   map 24% reduce 0%
   map 26% reduce 0%
   map 27% reduce 0%
```

In [227]:
```
# !mkdir /home/nileshbhoyar/output/HW55/index
# %time !python invertedIndex.py\
#           -r local \
#           --output-dir="/home/nileshbhoyar/output/HW55/index"\
#           --no-output \
#           --file features.txt\
#           --file vocabulary.txt\
#           "/home/nileshbhoyar/output/HW55/stripes"
```

In [228]:
```
!hdfs dfs -rm -r hdfs:///user/nileshbhoyar/output/HW55/index

%time !python invertedIndex.py\
        -r hadoop \
        --output-dir="hdfs:///user/nileshbhoyar/output/HW55/index/"\
        --no-output \
        --file features.txt\
        --file vocabulary.txt\
        "hdfs:///user/nileshbhoyar/output/HW55/stripes/"
```

```
17/06/22 18:19:46 INFO fs.TrashPolicyDefault: Namenode trash configuration: De
letion interval = 5760 minutes, Emptier interval = 360 minutes.
Moved: 'hdfs://nn-ia.s3s.altiscale.com:8020/user/nileshbhoyar/output/HW55/inde
x' to trash at: hdfs://nn-ia.s3s.altiscale.com:8020/user/nileshbhoyar/.Trash/C
urrent
No configs found; falling back on auto-configuration
Looking for hadoop binary in /opt/hadoop/bin...
Found hadoop binary: /opt/hadoop/bin/hadoop
Creating temp directory /tmp/invertedIndex.nileshbhoyar.20170622.181946.852792
Using Hadoop version 2.7.3
Copying local files to hdfs:///user/nileshbhoyar/tmp/mrjob/invertedIndex.niles
hbhoyar.20170622.181946.852792/files/...
Looking for Hadoop streaming jar in /opt/hadoop...
Found Hadoop streaming jar: /opt/hadoop/share/hadoop/tools/lib/hadoop-streamin
g-2.7.3.jar
Detected hadoop configuration property names that do not match hadoop version
2.7.3:
The have been translated as follows
 mapred.output.key.comparator.class: mapreduce.job.output.key.comparator.class
mapred.text.key.comparator.options: mapreduce.partition.keycomparator.options
mapred.text.key.partitioner.options: mapreduce.partition.keypartitioner.option
s
Running step 1 of 1...
  packageJobJar: [] [/opt/hadoop-2.7.3/share/hadoop/tools/lib/hadoop-streaming
-2.7.3.jar] /tmp/streamjob6234810784634808372.jar tmpDir=null
  Timeline service address: http://rm-ia.s3s.altiscale.com:8188/ws/v1/timeline
/
  Connecting to ResourceManager at rm-ia.s3s.altiscale.com/10.251.255.108:8032
  Connecting to Application History server at rm-ia.s3s.altiscale.com/10.251.2
55.108:10200
  Timeline service address: http://rm-ia.s3s.altiscale.com:8188/ws/v1/timeline
/
  Connecting to ResourceManager at rm-ia.s3s.altiscale.com/10.251.255.108:8032
  Connecting to Application History server at rm-ia.s3s.altiscale.com/10.251.2
55.108:10200
  Loaded native gpl library from the embedded binaries
  Successfully loaded & initialized native-lzo library [hadoop-lzo rev d62701d
4d05dfa6115bbaf8d9dff002df142e62d]
  Total input paths to process : 20
  number of splits:20
  Submitting tokens for job: job_1497906899862_2074
  Submitted application application_1497906899862_2074
  The url to track the job: http://rm-ia.s3s.altiscale.com:8088/proxy/applicat
ion_1497906899862_2074/
  Running job: job_1497906899862_2074
  Job job_1497906899862_2074 running in uber mode : false
   map 0% reduce 0%
   map 20% reduce 0%
   map 53% reduce 0%
   map 67% reduce 0%
   map 70% reduce 0%
   map 75% reduce 0%
   map 78% reduce 0%
   map 85% reduce 0%
   map 100% reduce 0%
   map 100% reduce 30%
   map 100% reduce 60%
   map 100% reduce 70%
   map 100% reduce 80%
   map 100% reduce 90%
   map 100% reduce 100%
  Job job_1497906899862_2074 completed successfully
  Output directory: hdfs:///user/nileshbhoyar/output/HW55/index/
Counters: 50
        File Input Format Counters
                Bytes Read=9159402
        File Output Format Counters
                Bytes Written=8280089
        File System Counters
                FILE: Number of bytes read=4558460
```

In [229]:
```
!hdfs dfs -rm -r hdfs:///user/nileshbhoyar/output/HW55/similarity
%time !python similarity.py\
             -r hadoop \
             --output-dir="hdfs:///user/nileshbhoyar/output/HW55/similarity/"\
             --no-output "hdfs:///user/nileshbhoyar/output/HW55/index"

