Report

Parallel Systems: Sequential Algorithms with OMP (2)

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Contents

1. Introduction

The following report shows performance analytics of several popular algorithms including quick sort, gaussean elimination, sieve of eratosthenes and dijkstra. The main goal was to review the time complexity of the algorithms when changing the dimensionality of the input data in respect of the amount of threads computing the programs, and to analyze execution time, speedup and efficiency metrics.

2. Methods and Resources

The algorithms were executed on a AMD EPYC 7702P 64-Core Processor via the programming language C and the library OpenMP. The program implementations are available on Github.com.

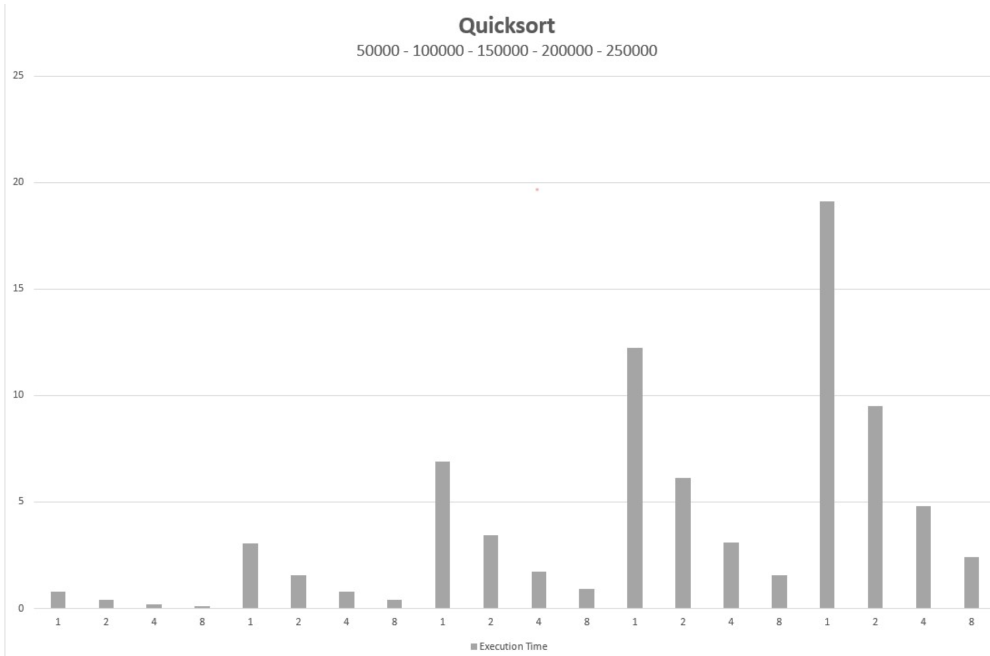
The methodical approach was to run each program execution with different input parameters, ranging from different element dimension to varying amounts of threads utilized. Lastly, the result is compared to the sequential version of the same algorithm to check the validity of the final result.

Algorithm	Elements	Threads
Quicksort	50000 100000 150000 200000 250000	1 2 4 8
Sieve	10000000 20000000 30000000 40000000 50000000	1 2 4 8
Dijkstra	10000 20000 30000 40000	1 2 4 8
Gauss	500 1000 1500 2000 2500	1 2 4 8

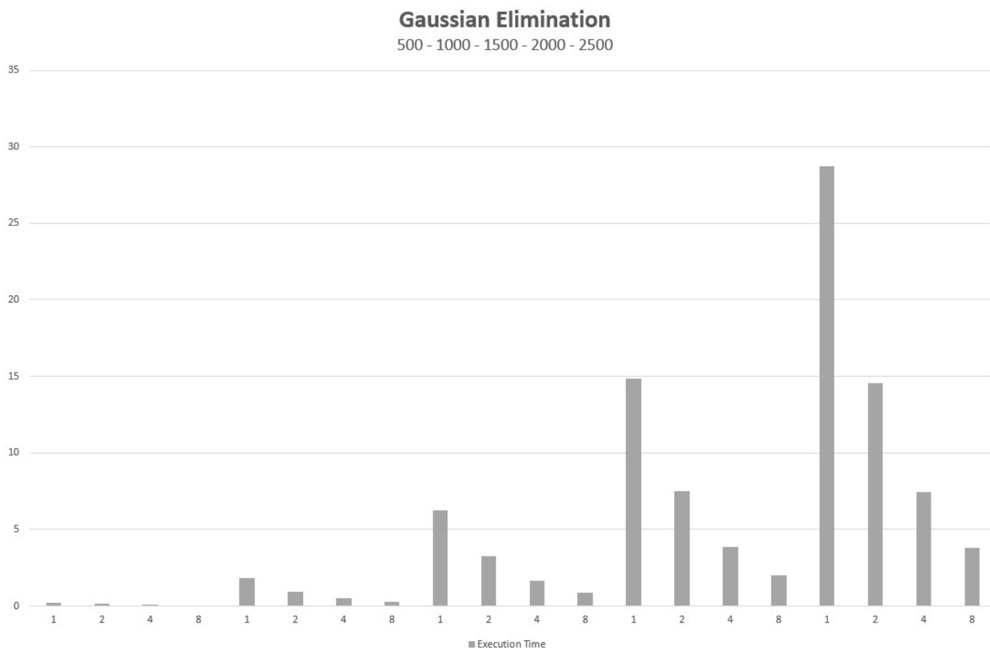
Table 2.1: The parametrization of each algorithm. Each process execution would run the set number of threads with each of the stated amount of elements.

