Introduction to MapReduce

EECS 4415
Big Data Systems

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MapReduce

- Our first peek into MapReduce implementation
- Using Python
- Example program: WordCount

Conventional approach

```
#!/usr/bin/python

import sys
import re

sums = {}

for line in sys.stdin:
    line = re.sub( r'^\W+|\W+$', '', line )
    words = re.split(r'\W+', line)

    for word in words:
        word = word.lower()
        sums[word] = sums.get( word, 0 ) + 1

print sums
```

Conventional (step 0)

Preparation:

```
import sys
import re

sums = {}
```

Loading file line by line:

```
for line in sys.stdin:
```

Conventional (step 1)

Removing non-word characters:

```
line = re.sub( r'^\W+|\W+$', '', line )
```

Splitting into words:

```
words = re.split( r'\W+', line )
```

Conventional (step 2)

Iterating over words:

```
for word in words:
```

Making everything lowercase:

```
word = word.lower()
```

Incrementing the count of every word in the dictionary

```
sums[word] = sums.get( word, 0 ) + 1
```

(if word doesn't exist, get 0)

Conventional (Moby Dick)

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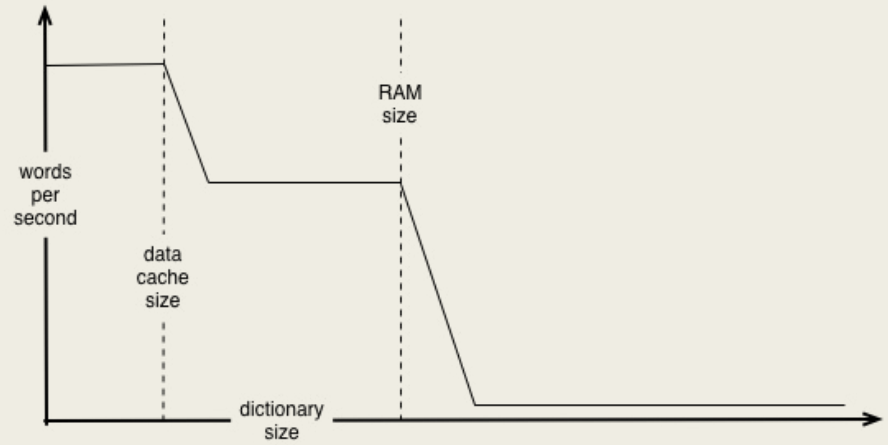
Conventional (output)

```
ty': 2, 'outset': 3, 'own': 205, 'polished': 7, 'boggy': 1, 'strangeness': 3, 's
ugary': 1, 'owe': 1, 'degenerated': 3, 'canaan': 2, 'trunks': 2, 'promise': 7, '
brush': 1, 'decree': 1, 'freeze': 1, 'zoology': 2, 'intricacies': 4, 'barques':
1, 'fired': 3, 'linnaeus': 5, 'van': 5, 'pillaged': 1, 'crave': 1, 'rivals': 2,
'transfer': 2, 'spiral': 1, 'captains': 24, 'continental': 2, 'intention': 8, 'a
ppals': 2, 'monopolising': 2, 'powdered': 1, 'breeding': 2, 'throttled': 1, 'vat
': 1, 'callings': 1, 'shank': 3, 'tashtego': 57, 'hollanders': 1, 'cankerous': 1
, 'billion': 1, 'mutter': 3, 'volume': 13, 'wight': 5, 'contradictory': 3, 'cana
llers': 8, 'assail': 1, 'swayings': 1, 'tinges': 1, 'unreverenced': 1, 'jaffa':
2, 'unwearied': 2, 'made': 178, 'israelites': 1, 'whether': 91, 'protesting': 1,
 'swashing': 2, 'recede': 1, 'nightgown': 1, 'venetian': 4, 'record': 7, 'below'
: 52, 'persian': 6, 'ruling': 1, 'cake': 2, 'demonstrate': 1, 'rickety': 1, 'hov
eringly': 1, 'stirring': 4, 'liturgies': 1, 'unfolding': 1, 'heralding': 1, 'eag
erness': 8, 'apothecary': 3, 'ploughing': 2, 'scepticism': 2, 'betrayed': 6, 'gn
awing': 1, 'sheered': 1, 'goodness': 5, 'globules': 2, 'theatre': 1, 'raced': 1,
 'trotting': 1, 'domesticated': 1, 'kant': 1, 'swaine': 1, 'mutual': 5, 'improvi
ng': 2, 'monsoons': 1, 'besmoked': 1, 'incredible': 9, 'honing': 1, 'afoam': 1,
'boot': 2, 'illinois': 3, 'unreluctantly': 1, 'book': 60, 'boom': 8, 'sick': 10,
 'unlettered': 1, 'repute': 1, 'incredibly': 1, 'flexion': 1, 'conclusion': 6, '
lance': 45, 'junk': 5, 'kinds': 3, 'scabbards': 1, 'nourishment': 2, 'june': 3,
'circumspection': 1, 'frustrate': 1, 'risked': 1, 'pumps': 15, 'earthly': 16, 'r
ichardson': 1, 'gap': 1, 'upwards': 19, 'auxiliary': 2, 'ranks': 2, 'pods': 4, '
yawed': 1, 'jewel': 2, 'gam': 7, 'sash': 1, 'uncatastrophied': 1, 'races': 1, 'v
olumes': 2, 'sleeves': 5, 'expands': 2, 'sunda': 6}
```

