Program Structures & Algorithms  
Spring 2022  
Assignment No. 4

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**Task**:

Your task is to implement a parallel sorting algorithm such that each partition of the array is sorted in parallel. You will consider two different schemes for deciding whether to sort in parallel.

1. A cutoff (defaults to, say, 1000) which you will update according to the first argument in the command line when running. It's your job to experiment and come up with a good value for this cutoff. If there are fewer elements to sort than the cutoff, then you should use the system sort instead.
2. Recursion depth or the number of available threads. Using this determination, you might decide on an ideal number (*t*) of separate threads (stick to powers of 2) and arrange for that number of partitions to be parallelized (by preventing recursion after the depth of *lg t* is reached).
3. An appropriate combination of these.

There is a *Main* class and the *ParSort* class in the *sort.par* package of the INFO6205 repository. The *Main* class can be used as is but the *ParSort* class needs to be implemented where you see "TODO..." [it turns out that these TODOs are already implemented].

Unless you have a good reason not to, you should just go along with the Java8-style future implementations provided for you in the class repository.

You must prepare a report that shows the results of your experiments and draws a conclusion (or more) about the efficacy of this method of parallelizing sort. Your experiments should involve sorting arrays of sufficient size for the parallel sort to make a difference. You should run with many different array sizes (they must be sufficiently large to make parallel sorting worthwhile, obviously) and different cutoff schemes.

**OUTPUT SCREENSHOTS:**

**Array Size 10000 Output**

**Graphical user interface, application, Word

Description automatically generated**

**Graphical user interface, application, Word

Description automatically generated**

**Graphical user interface, application, Word

Description automatically generated**

**Array Size 20000 Output**

**Graphical user interface, application, Word

Description automatically generated**

**Graphical user interface, application, Word

Description automatically generated**

**Graphical user interface, application, Word

Description automatically generated**

**Array Size 40000 Output**

**Graphical user interface, application, Word

Description automatically generated**

**Graphical user interface, application, Word

Description automatically generated**

**Graphical user interface, application, Word

Description automatically generated**

**RELATIONSHIP:**

I have ran the suite with varied inputs changing the number of elements in the array and the different number of threads. I have taken 100000 as first array size and then doubled to 200000 and 400000 for the relationship demonstration. Thread number used are 2,4,8,16,32 for different scenarios. The point which I noticed is that the upto 4 threads, there is a significant improvement in the performance and after that the improvement is negligible, so I consider that 4 is the optimal number of threads can be used. And with the cutoff of 25% the lowest runtime is achieved.

The relation between the number of threads and the depth of the recursion seems to be depth is almost equal to log to the base 2 times of the number of threads.

Recursion depth = lg(Number of threads)

And maximum depth(Beyond which it may go to the default system sorting) possible here is lg(number of elements in the array/ cutoff)

**EVIDENCE FOR THE RELATION:**

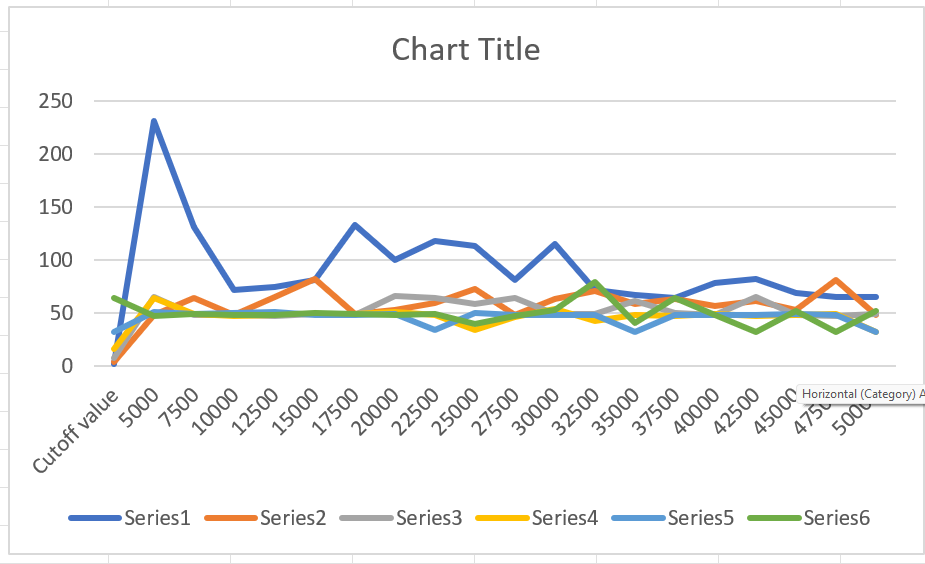
**Array Size 100000**

4 Thread Chart( Runtime(ms) vs Cutoff value)

**Chart, line chart

Description automatically generated**

Series 1- 2 Thread, Series 2- 4 Thread, Series 3- 8 Thread, Series 4- 16 Thread, Series 5- 32 Thread

