# Parallelizing techniques

## Requirement

Perform the multiplication of 2 polynomials. Use both the regular *$O(n^2)$* algorithm and the Karatsuba algorithm, and each in both the sequential form and a parallelized form. Compare the 4 variants.

## Solution

*$O(n^2)$ - sequential*

A simple solution is to one by one consider every term of first polynomial and multiply it with every term of second polynomial.

*$O(n^2)$ - parallelized*

Perform the multiplications in different threads. Use a mutex when adding the result on position i+j, i and j being the indices of the corresponding positions in each polynomial.

*Karatsuba - sequential*

Complexity:  O(n^log3)

A fast multiplication algorithm that uses a divide and conquer approach to multiply two numbers.

It reduces the multiplication of two n-digit numbers to at most  n^log3 approx n^1.58 single-digit multiplications in general (and exactly n^log3 when n is a power of 2).

*Karatsuba - parallelized*

Instead of computing the 3 different recursive calls sequentially, compute them asynchronous.

For big numbers, they are generated in the same way, but the generator used is a function that returns only random digits, not numbers, the results of the computations being the same, the only addition being that at the end we normalize the values from right to left adding the carries corresponding to each addition.

## Hardware

Processor: Intel(R) Core(™) i7-8750H CPU @ 2.20GHz 2.21 GHz
RAM: 16 GB

System type: 64-bit OS
Platform: Windows 10

Tests

| Polynomials sizes | Number of threads | Method | Time taken |
|---|---|---|---|
| 70 x 70 | 1 | $O(n^2)$ sequential | 0.00046 s |
| 70 x 70 | 1 | Karatsuba sequential | 0.009595 s |
| 70 x 70 | 100 | $O(n^2)$ parallelized | 0.0138622 s |
| 70 x 70 | 100 | Karatsuba parallelized | 0.141239 s |

| Big numbers digits | Number of threads | Method | Time taken |
|---|---|---|---|
| 70 x 70 | 1 | $O(n^2)$ sequential | 0.0003167 s |
| 70 x 70 | 1 | Karatsuba sequential | 0.0085549 s |
| 70 x 70 | 80 | $O(n^2)$ parallelized | 0.009698 s |
| 70 x 70 | 80 | Karatsuba parallelized | 0.195488 s |