# !hdfs dfs -rm -r hdfs:///user/nileshbhoyar/output/HW55/similarity
# !rm -r /home/nileshbhoyar/output/HW55/similarity/
# %time !python similarity.py\
#           -r local \
#           --output-dir="/home/nileshbhoyar/output/HW55/similarity/"\
#           --no-output \
#           --file features.txt\
#           --file vocabulary.txt\
#           "/home/nileshbhoyar/output/HW55/index/"
```

```
17/06/22 18:24:05 INFO fs.TrashPolicyDefault: Namenode trash configuration: De
letion interval = 5760 minutes, Emptier interval = 360 minutes.
Moved: 'hdfs://nn-ia.s3s.altiscale.com:8020/user/nileshbhoyar/output/HW55/simi
larity' to trash at: hdfs://nn-ia.s3s.altiscale.com:8020/user/nileshbhoyar/.Tr
ash/Current
No configs found; falling back on auto-configuration
Looking for hadoop binary in /opt/hadoop/bin...
Found hadoop binary: /opt/hadoop/bin/hadoop
Creating temp directory /tmp/similarity.nileshbhoyar.20170622.182406.394268
Using Hadoop version 2.7.3
Copying local files to hdfs:///user/nileshbhoyar/tmp/mrjob/similarity.nileshbh
oyar.20170622.182406.394268/files/...
Looking for Hadoop streaming jar in /opt/hadoop...
Found Hadoop streaming jar: /opt/hadoop/share/hadoop/tools/lib/hadoop-streamin
g-2.7.3.jar
Detected hadoop configuration property names that do not match hadoop version
2.7.3:
The have been translated as follows
 mapred.reduce.tasks: mapreduce.job.reduces
mapred.text.key.comparator.options: mapreduce.partition.keycomparator.options
Running step 1 of 1...
  packageJobJar: [] [/opt/hadoop-2.7.3/share/hadoop/tools/lib/hadoop-streaming
-2.7.3.jar] /tmp/streamjob5246956418942942580.jar tmpDir=null
  Timeline service address: http://rm-ia.s3s.altiscale.com:8188/ws/v1/timeline
/
  Connecting to ResourceManager at rm-ia.s3s.altiscale.com/10.251.255.108:8032
  Connecting to Application History server at rm-ia.s3s.altiscale.com/10.251.2
55.108:10200
  Timeline service address: http://rm-ia.s3s.altiscale.com:8188/ws/v1/timeline
/
  Connecting to ResourceManager at rm-ia.s3s.altiscale.com/10.251.255.108:8032
  Connecting to Application History server at rm-ia.s3s.altiscale.com/10.251.2
55.108:10200
  Loaded native gpl library from the embedded binaries
  Successfully loaded & initialized native-lzo library [hadoop-lzo rev d62701d
4d05dfa6115bbaf8d9dff002df142e62d]
  Total input paths to process : 10
  number of splits:24
  Submitting tokens for job: job_1497906899862_2078
  Submitted application application_1497906899862_2078
  The url to track the job: http://rm-ia.s3s.altiscale.com:8088/proxy/applicat
ion_1497906899862_2078/
  Running job: job_1497906899862_2078
  Job job_1497906899862_2078 running in uber mode : false
   map 0% reduce 0%
   map 6% reduce 0%
   map 10% reduce 0%
   map 19% reduce 0%
   map 30% reduce 0%
   map 32% reduce 0%
   map 33% reduce 0%
   map 37% reduce 0%
   map 41% reduce 0%
   map 46% reduce 0%
   map 49% reduce 0%
   map 50% reduce 0%
   map 51% reduce 0%
   map 52% reduce 0%
   map 55% reduce 0%
   map 57% reduce 0%
   map 58% reduce 0%
   map 62% reduce 0%
   map 64% reduce 0%
   map 65% reduce 0%
   map 66% reduce 0%
   map 68% reduce 0%
   map 69% reduce 0%
   map 71% reduce 0%
   map 72% reduce 0%
   map 74% reduce 0%
```

In [230]:
```
!rm /home/nileshbhoyar/output/HW55/similarity/part-00000
!hdfs dfs -cat hdfs:///user/nileshbhoyar/output/HW55/similarity/* > /home/niles
hbhoyar/output/HW55/similarity/part-00000
!sort -k4nr /home/nileshbhoyar/output/HW55/similarity/part-00000 > final_sorted
.txt
!head -1000 final_sorted.txt > result.txt
```

In [231]:
```
import json
from collections import defaultdict

