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DEGLI STUDI
FIRENZE

Sequential and parallel implementation of bigrams and trigrams, Java and C++

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Introduction

The main goal is to compute and estimate occurrences of bigrams and trigrams in a certain text.

More in general:

- A sequence of **two** letters (e.g. of) is called a **bigram**.
- A **three**-letter sequence (e.g. off) is called a **trigram**.
- The general term **n-gram** means '**sequence of length n**'.

Languages

We have implemented the task in 2 versions using different technologies:

Sequential version:

- **Java**
- **C++**

Parallel version:

- **Java Thread**
- **C++ Thread (Pthread)**

Computation

- Sequential version:

Algorithm 1: Sequential version

```
Data: n, filestring
for i = 0 to filestring.length-n+1 do
    key = "";
    for j = 0 to n - 1 do
        key = key + filestring[i+j];
    end
end
```

In particular
- n: Number of grams
- filestring: contains the characters from txt file

- Parallel version

Algorithm 2: Parallel version

```
Data: id, k, n, begin, stop, filestring
for i = this.begin to (this.stop - this.n+1) do
    key = "";
    for j = 0 to this.n - 1 do
        key = key + filestring[i+j];
    end
end
```

In particular
- id = idthread
- k = floor(text.length/nThreads) // Dimension of test splits
  where nThread = Number of threads
- n = n°grams
- begin = (k * i)
- stop = (i+1)*k + ((n-1)-1)
- filestring = txt

Thread's attributes
- id
- begin
- stop
- filestring

Sequential implementation - Java

Data preprocessing

- ***readTextFromFile()***: read the text to analyze and replace opportunely those characters defined *invalid.*

Data structure

- **HashMap**: constant time performance for the basic operation (*get(), put()*) for large sets.

Computation

- ***computeNgrams()***: follows the sequential computation explained above.
  - *int n*: identifies the number of grams (two or three).
  - *char [] filestring*: text to analyze.

Sequential implementation - C++

Data preprocessing

- ***readTextFromFile()***: read the text to analyze and replace opportunely those characters defined *invalid.*

Data structure

- **UnorderedMap**: is the chosen structure to replace the java Hash Maps.

Computation

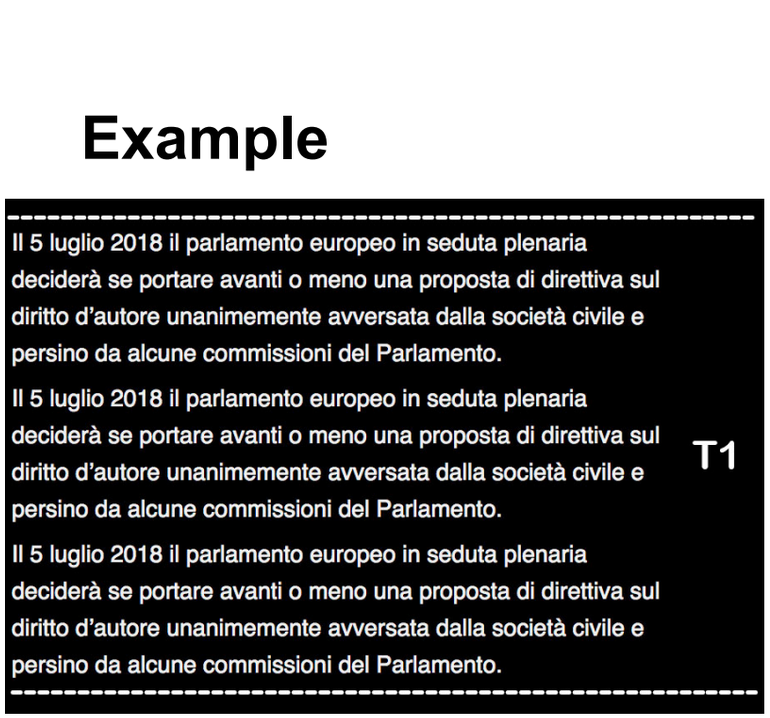
- ***computeNgrams()***: follows the sequential computation explained above.
  - *int n*: identifies the number of grams (two or three).
  - *char * filestring*: text to analyze.

Parallel implementation

Idea

- Divide the text in as many parts as are the thread instances.
- Entrust the search of bigrams and trigrams on a single part to a single thread.