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|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Cutoff value | 2 | 4 | 8 | 16 | 32 | 64 |
| 5000 | 231 | 48 | 65 | 64 | 51 | 47 |
| 7500 | 131 | 64 | 48 | 49 | 49 | 49 |
| 10000 | 72 | 48 | 48 | 47 | 50 | 48 |
| 12500 | 75 | 65 | 47 | 48 | 51 | 48 |
| 15000 | 81 | 82 | 49 | 48 | 48 | 50 |
| 17500 | 133 | 49 | 48 | 49 | 48 | 49 |
| 20000 | 100 | 53 | 66 | 51 | 49 | 48 |
| 22500 | 118 | 60 | 64 | 48 | 34 | 49 |
| 25000 | 113 | 73 | 59 | 34 | 50 | 40 |
| 27500 | 81 | 48 | 64 | 46 | 48 | 47 |
| 30000 | 115 | 63 | 49 | 54 | 48 | 53 |
| 32500 | 72 | 71 | 49 | 43 | 48 | 79 |
| 35000 | 67 | 59 | 62 | 48 | 32 | 41 |
| 37500 | 64 | 63 | 50 | 47 | 48 | 64 |
| 40000 | 79 | 57 | 48 | 49 | 48 | 48 |
| 42500 | 82 | 62 | 65 | 47 | 48 | 32 |
| 45000 | 69 | 53 | 48 | 48 | 49 | 52 |
| 47500 | 65 | 81 | 47 | 49 | 48 | 32 |
| 50000 | 65 | 48 | 49 | 32 | 32 | 52 |

**Array Size 200000**

4 Thread Chart ( Runtime(ms) vs Cutoff value)

**Chart, line chart

Description automatically generated**

Series 1- 2 Thread, Series 2- 4 Thread, Series 3- 8 Thread, Series 4- 16 Thread, Series 5- 32 Thread

**Chart, line chart

Description automatically generated**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Cutoff value | 2 | 4 | 8 | 16 | 32 | 64 |
| 5000 | 384 | 147 | 120 | 127 | 104 | 94 |
| 7500 | 254 | 98 | 91 | 88 | 95 | 89 |
| 10000 | 275 | 100 | 90 | 78 | 81 | 84 |
| 12500 | 134 | 83 | 105 | 98 | 87 | 93 |
| 15000 | 175 | 100 | 97 | 96 | 86 | 91 |
| 17500 | 198 | 82 | 98 | 111 | 88 | 85 |
| 20000 | 128 | 114 | 96 | 80 | 85 | 86 |
| 22500 | 108 | 106 | 90 | 81 | 76 | 98 |
| 25000 | 135 | 95 | 79 | 80 | 86 | 90 |
| 27500 | 137 | 130 | 97 | 84 | 74 | 80 |
| 30000 | 149 | 116 | 112 | 92 | 95 | 89 |
| 32500 | 125 | 101 | 82 | 82 | 74 | 77 |
| 35000 | 134 | 103 | 96 | 87 | 90 | 90 |
| 37500 | 139 | 97 | 100 | 89 | 80 | 69 |
| 40000 | 139 | 112 | 80 | 82 | 79 | 94 |
| 42500 | 141 | 97 | 80 | 92 | 89 | 87 |
| 45000 | 134 | 80 | 81 | 73 | 94 | 91 |
| 47500 | 141 | 97 | 113 | 96 | 72 | 89 |
| 50000 | 138 | 89 | 79 | 87 | 101 | 95 |

**Array Size 400000:**

4 Thread Chart ( Runtime(ms) vs Cutoff value)

Chart, line chart

Description automatically generated

Series 1- 2 Thread, Series 2- 4 Thread, Series 3- 8 Thread, Series 4- 16 Thread, Series 5- 32 Thread