print "{0:>15} |{1:>15}|{2:>15}|{3:>15}".format(
           "pair",  "jaccard","Dice","average")
print '-'*110
ndict = defaultdict(float)
print "{0:>15} |{1:>15}|{2:>15}|{3:>15}".format(
           "pair",  "jaccard","Dice","average")
print '-'*110

with open("result.txt","r") as f:
      lines = f.readlines()
      for line in lines:
          line = line.strip()

          pair,stripe = line.split("\t")


          result = stripe[1:-1].split(',')

          print "{0:>15} |{1:>15f}|{2:>15f}|{3:>15}".format(
              pair,float(result[0]),float(result[1] ),float(result[2]))
```

```
           pair |        jaccard|           Dice|        average
--------------------------------------------------------------------------------
---------------------------------
           pair |        jaccard|           Dice|        average
--------------------------------------------------------------------------------
---------------------------------
 ["may", "one"] |       0.912738|       0.954379| 0.933558409891
["one", "time"] |       0.903518|       0.949314| 0.926415604952
["one", "well"] |       0.873747|       0.932620| 0.903183907923
["angeles", "los"] |       0.869565|       0.930233| 0.899898887765
["one", "would"] |       0.865597|       0.927957| 0.896776889809
["first", "one"] |       0.853119|       0.920738| 0.886928520089
["may", "well"] |       0.839959|       0.913019| 0.876489307931
["may", "time"] |       0.836345|       0.910880| 0.873612821982
["may", "would"] |       0.829766|       0.906964| 0.868364666831
["time", "would"] |       0.829569|       0.906846|  0.86820751434
["one", "upon"] |       0.812249|       0.896399| 0.854323943975
["time", "well"] |       0.810101|       0.895089| 0.852595147908
["first", "time"] |       0.809231|       0.894558|  0.85189429618
["one", "part"] |       0.807615|       0.893570| 0.850592537625
["made", "one"] |       0.793555|       0.884896| 0.839225504981
["well", "would"] |       0.790224|       0.882821| 0.836522710264
["first", "may"] |       0.787726|       0.881261|  0.83449345482
["great", "one"] |       0.786935|       0.880765| 0.833849788877
 ["new", "one"] |       0.779456|       0.876061| 0.827758656948
["could", "would"] |       0.778618|       0.875531| 0.827074489779
["first", "would"] |       0.778006|       0.875145| 0.826575337583
["may", "upon"] |       0.773700|       0.872414| 0.823057049457
 ["one", "two"] |       0.773092|       0.872027| 0.822559774773
["first", "well"] |       0.771894|       0.871264| 0.821579230751
 ["one", "way"] |       0.769849|       0.869960| 0.819904748045
["also", "one"] |       0.768537|       0.869122|  0.81882944359