Example



1 thread

2 threads

3 threads

Parallel implementation - Java thread

Some features of *java.util.concurrent* package have been used:

- **Future**
- **ExecutorService**

Data preprocessing

- *readTextFromFile()*

Data structure

- **ConcurrentHashMap:**
  - Allows concurrent modifications of the map from several threads without blocking them.
  - It’s lock-free on reads.
  - Lock only the bucket that’s being altered.

Parallel implementation - Java thread

Computation

- **Declare** a thread class which implements *callable.*
- **Implement** the *call()* method which computes bigrams and trigrams as described before.
- **Implement** a *HashMerge()* function to merge the maps returned from threads.
- **Instantiate** a Future array and an ExecutorService specifying the thread pool size.
- **Use** the ExecutorService object to submit the compute method and get the results through *.get()* Future method.

Parallel implementation - C++ thread

Pthread API have been used to parallelize the C++ code.

Data preprocessing

- *readTextFromFile()*

Data structure

- UnorderedMap

Parallel implementation - C++ thread

Computation

- **Implement** the Thread class including <pthread.h>

- **Extend** the class above, including <Thread.h> defining ParallelThread class.

- **Implement** a ParallelThread method *int *run()* which computes bigrams and trigrams as described before. A getter method provides to return the map.

- **Define** a *HashMerge()* function to merge the returned maps from threads.

- **Declare** an array of threads and a vector of UnorderedMap. The threads are instantiated into the array and started. After the *join()* the returned maps are pushed back into the vector and merged.

Tests

Sequential version:

- The computational time has been collected 100 times vary with the text (from 50Kb to 150Mb) and averaged.

Parallel version:

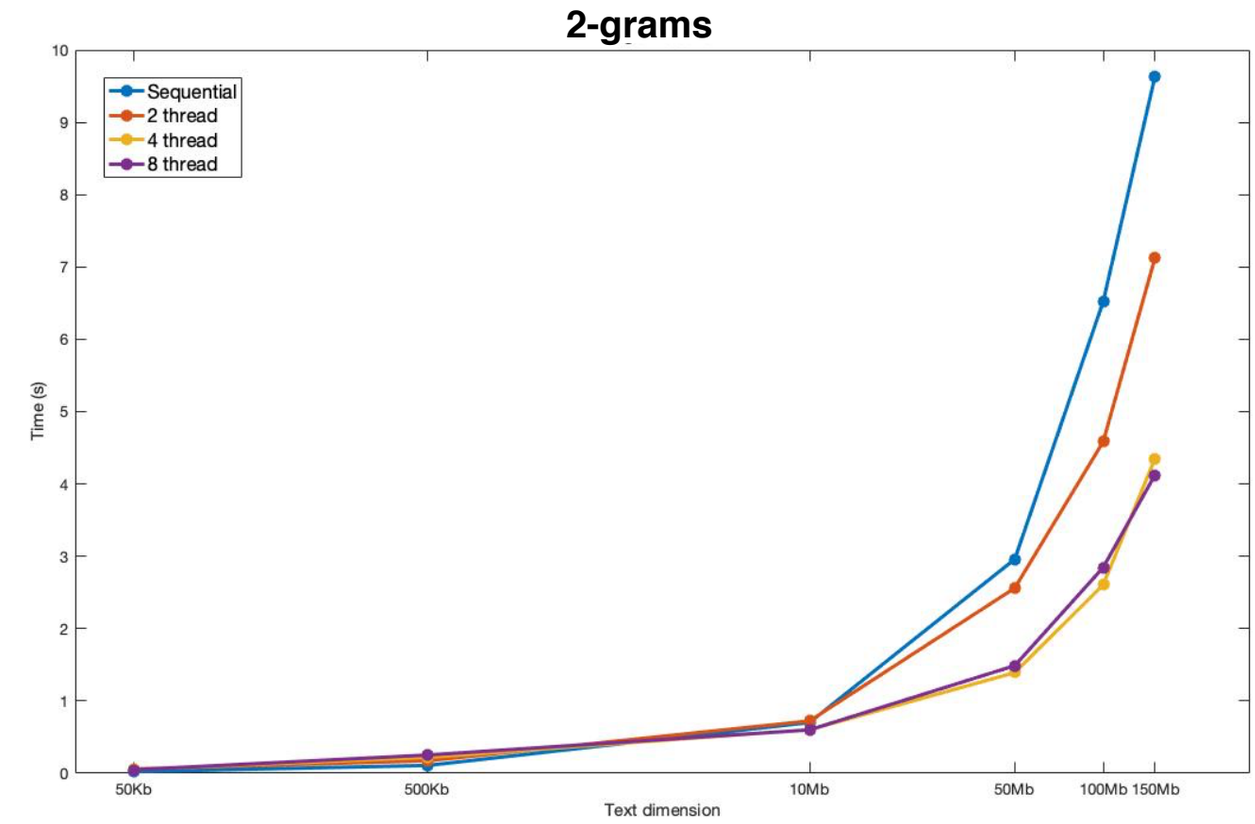
The number of tests is depending on the number of threads used.

