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**Program Structures & Algorithms**

**Fall 2021**

**Assignment No. 5**

* **Task :**
* 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.
* 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.
* 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).

**Output(Terminal)**

Size of Array: 500000

Degree of parallelism: 2 The size is: 500000

cutoff：5000 10times Time:740ms

cutoff：10000 10times Time:494ms

cutoff：15000 10times Time:436ms

cutoff：20000 10times Time:365ms

cutoff：25000 10times Time:374ms

cutoff：30000 10times Time:392ms

cutoff：35000 10times Time:355ms

cutoff：40000 10times Time:376ms

cutoff：45000 10times Time:347ms

cutoff：50000 10times Time:353ms

Degree of parallelism: 4 The size is: 500000

cutoff：5000 10times Time:421ms

cutoff：10000 10times Time:341ms

cutoff：15000 10times Time:370ms

cutoff：20000 10times Time:345ms

cutoff：25000 10times Time:333ms

cutoff：30000 10times Time:327ms

cutoff：35000 10times Time:323ms

cutoff：40000 10times Time:331ms

cutoff：45000 10times Time:364ms

cutoff：50000 10times Time:307ms

Degree of parallelism: 8 The size is: 500000

cutoff：5000 10times Time:390ms

cutoff：10000 10times Time:330ms

cutoff：15000 10times Time:315ms

cutoff：20000 10times Time:297ms

cutoff：25000 10times Time:289ms

cutoff：30000 10times Time:300ms

cutoff：35000 10times Time:289ms

cutoff：40000 10times Time:339ms

cutoff：45000 10times Time:354ms

cutoff：50000 10times Time:297ms

Degree of parallelism: 16 The size is: 500000

cutoff：5000 10times Time:930ms

cutoff：10000 10times Time:648ms

cutoff：15000 10times Time:633ms

cutoff：20000 10times Time:530ms

cutoff：25000 10times Time:575ms

cutoff：30000 10times Time:561ms

cutoff：35000 10times Time:369ms

cutoff：40000 10times Time:378ms

cutoff：45000 10times Time:352ms

cutoff：50000 10times Time:313ms

Degree of parallelism: 32 The size is: 500000

cutoff：5000 10times Time:3365ms

cutoff：10000 10times Time:1056ms

cutoff：15000 10times Time:1032ms

cutoff：20000 10times Time:579ms

cutoff：25000 10times Time:663ms

cutoff：30000 10times Time:639ms

cutoff：35000 10times Time:242ms

cutoff：40000 10times Time:218ms

cutoff：45000 10times Time:222ms

cutoff：50000 10times Time:251ms

Degree of parallelism: 64 The size is: 500000

cutoff：5000 10times Time:14563ms

cutoff：10000 10times Time:1120ms

cutoff：15000 10times Time:1208ms

cutoff：20000 10times Time:325ms

cutoff：25000 10times Time:269ms

cutoff：30000 10times Time:343ms

cutoff：35000 10times Time:217ms

cutoff：40000 10times Time:199ms

cutoff：45000 10times Time:201ms

cutoff：50000 10times Time:199ms

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Degree of parallelism: 2 The size is: 1000000