["could", "one"] |       0.766064|       0.867538| 0.816801315552
["part", "time"] |       0.763023|       0.865585|  0.81430433069
["may", "part"] |       0.760121|       0.863715| 0.811918118049
["must", "one"] |       0.759519|       0.863326| 0.811422389198
["great", "time"] |       0.758014|       0.862353| 0.810183709471
["may", "must"] |       0.757796|       0.862212| 0.810003983422
["time", "upon"] |       0.756867|       0.861610| 0.809238231169
["made", "may"] |       0.756397|       0.861305| 0.808851247695
["part", "well"] |       0.752832|       0.858989| 0.805910778015
["made", "would"] |       0.751312|       0.857999| 0.804655224553
["upon", "would"] |       0.750776|       0.857649| 0.804212369077
["also", "may"] |       0.750772|       0.857647| 0.804209729206
["made", "time"] |       0.746667|       0.854962| 0.800814249364
["new", "time"] |       0.746639|       0.854944| 0.800791421835
["great", "would"] |       0.744503|       0.853541| 0.799022017184
["upon", "well"] |       0.743091|       0.852613| 0.797852065504
["time", "way"] |       0.738636|       0.849673| 0.794154783125
["could", "time"] |       0.738366|       0.849494| 0.793930214632
["great", "may"] |       0.737323|       0.848803| 0.793062892166
["could", "may"] |       0.735656|       0.847698| 0.791676747247
 ["may", "way"] |       0.734151|       0.846698| 0.790424721225
["way", "would"] |       0.732143|       0.845361| 0.788751840943
["great", "well"] |       0.729618|       0.843675| 0.786646790358
["time", "two"] |       0.729508|       0.843602| 0.786555046228
["must", "would"] |       0.728707|       0.843066| 0.785886159018
["part", "would"] |       0.728294|       0.842790| 0.785541887921
["made", "well"] |       0.727366|       0.842168| 0.784767106131
["also", "well"] |       0.726895|       0.841852| 0.784373596991
["many", "one"] |       0.725904|       0.841187| 0.783545175466
 ["may", "two"] |       0.725152|       0.840682| 0.782917040805
["first", "new"] |       0.724974|       0.840562| 0.782767830073
["must", "time"] |       0.724563|       0.840286| 0.782424630702
 ["may", "new"] |       0.724417|       0.840188| 0.782302720323
["new", "would"] |       0.723958|       0.839879| 0.781918743706
["first", "two"] |       0.723920|       0.839853| 0.781886608217
["great", "upon"] |       0.722995|       0.839230| 0.781112472075
  ["one", "us"] |       0.722503|       0.838899| 0.780700587656
["first", "part"] |       0.720452|       0.837515| 0.778983571975
```

In [237]:
```
print "**********TOP 20 RECORDS**********"
!head -20 final_sorted.txt
print "\n\n"
print "**********Bottom 20 Records**********"
print "\n\n"
!tail -20 final_sorted.txt
```