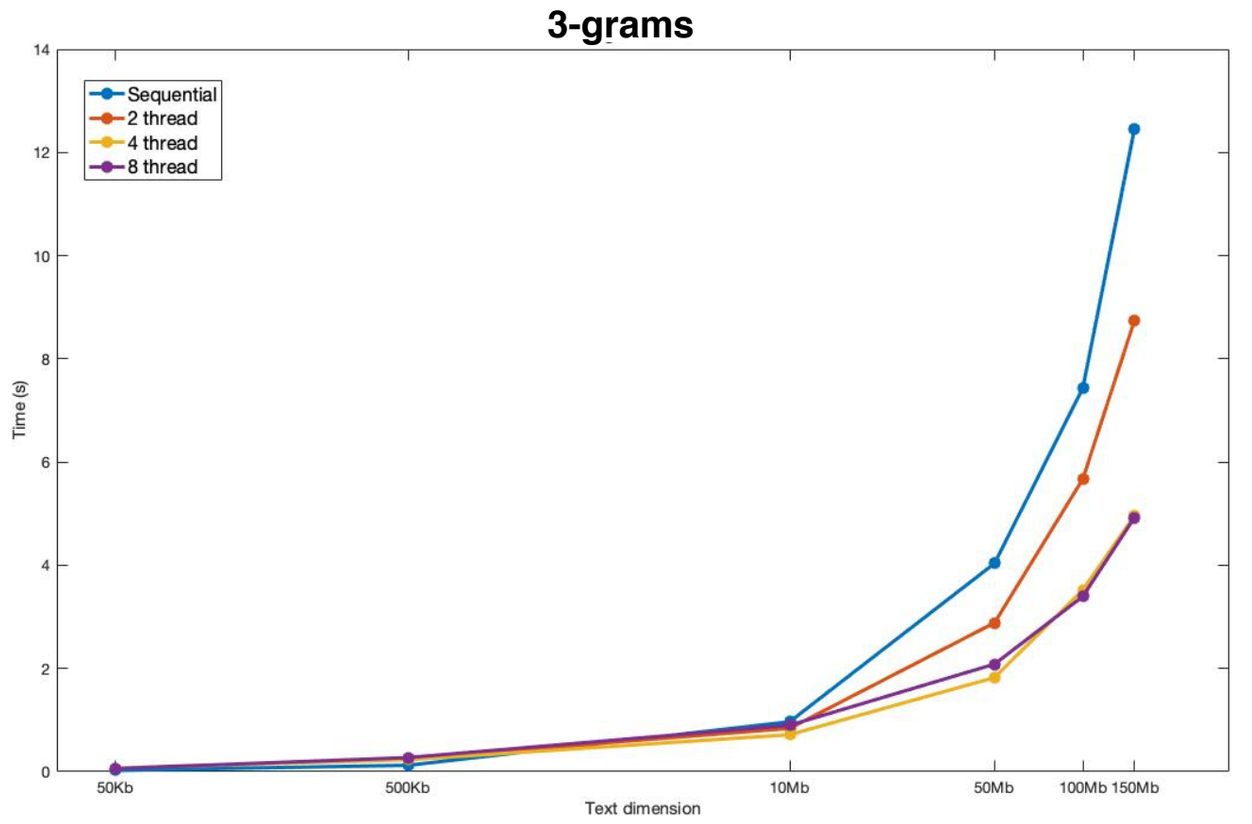
- 2, 4 and 8 threads for the java parallel version
- 2, 4 and 8 threads for the C++ parallel version

For every thread number the computational time has been collected 100 times and averaged.