Notably, the speedup was calculated as $S_p = T_1/T_p$, where T is the execution time and p is the amount of processors, while the efficiency is calculated as $E_p = S_p/p$, where S_p is the speedup and p is the amount of processors utilized.

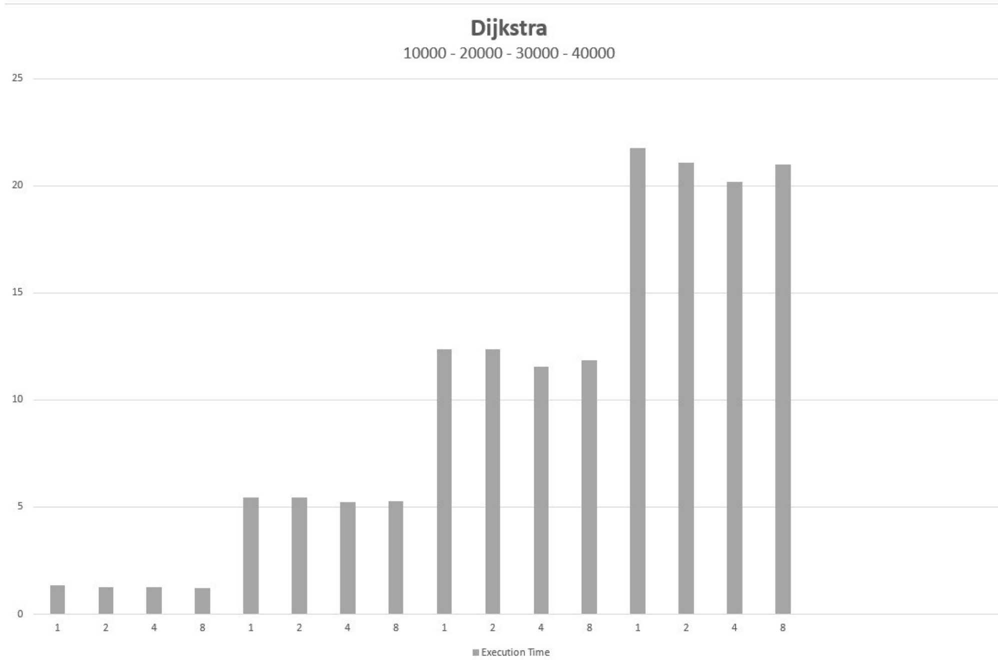
3. Results



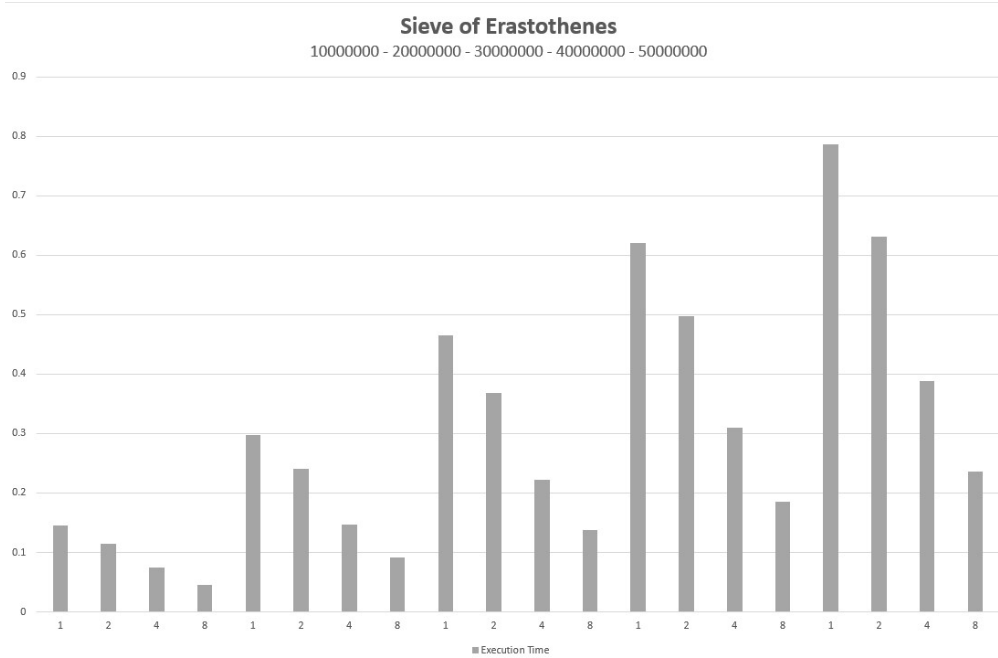
Elements	Threads	Execution Time	Speedup	Efficiency
50000	1	0.775689	1	1
50000	2	0.400874	1.934994537	0.967497268
50000	4	0.210868	3.678552459	0.919638115
50000	8	0.128504	6.036302372	0.754537796
100000	1	3.056718	1	1
100000	2	1.553926	1.967093671	0.983546836
100000	4	0.78471	3.895347326	0.973836831
100000	8	0.415125	7.36336766	0.920420958
150000	1	6.898998	1	1
150000	2	3.447924	2.000913593	1.000456797
150000	4	1.739329	3.966470978	0.991617745
150000	8	0.901691	7.651177621	0.956397203
200000	1	12.246717	1	1
200000	2	6.124838	1.999516885	0.999758443
200000	4	3.0787	3.977885796	0.994471449
200000	8	1.566689	7.816941971	0.977117746
250000	1	19.125711	1	1
250000	2	9.491847	2.014961998	1.007480999
250000	4	4.794321	3.989242898	0.997310725
250000	8	2.421326	7.898858312	0.987357289