cutoff：5000 10times Time:974ms

cutoff：10000 10times Time:825ms

cutoff：15000 10times Time:772ms

cutoff：20000 10times Time:672ms

cutoff：25000 10times Time:668ms

cutoff：30000 10times Time:657ms

cutoff：35000 10times Time:673ms

cutoff：40000 10times Time:667ms

cutoff：45000 10times Time:647ms

cutoff：50000 10times Time:639ms

Degree of parallelism: 4 The size is: 1000000

cutoff：5000 10times Time:831ms

cutoff：10000 10times Time:719ms

cutoff：15000 10times Time:707ms

cutoff：20000 10times Time:646ms

cutoff：25000 10times Time:715ms

cutoff：30000 10times Time:692ms

cutoff：35000 10times Time:677ms

cutoff：40000 10times Time:646ms

cutoff：45000 10times Time:637ms

cutoff：50000 10times Time:635ms

Degree of parallelism: 8 The size is: 1000000

cutoff：5000 10times Time:794ms

cutoff：10000 10times Time:723ms

cutoff：15000 10times Time:685ms

cutoff：20000 10times Time:688ms

cutoff：25000 10times Time:648ms

cutoff：30000 10times Time:654ms

cutoff：35000 10times Time:651ms

cutoff：40000 10times Time:644ms

cutoff：45000 10times Time:642ms

cutoff：50000 10times Time:635ms

Degree of parallelism: 16 The size is: 1000000

cutoff：5000 10times Time:1289ms

cutoff：10000 10times Time:1125ms

cutoff：15000 10times Time:1112ms

cutoff：20000 10times Time:1044ms

cutoff：25000 10times Time:993ms

cutoff：30000 10times Time:1010ms

cutoff：35000 10times Time:958ms

cutoff：40000 10times Time:936ms

cutoff：45000 10times Time:1000ms

cutoff：50000 10times Time:1005ms

Degree of parallelism: 32 The size is: 1000000

cutoff：5000 10times Time:3863ms

cutoff：10000 10times Time:1741ms

cutoff：15000 10times Time:1663ms

cutoff：20000 10times Time:1444ms

cutoff：25000 10times Time:1479ms

cutoff：30000 10times Time:1468ms

cutoff：35000 10times Time:934ms

cutoff：40000 10times Time:995ms

cutoff：45000 10times Time:897ms

cutoff：50000 10times Time:944ms

Degree of parallelism: 64 The size is: 1000000

cutoff：5000 10times Time:16086ms

cutoff：10000 10times Time:2500ms

cutoff：15000 10times Time:2567ms

cutoff：20000 10times Time:1311ms

cutoff：25000 10times Time:1273ms

cutoff：30000 10times Time:1371ms

cutoff：35000 10times Time:600ms

cutoff：40000 10times Time:592ms

cutoff：45000 10times Time:639ms

cutoff：50000 10times Time:582ms

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Degree of parallelism: 2 The size is: 2000000

cutoff：5000 10times Time:1899ms

cutoff：10000 10times Time:1782ms

cutoff：15000 10times Time:1524ms

cutoff：20000 10times Time:1899ms

cutoff：25000 10times Time:1826ms

cutoff：30000 10times Time:1583ms

cutoff：35000 10times Time:1798ms

cutoff：40000 10times Time:1691ms

cutoff：45000 10times Time:1574ms

cutoff：50000 10times Time:1436ms

Degree of parallelism: 4 The size is: 2000000

cutoff：5000 10times Time:1868ms

cutoff：10000 10times Time:1663ms

cutoff：15000 10times Time:2234ms

cutoff：20000 10times Time:2822ms

cutoff：25000 10times Time:1473ms

cutoff：30000 10times Time:1953ms

cutoff：35000 10times Time:1377ms

cutoff：40000 10times Time:1346ms

cutoff：45000 10times Time:1355ms

cutoff：50000 10times Time:1338ms

Degree of parallelism: 8 The size is: 2000000

cutoff：5000 10times Time:1894ms

cutoff：10000 10times Time:1530ms

cutoff：15000 10times Time:1715ms

cutoff：20000 10times Time:1841ms

cutoff：25000 10times Time:1515ms

cutoff：30000 10times Time:1488ms

cutoff：35000 10times Time:1376ms

cutoff：40000 10times Time:1451ms

cutoff：45000 10times Time:1440ms

cutoff：50000 10times Time:1481ms

Degree of parallelism: 16 The size is: 2000000

cutoff：5000 10times Time:2472ms

cutoff：10000 10times Time:1856ms

cutoff：15000 10times Time:1897ms

cutoff：20000 10times Time:1763ms

cutoff：25000 10times Time:1802ms

cutoff：30000 10times Time:1906ms

cutoff：35000 10times Time:1731ms

cutoff：40000 10times Time:1835ms

cutoff：45000 10times Time:1852ms

cutoff：50000 10times Time:2030ms

Degree of parallelism: 32 The size is: 2000000

cutoff：5000 10times Time:4819ms

cutoff：10000 10times Time:2859ms

cutoff：15000 10times Time:4307ms

cutoff：20000 10times Time:3176ms

cutoff：25000 10times Time:2270ms

cutoff：30000 10times Time:2518ms

cutoff：35000 10times Time:1876ms

cutoff：40000 10times Time:2039ms

cutoff：45000 10times Time:2506ms

cutoff：50000 10times Time:2481ms

Degree of parallelism: 64 The size is: 2000000

cutoff：5000 10times Time:23287ms

cutoff：10000 10times Time:3638ms

cutoff：15000 10times Time:3409ms

cutoff：20000 10times Time:3078ms

cutoff：25000 10times Time:3025ms

cutoff：30000 10times Time:2991ms

cutoff：35000 10times Time:1881ms

cutoff：40000 10times Time:1970ms

cutoff：45000 10times Time:1963ms

cutoff：50000 10times Time:2084ms

Process finished with exit code 0

* **Relationship Conclusion:**
* The experiment was done on Dell Inspiron Laptop - Intel(R) Core(TM) i7-8550U CPU @ 1.80GHz 1.99 GHz.

I took array sizes as 500000, 1000000, 2000000.

And thread sizes as 2, 4, 8, 16, 32 and 64(powers of 2) for testing

* From the below scatter plots, we were able to come to conclusion that size required is 16 and above that, there is no significant use and will not help in reducing the time complexity.
* We can also observe that 25% of the array size is best to achieve the best time for performance of the program.
* (t = number of threads available, d = Recursion Depth)
* Maximum Depth Possible is : lg(arrsize/cutoff)

The folder for all the data is src/assignment5\_results

**Graphical Representation - Evidence to support the Relationship**