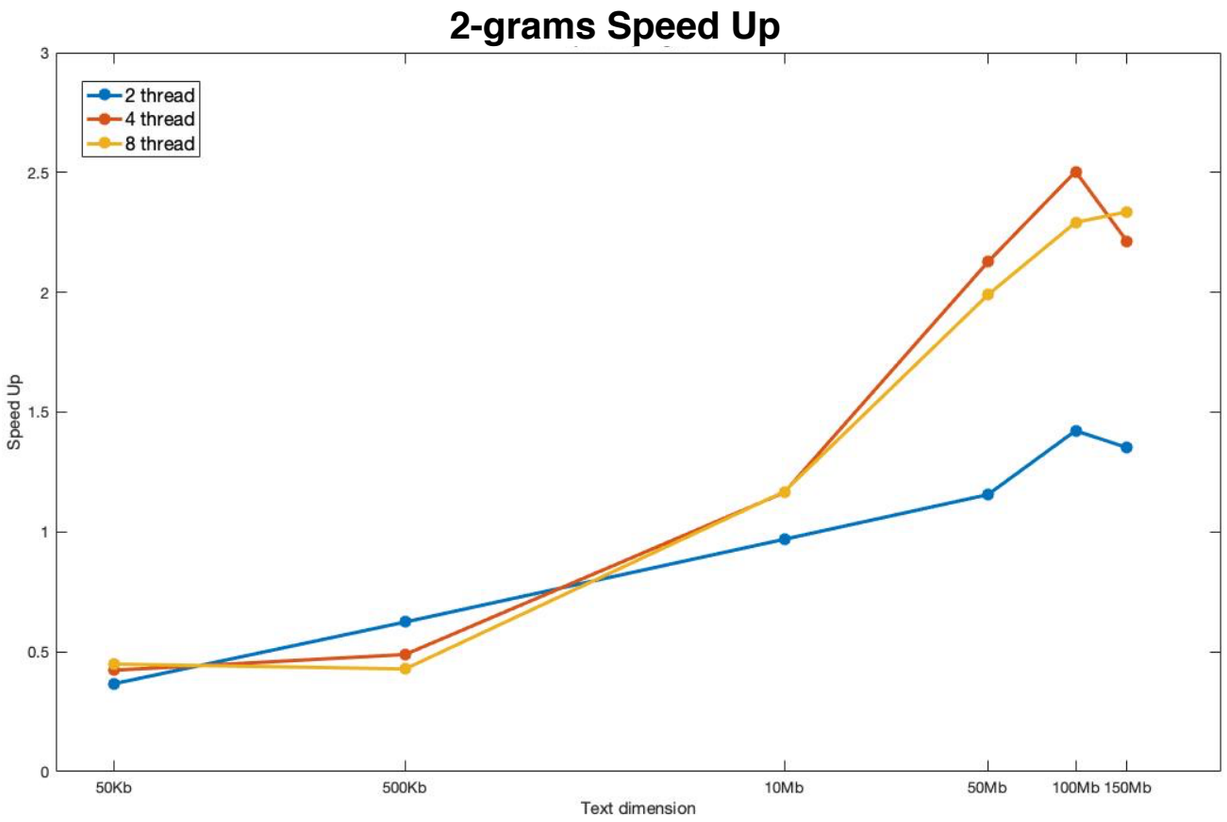
Over the maximum number of threads chosen, computational times don't improve more significantly.

