Oblig3 IN3030: Prime numbers

Introduction

This report is about the different versions of Sieve of Eratosthenes, one parallel and one sequential. There is also a parallel and sequential version of factorization of a large number. The Sieve gives us all the prime numbers up to n, and then the factorization will give us all the prime factors for every number from n*n-1 to n*n-100. This report will tell a bit about how I have implemented the different parts of the program and look at what my results are.

User guide

To use the program, you would need Oblig3.java, FacPara.java, ParaSieve.java, Oblig3Precode.java and SieveOfEratosthenes.java in the same folder, the last two are files we were given.

- javac Oblig3.java
- java Oblig3 {N} {number of threads}

N must be greater than 16 and if you want max possible threads for your computer just put 0 as number of threads.

Parallel Sieve of Eratosthenes

The code implements a parallel Sieve of Eratosthenes algorithm to find prime numbers up to n. It splits the work among multiple threads, where each thread marks non-prime numbers within its assigned range. Synchronization points ensure that each thread has completed their work before starting to count the primes. Finally, the count of primes is collected, and the prime numbers are extracted from the marked range. This approach efficiently utilizes multiple CPU cores for faster prime number generation.

Parallel factorization of a large number

I made a class to start the factorization and a worker class to do the threaded work. Called the function factorize() so that it could find all the numbers to be factorized and distribute the primes from the parallel sieve evenly amongst the threads and the threads could work together to factorize the large number at hand. After each thread is done the factorization is going through and ensuring that every factor is a prime number, and the factors add up to the total.

Implementation

When running the program, it starts off with several checks that the user has put in the necessary data to be able to run the program. After each of the checks are passed, we then go to the sequential sieve then the parallel sieve and then the sequential factorization and lastly the parallel factorization. After the sieves I am checking if I get all the same primes in both and

after the factorization, I have implemented a check to see if each of the precode objects is the same. For every part of the code that either uses the sieve or factorizes it is run 7 times in a loop to warmup the JVM. Each run is timed and stored in an array and after the part is done, I find the median value of and print it out for the user. After a sequential and a parallel is done I do a speed up comparison and calculate the speedup. For the sequential sieve I am just using the code given to us by the IN3030 GitHub, as of the parallel sieve I have explained above what it does. For the sequential factorization I am running a double for-loop with an inner while loop. The outer loop finds the number to be factorized and the inner loop factorizes the number using the primes from the sieve. The while loop is here to ensure that every factor is the smallest prime number it can be, if it is not the program will find the smallest and add it as a factor. Each time a factor is found it is stored using the addFactor() function from the object Oblig3Precode. When every number is factorized the program writes all the factors to a file. Lastly the parallel factorization which I have explained above.

Measurements

Cores used: 12

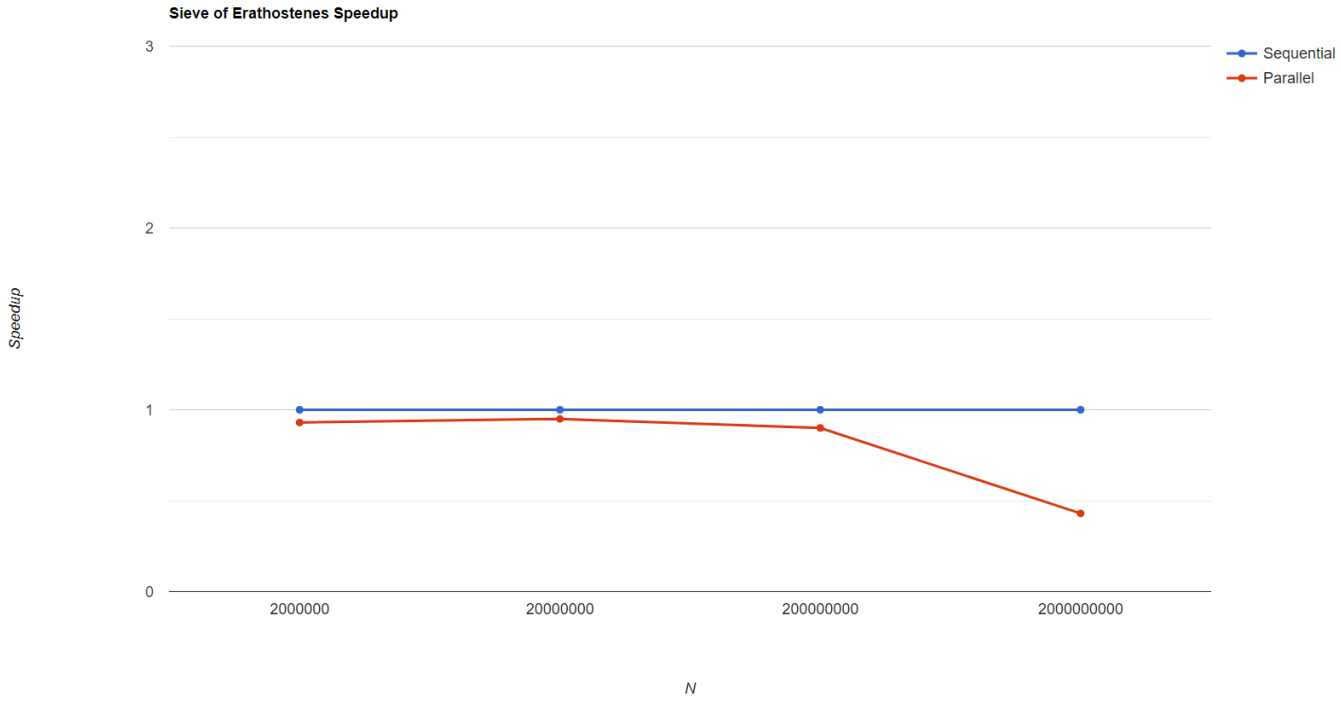
Sieve of Eratosthenes timing:

	Sequential	Parallel
N = 2 000 000	7.3336 ms	7.9061 ms
N = 20 000 000	74.682 ms	79.2979 ms
N = 200 000 000	861.4804 ms	865.1278 ms
N = 2 000 000 000	12073.4132 ms	28175.7453 ms

Factorization timing:

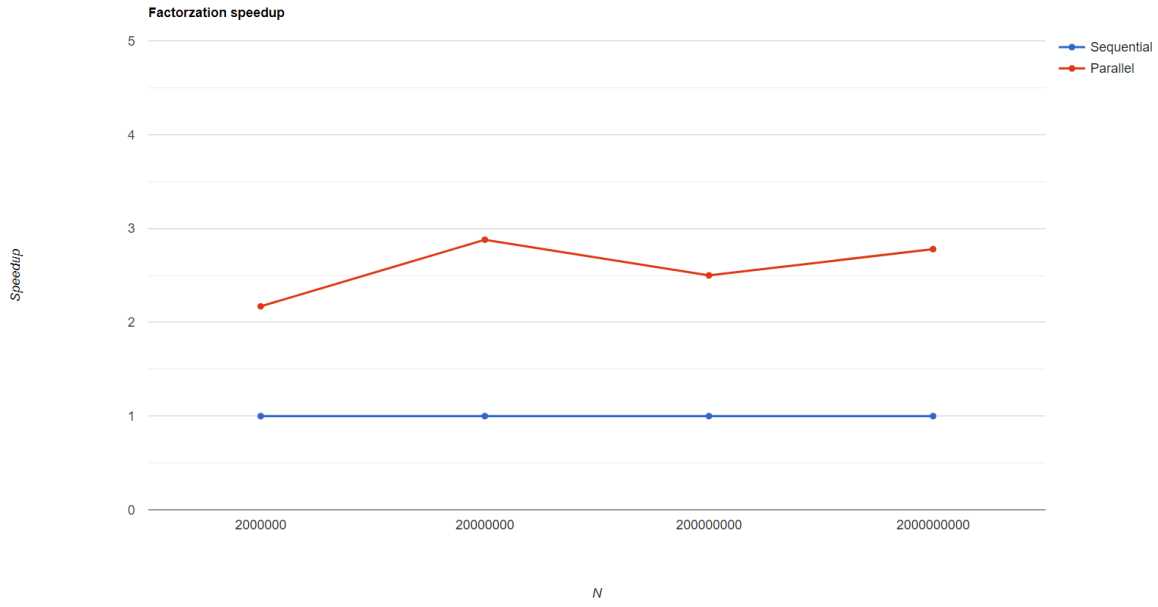
	Sequential	Parallel
N = 2 000 000	108.1685 ms	49.9605 ms
N = 20 000 000	939.1046 ms	325.8895 ms
N = 200 000 000	7983.6226 ms	3193.4301 ms
N = 2 000 000 000	70633.1589 ms	25463.5909 ms

Sieve of Eratosthenes speedup:



As we can see on the graph and in the table the parallelization, I did from last time I delivered to this time has just made the program slower. I now get alle the correct primes but the runtime I abysmal. It might be because I am dividing chunks of n instead of the primes in initially created last time. The reason I changed approach is because I could not find a way to get all the primes with the old paraSieve.

Factorization speedup:



Luckly I am getting a speed up for alle N in my factorization and this is because of the normal advantage of using several threads instead of just one.

Conclusion

In conclusion I now get correct primes and the correct factors, but my program is super slow. There might be an easy fix to this, but I could not find it. Overall I am satisfied with the result but a little sad about the runtime.

Appendix

Output of my program at N = 2 000 000 and max possible cores (which is 12):

```
PS C:\Users\tobbe\OneDrive\Dokumenter\Studie\V2024\IN3030\Obliger\oblig3> java Oblig3 2000000 0
Number of threads: 12

Median time for Seq runs: 7.398ms
Median time for Para runs: 7.9404ms
Runs speed up: 0.93x
Fant riktig primes

Median time for factorization Seq runs: 108.1685ms
Median time for factorization Para runs: 49.9605ms
Factorization speed up: 2.17x
Matching factors!!!
```