Chart, line chart

Description automatically generated

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Cutoff value | 2 | 4 | 8 | 16 | 32 | 64 |
| 5000 | 455 | 254 | 215 | 193 | 179 | 182 |
| 7500 | 504 | 212 | 201 | 176 | 161 | 158 |
| 10000 | 637 | 182 | 179 | 158 | 158 | 160 |
| 12500 | 327 | 171 | 179 | 188 | 164 | 161 |
| 15000 | 207 | 162 | 167 | 165 | 161 | 159 |
| 17500 | 230 | 220 | 144 | 150 | 143 | 150 |
| 20000 | 201 | 149 | 168 | 163 | 176 | 165 |
| 22500 | 221 | 197 | 182 | 159 | 165 | 162 |
| 25000 | 216 | 161 | 181 | 149 | 168 | 159 |
| 27500 | 241 | 159 | 145 | 146 | 176 | 153 |
| 30000 | 231 | 163 | 163 | 189 | 175 | 161 |
| 32500 | 235 | 157 | 145 | 181 | 151 | 187 |
| 35000 | 273 | 173 | 148 | 149 | 148 | 145 |
| 37500 | 180 | 168 | 152 | 141 | 144 | 162 |
| 40000 | 191 | 159 | 140 | 143 | 162 | 133 |
| 42500 | 181 | 160 | 145 | 166 | 150 | 164 |
| 45000 | 194 | 163 | 166 | 145 | 143 | 132 |
| 47500 | 175 | 160 | 147 | 143 | 144 | 163 |
| 50000 | 194 | 161 | 148 | 155 | 161 | 142 |