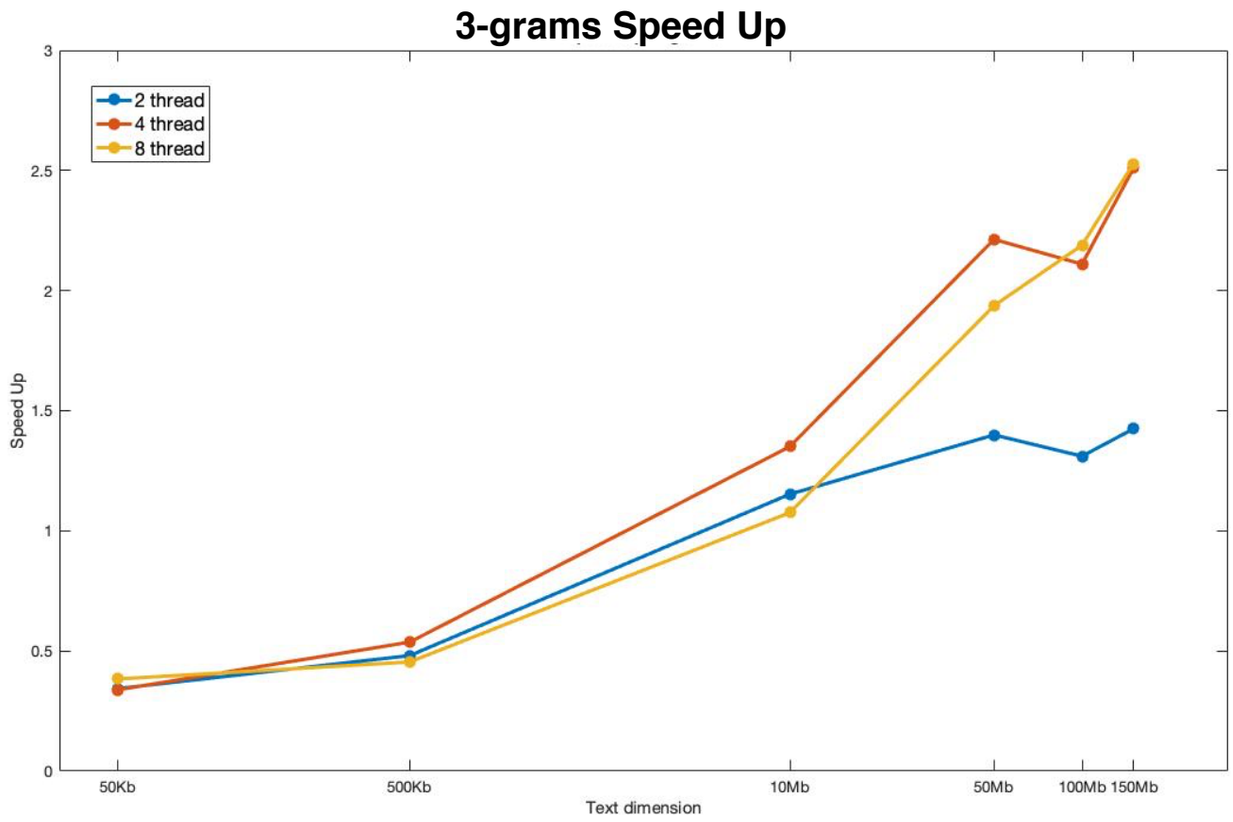
Results - Java



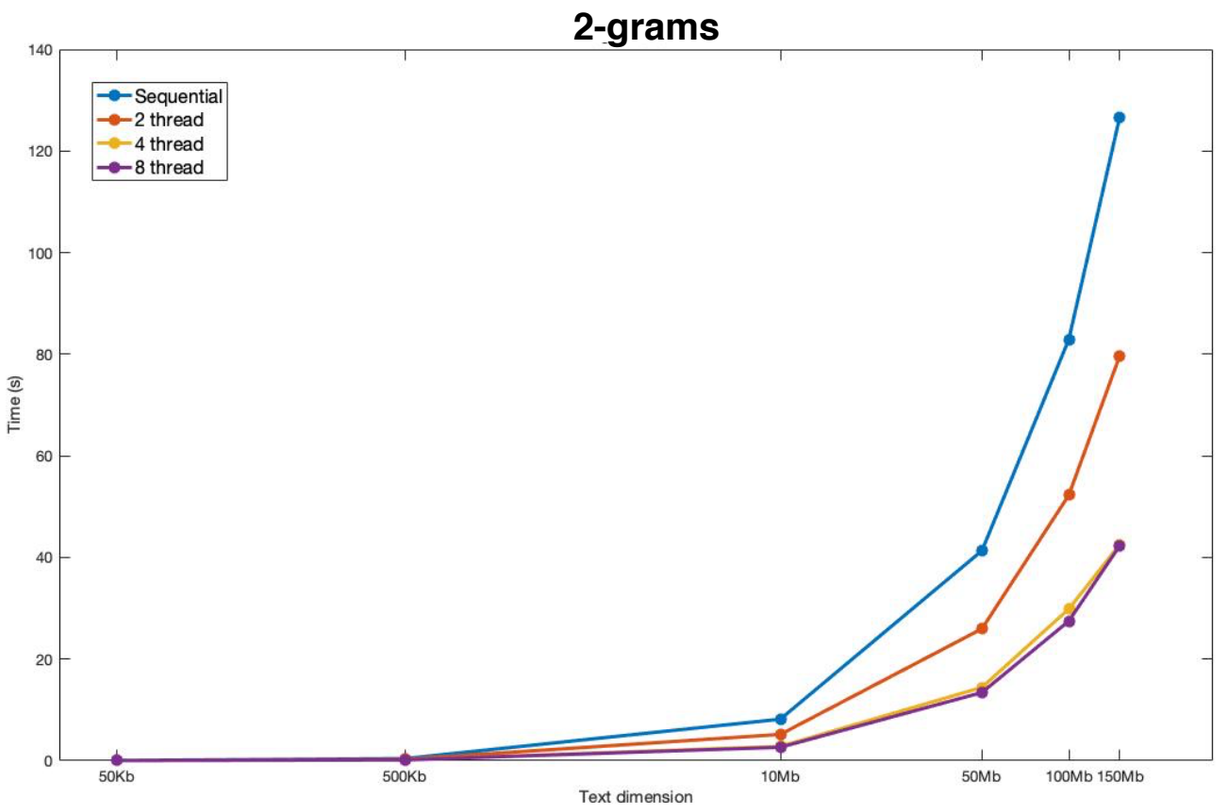


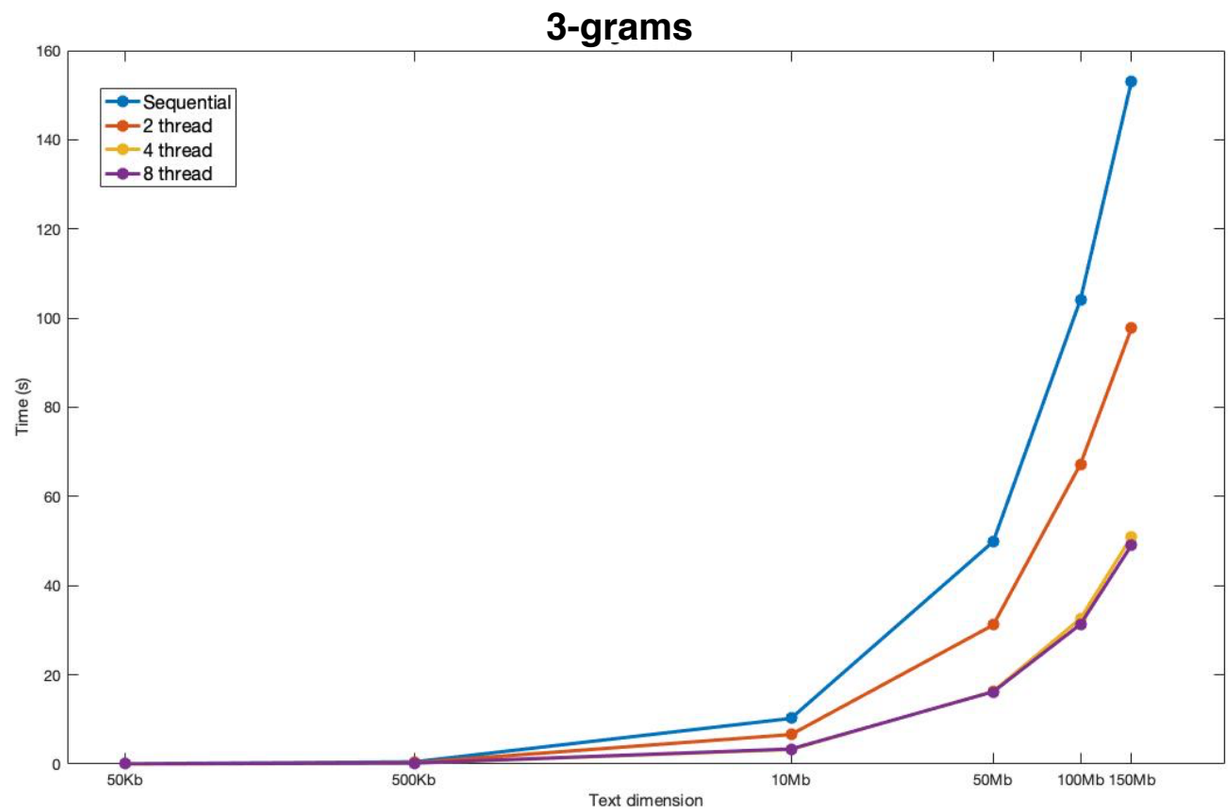
Results - Java



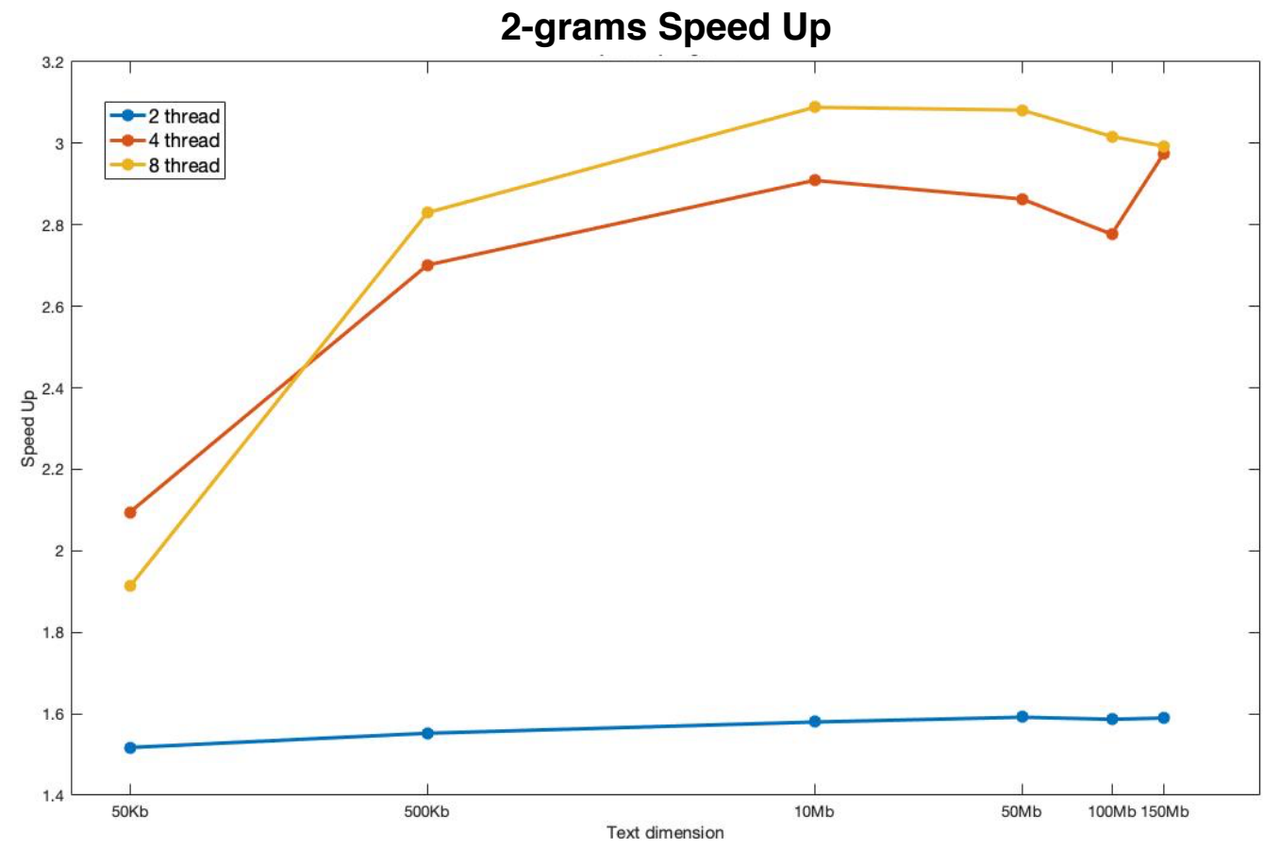