Elements	Threads	Execution Time	Speedup	Efficiency
500	1	0.234272	1	1
500	2	0.12492	1.875376241	0.93768812
500	4	0.066969	3.498215592	0.874553898
500	8	0.038337	6.110858961	0.76385737
1000	1	1.831963	1	1
1000	2	0.937822	1.953422931	0.976711466
1000	4	0.486209	3.767850862	0.941962716
1000	8	0.261493	7.005782182	0.875722773
1500	1	6.269111	1	1
1500	2	3.258832	1.923729422	0.961864711
1500	4	1.650532	3.798236569	0.949559142
1500	8	0.859762	7.291681884	0.911460236
2000	1	14.873661	1	1
2000	2	7.525389	1.976464074	0.988232037
2000	4	3.859083	3.854195673	0.963548918
2000	8	1.978362	7.518169577	0.939771197
2500	1	28.706882	1	1
2500	2	14.568114	1.970528375	0.985264187
2500	4	7.419112	3.869315088	0.967328772
2500	8	3.796063	7.562277549	0.945284694



Elements	Threads	Execution Time	Speedup	Efficiency
10000	1	1.338108	1	1
10000	2	1.256426	1.065011389	0.532505695
10000	4	1.243389	1.076178091	0.269044523
10000	8	1.206436	1.109141305	0.138642663
20000	1	5.431619	1	1
20000	2	5.462286	0.994385684	0.497192842
20000	4	5.236015	1.037357418	0.259339354
20000	8	5.273222	1.030037992	0.128754749
30000	1	12.358053	1	1
30000	2	12.38346	0.997948312	0.498974156
30000	4	11.536593	1.071204731	0.267801183
30000	8	11.849864	1.04288564	0.130360705
40000	1	21.745368	1	1
40000	2	21.083123	1.031411143	0.515705572
40000	4	20.171716	1.078012798	0.269503199
40000	8	20.985627	1.036202921	0.129525365



Elements	Threads	Execution Time	Speedup	Efficiency
10000000	1	0.145243	1	1
10000000	2	0.114836	1.264786304	0.632393152
10000000	4	0.074409	1.951954737	0.487988684
10000000	8	0.045131	3.218253529	0.402281691
20000000	1	0.297384	1	1
20000000	2	0.240418	1.236945653	0.618472826
20000000	4	0.146255	2.033325356	0.508331339
20000000	8	0.091809	3.23915956	0.404894945
30000000	1	0.464699	1	1
30000000	2	0.368692	1.260398924	0.630199462
30000000	4	0.221657	2.096477892	0.524119473
30000000	8	0.138072	3.365628078	0.42070351
40000000	1	0.620618	1	1
40000000	2	0.496802	1.24922605	0.624613025
40000000	4	0.309458	2.005499939	0.501374985
40000000	8	0.184713	3.359904284	0.419988035
50000000	1	0.786157	1	1
50000000	2	0.631426	1.245050093	0.622525046
50000000	4	0.388373	2.02423186	0.506057965
50000000	8	0.236264	3.327451495	0.415931437

4. Discussion

The results of parallelizing algorithms show significant changes in execution time at the cost of efficiency per process.

The speedup of Gaussian Elimination and Quicksort were the most remarkable, with up to 6x faster execution time, with similarly low negative impact of efficiency per utilized processor, ranking from 10 to 25%. Dijkstra did not experience any significant boost with at most 0.1x improvement in execution time, but at extreme efficiency penalties of up to 90%. The Sieve of eratosthenes reached speedups of up to 3x, at the cost of up to 60% processor efficiency.

5. Conclusion

The OpenMP library enabled parallelism for algorithms of various kinds. At times, it is difficult to understand the concepts running in the background of the openMP library, yet it is easy to implement in an already-running project. In comparison, POSIX threads would be significantly more complex to implement, but would have allowed deeper insights into the program's code and execution.