**OUTPUT:**

Number of elements in the array: 100000

Parallelism Degree: 2

Cutoff - 5000 Number of runs - 20times Time Taken:231ms

Cutoff - 7500 Number of runs - 20times Time Taken:131ms

Cutoff - 10000 Number of runs - 20times Time Taken:72ms

Cutoff - 12500 Number of runs - 20times Time Taken:75ms

Cutoff - 15000 Number of runs - 20times Time Taken:81ms

Cutoff - 17500 Number of runs - 20times Time Taken:133ms

Cutoff - 20000 Number of runs - 20times Time Taken:100ms

Cutoff - 22500 Number of runs - 20times Time Taken:118ms

Cutoff - 25000 Number of runs - 20times Time Taken:113ms

Cutoff - 27500 Number of runs - 20times Time Taken:81ms

Cutoff - 30000 Number of runs - 20times Time Taken:115ms

Cutoff - 32500 Number of runs - 20times Time Taken:72ms

Cutoff - 35000 Number of runs - 20times Time Taken:67ms

Cutoff - 37500 Number of runs - 20times Time Taken:64ms

Cutoff - 40000 Number of runs - 20times Time Taken:79ms

Cutoff - 42500 Number of runs - 20times Time Taken:82ms

Cutoff - 45000 Number of runs - 20times Time Taken:69ms

Cutoff - 47500 Number of runs - 20times Time Taken:65ms

Cutoff - 50000 Number of runs - 20times Time Taken:65ms

Parallelism Degree: 4

Cutoff - 5000 Number of runs - 20times Time Taken:48ms

Cutoff - 7500 Number of runs - 20times Time Taken:64ms

Cutoff - 10000 Number of runs - 20times Time Taken:48ms

Cutoff - 12500 Number of runs - 20times Time Taken:65ms

Cutoff - 15000 Number of runs - 20times Time Taken:82ms

Cutoff - 17500 Number of runs - 20times Time Taken:49ms

Cutoff - 20000 Number of runs - 20times Time Taken:53ms

Cutoff - 22500 Number of runs - 20times Time Taken:60ms

Cutoff - 25000 Number of runs - 20times Time Taken:73ms

Cutoff - 27500 Number of runs - 20times Time Taken:48ms

Cutoff - 30000 Number of runs - 20times Time Taken:63ms

Cutoff - 32500 Number of runs - 20times Time Taken:71ms

Cutoff - 35000 Number of runs - 20times Time Taken:59ms

Cutoff - 37500 Number of runs - 20times Time Taken:63ms

Cutoff - 40000 Number of runs - 20times Time Taken:57ms

Cutoff - 42500 Number of runs - 20times Time Taken:62ms

Cutoff - 45000 Number of runs - 20times Time Taken:53ms

Cutoff - 47500 Number of runs - 20times Time Taken:81ms

Cutoff - 50000 Number of runs - 20times Time Taken:48ms

Parallelism Degree: 8

Cutoff - 5000 Number of runs - 20times Time Taken:65ms

Cutoff - 7500 Number of runs - 20times Time Taken:48ms

Cutoff - 10000 Number of runs - 20times Time Taken:48ms

Cutoff - 12500 Number of runs - 20times Time Taken:47ms

Cutoff - 15000 Number of runs - 20times Time Taken:49ms

Cutoff - 17500 Number of runs - 20times Time Taken:48ms

Cutoff - 20000 Number of runs - 20times Time Taken:66ms

Cutoff - 22500 Number of runs - 20times Time Taken:64ms

Cutoff - 25000 Number of runs - 20times Time Taken:59ms

Cutoff - 27500 Number of runs - 20times Time Taken:64ms

Cutoff - 30000 Number of runs - 20times Time Taken:49ms

Cutoff - 32500 Number of runs - 20times Time Taken:49ms

Cutoff - 35000 Number of runs - 20times Time Taken:52ms

Cutoff - 37500 Number of runs - 20times Time Taken:50ms

Cutoff - 40000 Number of runs - 20times Time Taken:48ms

Cutoff - 42500 Number of runs - 20times Time Taken:65ms

Cutoff - 45000 Number of runs - 20times Time Taken:48ms

Cutoff - 47500 Number of runs - 20times Time Taken:47ms

Cutoff - 50000 Number of runs - 20times Time Taken:49ms

Parallelism Degree: 16

Cutoff - 5000 Number of runs - 20times Time Taken:64ms

Cutoff - 7500 Number of runs - 20times Time Taken:49ms

Cutoff - 10000 Number of runs - 20times Time Taken:47ms

Cutoff - 12500 Number of runs - 20times Time Taken:48ms

Cutoff - 15000 Number of runs - 20times Time Taken:37ms

Cutoff - 17500 Number of runs - 20times Time Taken:49ms

Cutoff - 20000 Number of runs - 20times Time Taken:51ms

Cutoff - 22500 Number of runs - 20times Time Taken:48ms

Cutoff - 25000 Number of runs - 20times Time Taken:34ms

Cutoff - 27500 Number of runs - 20times Time Taken:46ms

Cutoff - 30000 Number of runs - 20times Time Taken:54ms

Cutoff - 32500 Number of runs - 20times Time Taken:43ms