```
**********TOP 20 RECORDS**********
["may", "one"]  [0.91273821464393179, 0.95437860513896167, 0.93355840989144667
]
["one", "time"] [0.9035175879396985, 0.94931362196409719, 0.9264156049518979]
["one", "well"] [0.87374749498997994, 0.93262032085561497, 0.90318390792279746
]
["angeles", "los"]      [0.86956521739130432, 0.93023255813953487, 0.899898887
7654196]
["one", "would"]        [0.86559679037111337, 0.92795698924731185, 0.896776889
80921255]
["first", "one"]        [0.85311871227364189, 0.92073832790445165, 0.886928520
08904677]
["may", "well"] [0.83995922528032618, 0.91301939058171744, 0.87648930793102187
]
["may", "time"] [0.83634538152610438, 0.91088026243849096, 0.87361282198229762
]
["may", "would"]        [0.82976554536187563, 0.90696378830083568, 0.868364666
8313556]
["time", "would"]       [0.82956878850102667, 0.90684624017957349, 0.868207514
34030008]
["one", "upon"] [0.81224899598393574, 0.89639889196675904, 0.85432394397534739
]
["time", "well"]        [0.8101010101010101, 0.8950892857142857, 0.85259514790
76479]
["first", "time"]       [0.8092307692307692, 0.89455782312925169, 0.8518942961
8001045]
["one", "part"] [0.80761523046092187, 0.89356984478935697, 0.85059253762513942
]
["made", "one"] [0.79355488418932529, 0.88489612577203813, 0.83922550498068171
]
["well", "would"]       [0.79022403258655805, 0.88282138794084186, 0.836522710
26369995]
["first", "may"]        [0.78772635814889336, 0.88126055149127747, 0.834493454
82008541]
["great", "one"]        [0.7869346733668342, 0.88076490438695165, 0.8338497888
7689298]
["new", "one"]  [0.77945619335347427, 0.87606112054329377, 0.82775865694838402
]
["could", "would"]      [0.77861771058315332, 0.87553126897389189, 0.827074489
7785226]



**********Bottom 20 Records**********



["participant", "well"] [0.0011299435028248588, 0.002257336343115124, 0.001693
6399229699915]
["fascinated", "well"]  [0.001128668171557562, 0.0022547914317925591, 0.001691
7298016750604]
["proposes", "well"]    [0.001128668171557562, 0.0022547914317925591, 0.001691
7298016750604]
["dad", "time"] [0.0011013215859030838, 0.0022002200220022001, 0.0016507708039
526421]
["misunderstanding", "time"]    [0.0011013215859030838, 0.0022002200220022001,
0.0016507708039526421]
["revert", "time"]      [0.0011013215859030838, 0.0022002200220022001, 0.00165
07708039526421]
["concede", "time"]     [0.0011001100110011001, 0.0021978021978021978, 0.00164
89561044016488]
["continuum", "time"]   [0.0011001100110011001, 0.0021978021978021978, 0.00164
89561044016488]
["foreseen", "time"]    [0.0011001100110011001, 0.0021978021978021978, 0.00164
89561044016488]
["negligible", "time"]  [0.0011001100110011001, 0.0021978021978021978, 0.00164
89561044016488]
["electrodes", "time"]  [0.0010989010989010989, 0.0021953896816684962, 0.00164
71453902847976]
["proposes", "time"]    [0.0010989010989010989, 0.0021953896816684962, 0.00164
```

Run time for Stripes Job

```
Map 190
Reducers 20

Job Name:   streamjob7789550624839722782.jar
User Name:  nileshbhoyar
Queue:  berkeley
State:  SUCCEEDED
Uberized:   false
Submitted:  Thu Jun 22 18:17:30 UTC 2017
Started:    Thu Jun 22 18:17:39 UTC 2017
Finished:   Thu Jun 22 18:19:38 UTC 2017
Elapsed:    1mins, 59sec
Diagnostics:
Average Map Time    1mins, 17sec
Average Shuffle Time    3sec
Average Merge Time  0sec
Average Reduce Time     2sec
```

Run time for Inverted index job

```
 NO OF MAPS 20
 NO of REDUCERS 10

 Job Name:  streamjob6234810784634808372.jar
User Name:  nileshbhoyar
Queue:  berkeley
State:  SUCCEEDED
Uberized:   false
Submitted:  Thu Jun 22 18:20:11 UTC 2017
Started:    Thu Jun 22 18:20:19 UTC 2017
Finished:   Thu Jun 22 18:23:57 UTC 2017
Elapsed:    3mins, 37sec
Diagnostics:
Average Map Time    39sec
Average Shuffle Time    11sec
Average Merge Time  0sec
Average Reduce Time     3sec
```

Run time for similarity jobs