Limitations of approach

- Requires use of dictionary
  - *entire object stored in memory*
  - *if too big for memory crashes*
- Slower as dictionary grows
  - *the bigger it is, the more time needed to get key (word)*

Limitations of approach (graph)



MapReduce approach

Does not require a central data structure (dictionary)

Steps:

- **map**: intermediate results, associates them with output key
- **shuffle**: intermediate results, same output key
- **reduce**: final result, takes keys as input

MapReduce Mapper

```
#!/usr/bin/python

import sys
import re

for line in sys.stdin:
    line = re.sub( r'^\W+|\W+$', '', line )
    words = re.split(r"\W+", line)

    for word in words:
        print( word.lower() + "\t1" )
```

MapReduce Mapper (step 0)

Same first steps:

```
import sys
import re

sums = {}

for line in sys.stdin:
       line = re.sub( r'^\W+|\W+$', '', line )
       words = re.split( r'\W+', line )

       for word in words:
```

MapReduce Mapper (step 1)

Output word and count:

- convert to lowercase
- "\t" (tab) is Hadoop for ":" separates key from value

```
print( word.lower() + "\t1" )
```

Conventional execution:

```
./mapper.py < input.txt
```

MapReduce Mapper (output)

```
gutenberg       1
literary        1
archive 1
foundation      1
how     1
to      1
help    1
produce 1
our     1
new     1
ebooks  1
and     1
how     1
to      1
subscribe       1
to      1
our     1
email   1
newsletter      1
to      1
hear    1
about   1
new     1
ebooks  1
```

MapReduce Shuffle

Simple sort of calculated words

- Running on a cluster, more distribution happens here

Conventional execution (Linux command):

```
./mapper.py < input.txt | sort
```

MapReduce Shuffle (output)

```
zealanders      1
zephyr  1
zeuglodon       1
zig     1
zip     1
zodiac  1
zodiac  1
zodiac  1
zodiac  1
zodiac  1
zogranda        1
zone    1
zone    1
zone    1
zone    1
zone    1
zoned   1
zoned   1
zones   1
zones   1
zones   1
zoology 1
zoology 1
zoroaster       1
```

MapReduce Reducer

```
#!/usr/bin/python

import sys

previous = None
sum = 0

for line in sys.stdin:
    key, value = line.split( '\t' )

    if key != previous:
        if previous is not None:
            print str( sum ) + '\t' + previous
        previous = key
        sum = 0

    sum = sum + int( value )

print str( sum ) + '\t' + previous
```

MapReduce Reducer (step 0)

Preparation:

```
import sys

previous = None
sum = 0
```

Loading previous results line by line:

```
for line in sys.stdin:
```

MapReduce Reducer (step 1)

Split pairs again:

```
key, value = line.split( '\t' )
```

If we are still counting occurences of the same word:

```
if key != previous:
```

Unless it's the first entry:

```
if previous is not None:
```

MapReduce Reducer (step 1)

Sum up 2 words:

```
print str( sum ) + '\t' + previous
```

Otherwise, re-initialize for next word

```
previous = key
        sum = 0
```

Either way, add new value to sum

```
sum = sum + int( value )
```

MapReduce Reducer (step 4)

Return those two words:

```
print str( sum ) + '\t' + previous
```

Conventional execution:

```
./mapper.py < input.txt | sort | ./reducer.py
```

MapReduce Reduce (output)

```
258     your
9       yours
1       yourselbs
26      yourself
7       yourselves
9       youth
2       youthful
1       zag
1       zay
2       zeal
7       zealand
1       zealanders
1       zephyr
1       zeuglodon
1       zig
1       zip
5       zodiac
1       zogranda
5       zone
2       zoned
3       zones
2       zoology
1       zoroaster
```

MapReduce Execution

```
hadoop jar /usr/hadoop-3.0.0/share/hadoop/tools/lib/hadoop-streaming-
3.0.0.jar \
-file ./mapper.py \
-mapper ./mapper.py \
-file ./reducer.py \
-reducer ./reducer.py \
-input /input.txt \
-output /output
```

Thank you!

Based on

https://zettadatanet.wordpress.com/2015/04/04/a-hands-on-introduction-to-mapreduce-in-python/