Cutoff - 35000 Number of runs - 20times Time Taken:48ms

Cutoff - 37500 Number of runs - 20times Time Taken:47ms

Cutoff - 40000 Number of runs - 20times Time Taken:49ms

Cutoff - 42500 Number of runs - 20times Time Taken:47ms

Cutoff - 45000 Number of runs - 20times Time Taken:48ms

Cutoff - 47500 Number of runs - 20times Time Taken:49ms

Cutoff - 50000 Number of runs - 20times Time Taken:32ms

Parallelism Degree: 32

Cutoff - 5000 Number of runs - 20times Time Taken:51ms

Cutoff - 7500 Number of runs - 20times Time Taken:49ms

Cutoff - 10000 Number of runs - 20times Time Taken:50ms

Cutoff - 12500 Number of runs - 20times Time Taken:51ms

Cutoff - 15000 Number of runs - 20times Time Taken:48ms

Cutoff - 17500 Number of runs - 20times Time Taken:48ms

Cutoff - 20000 Number of runs - 20times Time Taken:49ms

Cutoff - 22500 Number of runs - 20times Time Taken:34ms

Cutoff - 25000 Number of runs - 20times Time Taken:50ms

Cutoff - 27500 Number of runs - 20times Time Taken:48ms

Cutoff - 30000 Number of runs - 20times Time Taken:48ms

Cutoff - 32500 Number of runs - 20times Time Taken:48ms

Cutoff - 35000 Number of runs - 20times Time Taken:32ms

Cutoff - 37500 Number of runs - 20times Time Taken:48ms

Cutoff - 40000 Number of runs - 20times Time Taken:48ms

Cutoff - 42500 Number of runs - 20times Time Taken:48ms

Cutoff - 45000 Number of runs - 20times Time Taken:49ms

Cutoff - 47500 Number of runs - 20times Time Taken:48ms

Cutoff - 50000 Number of runs - 20times Time Taken:32ms

Parallelism Degree: 64

Cutoff - 5000 Number of runs - 20times Time Taken:47ms

Cutoff - 7500 Number of runs - 20times Time Taken:49ms

Cutoff - 10000 Number of runs - 20times Time Taken:48ms

Cutoff - 12500 Number of runs - 20times Time Taken:48ms

Cutoff - 15000 Number of runs - 20times Time Taken:50ms

Cutoff - 17500 Number of runs - 20times Time Taken:49ms

Cutoff - 20000 Number of runs - 20times Time Taken:48ms

Cutoff - 22500 Number of runs - 20times Time Taken:49ms

Cutoff - 25000 Number of runs - 20times Time Taken:40ms

Cutoff - 27500 Number of runs - 20times Time Taken:47ms

Cutoff - 30000 Number of runs - 20times Time Taken:53ms

Cutoff - 32500 Number of runs - 20times Time Taken:79ms

Cutoff - 35000 Number of runs - 20times Time Taken:41ms

Cutoff - 37500 Number of runs - 20times Time Taken:64ms

Cutoff - 40000 Number of runs - 20times Time Taken:48ms

Cutoff - 42500 Number of runs - 20times Time Taken:32ms

Cutoff - 45000 Number of runs - 20times Time Taken:52ms

Cutoff - 47500 Number of runs - 20times Time Taken:32ms

Cutoff - 50000 Number of runs - 20times Time Taken:52ms

Process finished with exit code 0

Number of elements in the array: 200000

Parallelism Degree: 2

Cutoff - 5000 Number of runs - 20times Time Taken:384ms

Cutoff - 7500 Number of runs - 20times Time Taken:254ms

Cutoff - 10000 Number of runs - 20times Time Taken:275ms

Cutoff - 12500 Number of runs - 20times Time Taken:134ms

Cutoff - 15000 Number of runs - 20times Time Taken:175ms

Cutoff - 17500 Number of runs - 20times Time Taken:198ms

Cutoff - 20000 Number of runs - 20times Time Taken:128ms

Cutoff - 22500 Number of runs - 20times Time Taken:108ms

Cutoff - 25000 Number of runs - 20times Time Taken:135ms

Cutoff - 27500 Number of runs - 20times Time Taken:137ms

Cutoff - 30000 Number of runs - 20times Time Taken:149ms

Cutoff - 32500 Number of runs - 20times Time Taken:125ms

Cutoff - 35000 Number of runs - 20times Time Taken:134ms

Cutoff - 37500 Number of runs - 20times Time Taken:139ms

Cutoff - 40000 Number of runs - 20times Time Taken:139ms

Cutoff - 42500 Number of runs - 20times Time Taken:141ms

Cutoff - 45000 Number of runs - 20times Time Taken:134ms

Cutoff - 47500 Number of runs - 20times Time Taken:141ms

Cutoff - 50000 Number of runs - 20times Time Taken:138ms

Parallelism Degree: 4

Cutoff - 5000 Number of runs - 20times Time Taken:147ms

Cutoff - 7500 Number of runs - 20times Time Taken:98ms

Cutoff - 10000 Number of runs - 20times Time Taken:100ms

Cutoff - 12500 Number of runs - 20times Time Taken:83ms