```
No of Mappers 24
No of Reducers 10

Job Name:   streamjob5246956418942942580.jar
User Name:  nileshbhoyar
Queue:  berkeley
State:  SUCCEEDED
Uberized:   false
Submitted:  Thu Jun 22 18:24:25 UTC 2017
Started:    Thu Jun 22 18:25:40 UTC 2017
Finished:   Thu Jun 22 18:43:19 UTC 2017
Elapsed:    17mins, 38sec
Diagnostics:
```

Top/Bottom 20 results - Similarity measures - sorted by cosine (From the entire data set)

pair	cosine	jaccard	overlap	dice	average
cons - pros	0.894427	0.800000	1.000000	0.888889	0.895829
forties - twenties	0.816497	0.666667	1.000000	0.800000	0.820791
own - time	0.809510	0.670563	0.921168	0.802799	0.801010
little - time	0.784197	0.630621	0.926101	0.773473	0.778598
found - time	0.783434	0.636364	0.883788	0.777778	0.770341
nova - scotia	0.774597	0.600000	1.000000	0.750000	0.781149
hong - kong	0.769800	0.615385	0.888889	0.761905	0.758995
life - time	0.769666	0.608789	0.925081	0.756829	0.765091
time - world	0.755476	0.585049	0.937500	0.738209	0.754058
means - time	0.752181	0.587117	0.902597	0.739854	0.745437
form - time	0.749943	0.588418	0.876733	0.740885	0.738995
infarction - myocardial	0.748331	0.560000	1.000000	0.717949	0.756570
people - time	0.745788	0.573577	0.923875	0.729010	0.743063
angeles - los	0.745499	0.586207	0.850000	0.739130	0.730209
little - own	0.739343	0.585834	0.767296	0.738834	0.707827
life - own	0.737053	0.582217	0.778502	0.735951	0.708430
anterior - posterior	0.733388	0.576471	0.790323	0.731343	0.707881
power - time	0.719611	0.533623	0.933586	0.695898	0.720680
dearly - install	0.707107	0.500000	1.000000	0.666667	0.718443
found - own	0.704802	0.544134	0.710949	0.704776	0.666165

arrival - essential | 0.008258 | 0.004098 | 0.009615 | 0.008163 | 0.007534 governments - surface | 0.008251 | 0.003534 | 0.014706 | 0.007042 | 0.008383 king - lesions | 0.008178 | 0.003106 | 0.017857 | 0.006192 | 0.008833 clinical - stood | 0.008178 | 0.003831 | 0.011905 | 0.007634 | 0.007887 till - validity | 0.008172 | 0.003367 | 0.015625 | 0.006711 | 0.008469 evidence - started | 0.008159 | 0.003802 | 0.012048 | 0.007576 | 0.007896 forces - record | 0.008152 | 0.003876 | 0.011364 | 0.007722 | 0.007778 primary - stone | 0.008146 | 0.004065 | 0.009091 | 0.008097 | 0.007350 beneath - federal | 0.008134 | 0.004082 | 0.008403 | 0.008130 | 0.007187 factors - rose | 0.008113 | 0.004032 | 0.009346 | 0.008032 | 0.007381 evening - functions | 0.008069 | 0.004049 | 0.008333 | 0.008065 | 0.007129 bone - told | 