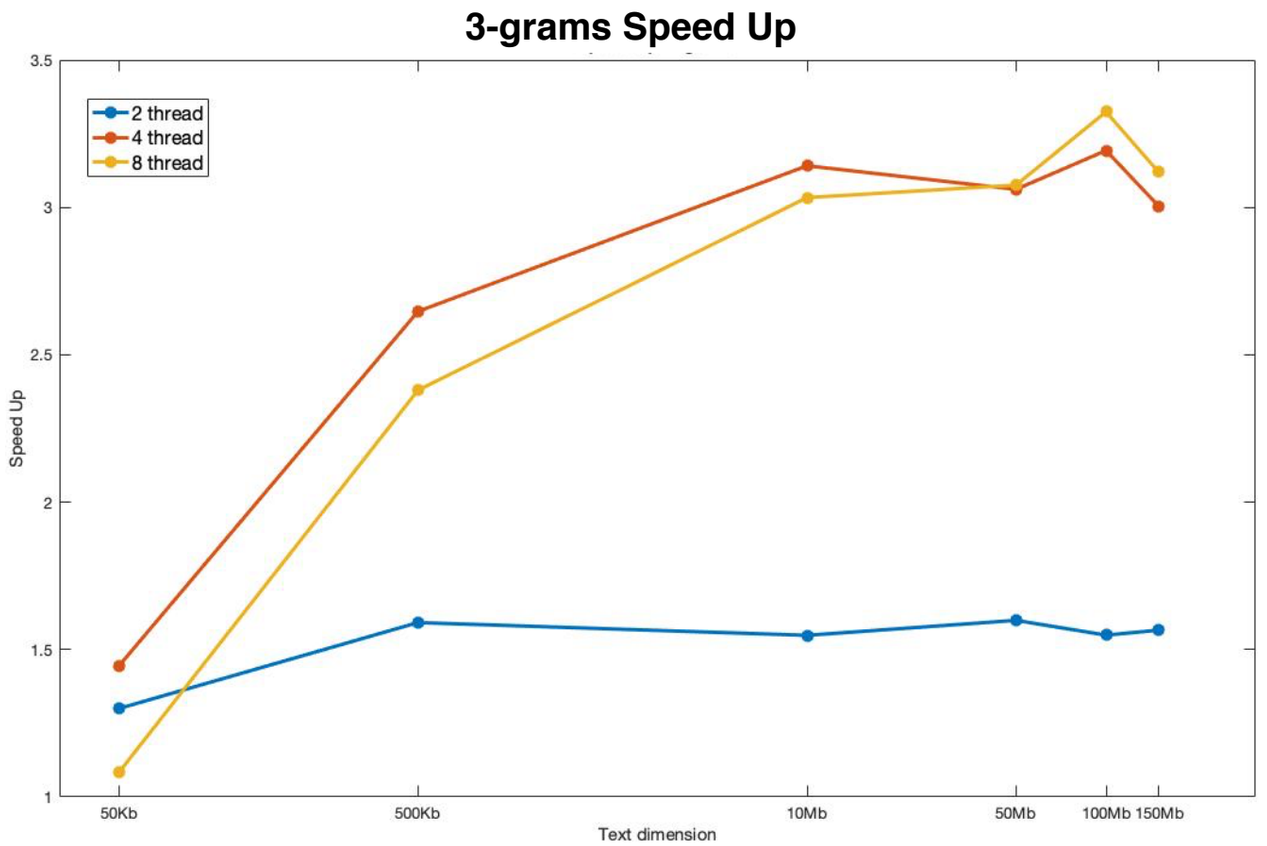
Results - C++


2-grams
Sequential
2 thread
4 thread
8 thread
Time (s)
Text dimension
50Kb
500Kb
10Mb
50Mb
100Mb
150Mb
0
20
40
60
80
100
120
140


3-grams
Sequential
2 thread
4 thread
8 thread
Time (s)
Text dimension
50Kb
500Kb
10Mb
50Mb
100Mb
150Mb
0
20
40
60
80
100
120
140
160

Results - C++


2-grams Speed Up
2 thread
4 thread
8 thread
Speed Up
3.2
3
2.8
2.6
2.4
2.2
2
1.8
1.6
1.4
50Kb
500Kb
10Mb
50Mb
100Mb
150Mb
Text dimension


3-grams Speed Up
2 thread
4 thread
8 thread
Speed Up
3.5
3
2.5
2
1.5
1
50Kb
500Kb
10Mb
50Mb
100Mb
150Mb
Text dimension

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