Cutoff - 15000 Number of runs - 20times Time Taken:100ms

Cutoff - 17500 Number of runs - 20times Time Taken:82ms

Cutoff - 20000 Number of runs - 20times Time Taken:114ms

Cutoff - 22500 Number of runs - 20times Time Taken:106ms

Cutoff - 25000 Number of runs - 20times Time Taken:95ms

Cutoff - 27500 Number of runs - 20times Time Taken:130ms

Cutoff - 30000 Number of runs - 20times Time Taken:116ms

Cutoff - 32500 Number of runs - 20times Time Taken:101ms

Cutoff - 35000 Number of runs - 20times Time Taken:103ms

Cutoff - 37500 Number of runs - 20times Time Taken:97ms

Cutoff - 40000 Number of runs - 20times Time Taken:112ms

Cutoff - 42500 Number of runs - 20times Time Taken:97ms

Cutoff - 45000 Number of runs - 20times Time Taken:80ms

Cutoff - 47500 Number of runs - 20times Time Taken:97ms

Cutoff - 50000 Number of runs - 20times Time Taken:89ms

Parallelism Degree: 8

Cutoff - 5000 Number of runs - 20times Time Taken:120ms

Cutoff - 7500 Number of runs - 20times Time Taken:91ms

Cutoff - 10000 Number of runs - 20times Time Taken:90ms

Cutoff - 12500 Number of runs - 20times Time Taken:105ms

Cutoff - 15000 Number of runs - 20times Time Taken:97ms

Cutoff - 17500 Number of runs - 20times Time Taken:98ms

Cutoff - 20000 Number of runs - 20times Time Taken:96ms

Cutoff - 22500 Number of runs - 20times Time Taken:90ms

Cutoff - 25000 Number of runs - 20times Time Taken:79ms

Cutoff - 27500 Number of runs - 20times Time Taken:97ms

Cutoff - 30000 Number of runs - 20times Time Taken:112ms

Cutoff - 32500 Number of runs - 20times Time Taken:82ms

Cutoff - 35000 Number of runs - 20times Time Taken:96ms

Cutoff - 37500 Number of runs - 20times Time Taken:100ms

Cutoff - 40000 Number of runs - 20times Time Taken:80ms

Cutoff - 42500 Number of runs - 20times Time Taken:80ms

Cutoff - 45000 Number of runs - 20times Time Taken:81ms

Cutoff - 47500 Number of runs - 20times Time Taken:113ms

Cutoff - 50000 Number of runs - 20times Time Taken:79ms

Parallelism Degree: 16

Cutoff - 5000 Number of runs - 20times Time Taken:127ms

Cutoff - 7500 Number of runs - 20times Time Taken:88ms

Cutoff - 10000 Number of runs - 20times Time Taken:78ms

Cutoff - 12500 Number of runs - 20times Time Taken:98ms

Cutoff - 15000 Number of runs - 20times Time Taken:96ms

Cutoff - 17500 Number of runs - 20times Time Taken:111ms

Cutoff - 20000 Number of runs - 20times Time Taken:80ms

Cutoff - 22500 Number of runs - 20times Time Taken:81ms

Cutoff - 25000 Number of runs - 20times Time Taken:80ms

Cutoff - 27500 Number of runs - 20times Time Taken:84ms

Cutoff - 30000 Number of runs - 20times Time Taken:92ms

Cutoff - 32500 Number of runs - 20times Time Taken:82ms

Cutoff - 35000 Number of runs - 20times Time Taken:87ms

Cutoff - 37500 Number of runs - 20times Time Taken:89ms

Cutoff - 40000 Number of runs - 20times Time Taken:82ms

Cutoff - 42500 Number of runs - 20times Time Taken:92ms

Cutoff - 45000 Number of runs - 20times Time Taken:73ms

Cutoff - 47500 Number of runs - 20times Time Taken:96ms

Cutoff - 50000 Number of runs - 20times Time Taken:87ms

Parallelism Degree: 32

Cutoff - 5000 Number of runs - 20times Time Taken:104ms

Cutoff - 7500 Number of runs - 20times Time Taken:95ms

Cutoff - 10000 Number of runs - 20times Time Taken:81ms

Cutoff - 12500 Number of runs - 20times Time Taken:87ms

Cutoff - 15000 Number of runs - 20times Time Taken:86ms

Cutoff - 17500 Number of runs - 20times Time Taken:88ms

Cutoff - 20000 Number of runs - 20times Time Taken:85ms

Cutoff - 22500 Number of runs - 20times Time Taken:76ms

Cutoff - 25000 Number of runs - 20times Time Taken:86ms

Cutoff - 27500 Number of runs - 20times Time Taken:74ms

Cutoff - 30000 Number of runs - 20times Time Taken:95ms

Cutoff - 32500 Number of runs - 20times Time Taken:74ms

Cutoff - 35000 Number of runs - 20times Time Taken:90ms

Cutoff - 37500 Number of runs - 20times Time Taken:80ms

Cutoff - 40000 Number of runs - 20times Time Taken:79ms

Cutoff - 42500 Number of runs - 20times Time Taken:89ms

Cutoff - 45000 Number of runs - 20times Time Taken:94ms

Cutoff - 47500 Number of runs - 20times Time Taken:72ms

Cutoff - 50000 Number of runs - 20times Time Taken:101ms

Parallelism Degree: 64

Cutoff - 5000 Number of runs - 20times Time Taken:94ms

Cutoff - 7500 Number of runs - 20times Time Taken:89ms

Cutoff - 10000 Number of runs - 20times Time Taken:84ms

Cutoff - 12500 Number of runs - 20times Time Taken:93ms

Cutoff - 15000 Number of runs - 20times Time Taken:91ms

Cutoff - 17500 Number of runs - 20times Time Taken:85ms

Cutoff - 20000 Number of runs - 20times Time Taken:86ms

Cutoff - 22500 Number of runs - 20times Time Taken:98ms

Cutoff - 25000 Number of runs - 20times Time Taken:90ms

Cutoff - 27500 Number of runs - 20times Time Taken:80ms

Cutoff - 30000 Number of runs - 20times Time Taken:89ms

Cutoff - 32500 Number of runs - 20times Time Taken:77ms

Cutoff - 35000 Number of runs - 20times Time Taken:90ms

Cutoff - 37500 Number of runs - 20times Time Taken:69ms

Cutoff - 40000 Number of runs - 20times Time Taken:94ms

Cutoff - 42500 Number of runs - 20times Time Taken:87ms

Cutoff - 45000 Number of runs - 20times Time Taken:91ms

Cutoff - 47500 Number of runs - 20times Time Taken:89ms

Cutoff - 50000 Number of runs - 20times Time Taken:95ms

Process finished with exit code 0

Number of elements in the array: 400000

Parallelism Degree: 2

Cutoff - 5000 Number of runs - 20times Time Taken:455ms

Cutoff - 7500 Number of runs - 20times Time Taken:504ms

Cutoff - 10000 Number of runs - 20times Time Taken:637ms

Cutoff - 12500 Number of runs - 20times Time Taken:327ms

Cutoff - 15000 Number of runs - 20times Time Taken:207ms

Cutoff - 17500 Number of runs - 20times Time Taken:230ms

Cutoff - 20000 Number of runs - 20times Time Taken:201ms

Cutoff - 22500 Number of runs - 20times Time Taken:221ms

Cutoff - 25000 Number of runs - 20times Time Taken:216ms

Cutoff - 27500 Number of runs - 20times Time Taken:241ms

Cutoff - 30000 Number of runs - 20times Time Taken:231ms

Cutoff - 32500 Number of runs - 20times Time Taken:235ms

Cutoff - 35000 Number of runs - 20times Time Taken:273ms

Cutoff - 37500 Number of runs - 20times Time Taken:180ms

Cutoff - 40000 Number of runs - 20times Time Taken:191ms

Cutoff - 42500 Number of runs - 20times Time Taken:181ms

Cutoff - 45000 Number of runs - 20times Time Taken:194ms

Cutoff - 47500 Number of runs - 20times Time Taken:175ms

Cutoff - 50000 Number of runs - 20times Time Taken:194ms

Parallelism Degree: 4

Cutoff - 5000 Number of runs - 20times Time Taken:254ms

Cutoff - 7500 Number of runs - 20times Time Taken:212ms

Cutoff - 10000 Number of runs - 20times Time Taken:182ms

Cutoff - 12500 Number of runs - 20times Time Taken:171ms

Cutoff - 15000 Number of runs - 20times Time Taken:162ms

Cutoff - 17500 Number of runs - 20times Time Taken:220ms

Cutoff - 20000 Number of runs - 20times Time Taken:149ms

Cutoff - 22500 Number of runs - 20times Time Taken:197ms

Cutoff - 25000 Number of runs - 20times Time Taken:161ms

Cutoff - 27500 Number of runs - 20times Time Taken:159ms

Cutoff - 30000 Number of runs - 20times Time Taken:163ms

Cutoff - 32500 Number of runs - 20times Time Taken:157ms

Cutoff - 35000 Number of runs - 20times Time Taken:173ms

Cutoff - 37500 Number of runs - 20times Time Taken:168ms

Cutoff - 40000 Number of runs - 20times Time Taken:159ms

Cutoff - 42500 Number of runs - 20times Time Taken:160ms

Cutoff - 45000 Number of runs - 20times Time Taken:163ms

Cutoff - 47500 Number of runs - 20times Time Taken:160ms

Cutoff - 50000 Number of runs - 20times Time Taken:161ms

Parallelism Degree: 8

Cutoff - 5000 Number of runs - 20times Time Taken:215ms

Cutoff - 7500 Number of runs - 20times Time Taken:201ms

Cutoff - 10000 Number of runs - 20times Time Taken:179ms

Cutoff - 12500 Number of runs - 20times Time Taken:179ms

Cutoff - 15000 Number of runs - 20times Time Taken:167ms

Cutoff - 17500 Number of runs - 20times Time Taken:144ms

Cutoff - 20000 Number of runs - 20times Time Taken:168ms

Cutoff - 22500 Number of runs - 20times Time Taken:182ms

Cutoff - 25000 Number of runs - 20times Time Taken:181ms

Cutoff - 27500 Number of runs - 20times Time Taken:145ms

Cutoff - 30000 Number of runs - 20times Time Taken:163ms

Cutoff - 32500 Number of runs - 20times Time Taken:145ms

Cutoff - 35000 Number of runs - 20times Time Taken:148ms

Cutoff - 37500 Number of runs - 20times Time Taken:152ms

Cutoff - 40000 Number of runs - 20times Time Taken:140ms

Cutoff - 42500 Number of runs - 20times Time Taken:145ms

Cutoff - 45000 Number of runs - 20times Time Taken:166ms

Cutoff - 47500 Number of runs - 20times Time Taken:147ms

Cutoff - 50000 Number of runs - 20times Time Taken:148ms

Parallelism Degree: 16

Cutoff - 5000 Number of runs - 20times Time Taken:193ms

Cutoff - 7500 Number of runs - 20times Time Taken:176ms

Cutoff - 10000 Number of runs - 20times Time Taken:158ms

Cutoff - 12500 Number of runs - 20times Time Taken:188ms

Cutoff - 15000 Number of runs - 20times Time Taken:165ms

Cutoff - 17500 Number of runs - 20times Time Taken:150ms

Cutoff - 20000 Number of runs - 20times Time Taken:163ms

Cutoff - 22500 Number of runs - 20times Time Taken:159ms

Cutoff - 25000 Number of runs - 20times Time Taken:149ms

Cutoff - 27500 Number of runs - 20times Time Taken:146ms

Cutoff - 30000 Number of runs - 20times Time Taken:189ms

Cutoff - 32500 Number of runs - 20times Time Taken:181ms

Cutoff - 35000 Number of runs - 20times Time Taken:149ms

Cutoff - 37500 Number of runs - 20times Time Taken:141ms

Cutoff - 40000 Number of runs - 20times Time Taken:143ms

Cutoff - 42500 Number of runs - 20times Time Taken:166ms

Cutoff - 45000 Number of runs - 20times Time Taken:145ms

Cutoff - 47500 Number of runs - 20times Time Taken:143ms

Cutoff - 50000 Number of runs - 20times Time Taken:155ms

Parallelism Degree: 32

Cutoff - 5000 Number of runs - 20times Time Taken:179ms

Cutoff - 7500 Number of runs - 20times Time Taken:161ms

Cutoff - 10000 Number of runs - 20times Time Taken:158ms

Cutoff - 12500 Number of runs - 20times Time Taken:164ms

Cutoff - 15000 Number of runs - 20times Time Taken:161ms

Cutoff - 17500 Number of runs - 20times Time Taken:143ms

Cutoff - 20000 Number of runs - 20times Time Taken:176ms

Cutoff - 22500 Number of runs - 20times Time Taken:165ms

Cutoff - 25000 Number of runs - 20times Time Taken:168ms

Cutoff - 27500 Number of runs - 20times Time Taken:176ms

Cutoff - 30000 Number of runs - 20times Time Taken:175ms

Cutoff - 32500 Number of runs - 20times Time Taken:151ms

Cutoff - 35000 Number of runs - 20times Time Taken:148ms

Cutoff - 37500 Number of runs - 20times Time Taken:144ms

Cutoff - 40000 Number of runs - 20times Time Taken:162ms

Cutoff - 42500 Number of runs - 20times Time Taken:150ms

Cutoff - 45000 Number of runs - 20times Time Taken:143ms

Cutoff - 47500 Number of runs - 20times Time Taken:144ms

Cutoff - 50000 Number of runs - 20times Time Taken:161ms

Parallelism Degree: 64

Cutoff - 5000 Number of runs - 20times Time Taken:182ms

Cutoff - 7500 Number of runs - 20times Time Taken:158ms

Cutoff - 10000 Number of runs - 20times Time Taken:160ms

Cutoff - 12500 Number of runs - 20times Time Taken:161ms

Cutoff - 15000 Number of runs - 20times Time Taken:159ms

Cutoff - 17500 Number of runs - 20times Time Taken:150ms

Cutoff - 20000 Number of runs - 20times Time Taken:165ms

Cutoff - 22500 Number of runs - 20times Time Taken:162ms

Cutoff - 25000 Number of runs - 20times Time Taken:159ms

Cutoff - 27500 Number of runs - 20times Time Taken:153ms

Cutoff - 30000 Number of runs - 20times Time Taken:161ms

Cutoff - 32500 Number of runs - 20times Time Taken:187ms

Cutoff - 35000 Number of runs - 20times Time Taken:145ms

Cutoff - 37500 Number of runs - 20times Time Taken:162ms

Cutoff - 40000 Number of runs - 20times Time Taken:133ms

Cutoff - 42500 Number of runs - 20times Time Taken:164ms

Cutoff - 45000 Number of runs - 20times Time Taken:132ms

Cutoff - 47500 Number of runs - 20times Time Taken:163ms

Cutoff - 50000 Number of runs - 20times Time Taken:142ms

Process finished with exit code 0