0.008061 | 0.003704 | 0.012346 | 0.007380 | 0.007873 building - occurs | 0.008002 | 0.003891 | 0.010309 | 0.007752 | 0.007489 company - fig | 0.007913 | 0.003257 | 0.015152 | 0.006494 | 0.008204 chronic - north | 0.007803 | 0.003268 | 0.014493 | 0.006515 | 0.008020 evaluation - king | 0.007650 | 0.003030 | 0.015625 | 0.006042 | 0.008087 resulting - stood | 0.007650 | 0.003663 | 0.010417 | 0.007299 | 0.007257 agent - round | 0.007515 | 0.003289 | 0.012821 | 0.006557 | 0.007546 afterwards -

3. HW5.6 Evaluation of synonyms that your discovered

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In this part of the assignment you will evaluate the success of you synonym detector (developed in response to HW5.4). Take the top 1,000 closest/most similar/correlative pairs of words as determined by your measure in HW5.4, and use the synonyms function in the accompanying python code:

nltk_synonyms.py

Note: This will require installing the python nltk package:

http://www.nltk.org/install.html (http://www.nltk.org/install.html)

and downloading its data with nltk.download().

For each (word1,word2) pair, check to see if word1 is in the list, synonyms(word2), and vice-versa. If one of the two is a synonym of the other, then consider this pair a 'hit', and then report the precision, recall, and F1 measure of your detector across your 1,000 best guesses. Report the macro averages of these measures.

Calculate performance measures:

$$Precision(P) = \frac{TP}{TP + FP}$$

$$Recall(R) = \frac{TP}{TP + FN}$$

$$F1 = \frac{2 * (precision * recall)}{precision + recall}$$

We calculate Precision by counting the number of hits and dividing by the number of occurances in our top1000 (opportunities)
We calculate Recall by counting the number of hits, and dividing by the number of synonyms in wordnet (syns)

Other diagnostic measures not implemented here: https://en.wikipedia.org/wiki/F1_score#Diagnostic_Testing (https://en.wikipedia.org/wiki/F1_score#Diagnostic_Testing)

In [ ]:
```
nltk.download('wordnet')
```

In [238]:
```
''' Performance measures '''
from __future__ import division
import numpy as np
import json
import nltk
from nltk.corpus import wordnet as wn
import sys
import re
#print all the synset element of an element
def synonyms(string):
    syndict = {}
    for i,j in enumerate(wn.synsets(string)):
        syns = j.lemma_names()
        for syn in syns:
            syndict.setdefault(syn,1)
    return syndict.keys()
hits = []

TP = 0
FP = 0

TOTAL = 0
flag = False # so we don't double count, but at the same time don't miss hits

top1000sims = []
lisst =[]
with open("result.txt","r") as f:
   for line in f.readlines():#

       line = line.strip()
       pair,stripe = line.split("\t")


       result = stripe[1:-1].split(',')
#        avg,lisst = line.split("\t")
#        lisst = json.loads(lisst)
       lisst.append(result[2])
       top1000sims.append(pair)


measures = {}
not_in_wordnet = []

for line in top1000sims:
    TOTAL += 1

    #pair = line[0]
    #words = pair.split(" - ")
    #rec = line[0]
    #print line
    #break
    words = re.findall("\w+", line.lower())
#     print words
#     break

    for word in words:
        if word not in measures:
            measures[word] = {"syns":0,"opps": 0,"hits":0}
        measures[word]["opps"] += 1

    syns0 = synonyms(words[0])
    measures[words[1]]["syns"] = len(syns0)
    if len(syns0) == 0:
        not_in_wordnet.append(words[0])

    if words[1] in syns0:
        TP += 1
        hits.append(line)
        flag = True
```

```
--------------------------------------------------------------------------------
----------------------------------
Number of Hits: 12 out of top 1000
Number of words without synonyms: 224
--------------------------------------------------------------------------------
----------------------------------
Precision       0.0182387273359
Recall          0.0340782004282
F1              0.0128139662472
--------------------------------------------------------------------------------
----------------------------------
Words without synonyms:
--------------------------------------------------------------------------------
----------------------
[] angeles
[] los
[] would
[] would
[] would
[] upon
[] would
[] could
[] would
[] would
[] upon
[] could
[] upon
[] would
[] upon
[] would
[] would
[] upon
[] could
[] could
[] would
[] would
[] would
[] would
[] upon
[] upon
[] upon
[] would
[] could
[] could
[] would
[] upon
[] could
[] upon
[] would
[] could
[] could
[] would
[] would
[] could
[] could
[] upon
[] could
[] would
[] upon
[] upon
[] upon
[] upon
[] would
[] could
[] without
[] would
[] could
[] could
[] upon
[] would
```

Sample output

In [ ]:
```
--------------------------------------------------------------------------------
Number of Hits: 31 out of top 1000
Number of words without synonyms: 67
--------------------------------------------------------------------------------
Precision       0.0280214404967
Recall          0.0178598869579
F1              0.013965517619
--------------------------------------------------------------------------------
Words without synonyms:
--------------------------------------------------------------------------------
[] scotia
[] hong
[] kong
[] angeles
[] los
[] nor
[] themselves
[]
.......
```

3. HW5.7 OPTIONAL: using different vocabulary subsets

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Repeat HW5 using vocabulary words ranked from 8001,-10,000; 7001,-10,000; 6001,-10,000; 5001,-10,000; 3001,-10,000; and 1001,-10,000; Dont forget to report you Cluster configuration.

Generate the following graphs: -- vocabulary size (X-Axis) versus CPU time for indexing -- vocabulary size (X-Axis) versus number of pairs processed -- vocabulary size (X-Axis) versus F1 measure, Precision, Recall

In [ ]:

3. HW5.8 OPTIONAL: filter stopwords

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There is also a corpus of stopwords, that is, high-frequency words like "the", "to" and "also" that we sometimes want to filter out of a document before further processing. Stopwords usually have little lexical content, and their presence in a text fails to distinguish it from other texts. Python's nltk comes with a prebuilt list of stopwords (see below). Using this stopword list filter out these tokens from your analysis and rerun the experiments in 5.5 and disucuss the results of using a stopword list and without using a stopword list.

```
from nltk.corpus import stopwords
```

```
stopwords.words('english') ['i', 'me', 'my', 'myself', 'we', 'our', 'ours', 'ourselves', 'you',
'your', 'yours', 'yourself', 'yourselves', 'he', 'him', 'his', 'himself', 'she', 'her', 'hers',
'herself', 'it', 'its', 'itself', 'they', 'them', 'their', 'theirs', 'themselves', 'what', 'which', 'who',
'whom', 'this', 'that', 'these', 'those', 'am', 'is', 'are', 'was', 'were', 'be', 'been', 'being',
'have', 'has', 'had', 'having', 'do', 'does', 'did', 'doing', 'a', 'an', 'the', 'and', 'but', 'if', 'or',
'because', 'as', 'until', 'while', 'of', 'at', 'by', 'for', 'with', 'about', 'against', 'between',
'into', 'through', 'during', 'before', 'after', 'above', 'below', 'to', 'from', 'up', 'down', 'in',
'out', 'on', 'off', 'over', 'under', 'again', 'further', 'then', 'once', 'here', 'there', 'when',
'where', 'why', 'how', 'all', 'any', 'both', 'each', 'few', 'more', 'most', 'other', 'some',
'such', 'no', 'nor', 'not', 'only', 'own', 'same', 'so', 'than', 'too', 'very', 's', 't', 'can', 'will',
'just', 'don', 'should', 'now']
```

In [ ]:

3. HW5.9 OPTIONAL

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There are many good ways to build our synonym detectors, so for this optional homework, measure co-occurrence by (left/right/all) consecutive words only, or make stripes according to word co-occurrences with the accompanying 2-, 3-, or 4-grams (note here that your output will no longer be interpretable as a network) inside of the 5-grams.

In [ ]:

3. HW5.10 OPTIONAL

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Once again, benchmark your top 10,000 associations (as in 5.5), this time for your results from 5.6. Has your detector improved?

In [ ]: