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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)

parallelism degree = 2 and the size is: 500000

cutoff : 5000----- 10times Time:697ms

cutoff : 10000----- 10times Time:453ms

cutoff : 15000----- 10times Time:287ms

cutoff : 20000----- 10times Time:298ms

cutoff : 25000----- 10times Time:281ms

cutoff : 30000----- 10times Time:252ms

cutoff : 35000----- 10times Time:290ms

cutoff : 40000----- 10times Time:350ms

cutoff : 45000----- 10times Time:276ms

cutoff : 50000----- 10times Time:386ms

parallelism degree = 4 and the size is: 500000

cutoff : 5000----- 10times Time:309ms

cutoff : 10000----- 10times Time:232ms

cutoff : 15000----- 10times Time:220ms

cutoff : 20000----- 10times Time:222ms

cutoff : 25000----- 10times Time:222ms

cutoff : 30000----- 10times Time:234ms

cutoff : 35000----- 10times Time:235ms

cutoff : 40000----- 10times Time:233ms

cutoff : 45000----- 10times Time:239ms

cutoff : 50000----- 10times Time:230ms

parallelism degree = 8 and the size is: 500000

cutoff : 5000----- 10times Time:249ms

cutoff : 10000----- 10times Time:224ms

cutoff : 15000----- 10times Time:218ms

cutoff : 20000----- 10times Time:214ms

cutoff : 25000----- 10times Time:213ms

cutoff : 30000----- 10times Time:213ms

cutoff : 35000----- 10times Time:217ms

cutoff : 40000----- 10times Time:211ms

cutoff : 45000----- 10times Time:216ms

cutoff : 50000----- 10times Time:212ms

parallelism degree = 16 and the size is: 500000

cutoff : 5000----- 10times Time:261ms

cutoff : 10000----- 10times Time:222ms

cutoff : 15000----- 10times Time:220ms

cutoff : 20000----- 10times Time:211ms

cutoff : 25000----- 10times Time:216ms

cutoff : 30000----- 10times Time:217ms

cutoff : 35000----- 10times Time:210ms

cutoff : 40000----- 10times Time:214ms

cutoff : 45000----- 10times Time:214ms

cutoff : 50000----- 10times Time:218ms

parallelism degree = 32 and the size is: 500000

cutoff : 5000----- 10times Time:259ms

cutoff : 10000----- 10times Time:216ms

cutoff : 15000----- 10times Time:222ms

cutoff : 20000----- 10times Time:219ms

cutoff : 25000----- 10times Time:218ms

cutoff : 30000----- 10times Time:211ms

cutoff : 35000----- 10times Time:215ms

cutoff : 40000----- 10times Time:209ms

cutoff : 45000----- 10times Time:220ms

cutoff : 50000----- 10times Time:209ms

parallelism degree = 64 and the size is: 500000

cutoff : 5000----- 10times Time:248ms

cutoff : 10000----- 10times Time:219ms

cutoff : 15000----- 10times Time:221ms

cutoff : 20000----- 10times Time:213ms

cutoff : 25000----- 10times Time:215ms

cutoff : 30000----- 10times Time:210ms

cutoff : 35000----- 10times Time:213ms

cutoff : 40000----- 10times Time:207ms

cutoff : 45000----- 10times Time:215ms

cutoff : 50000----- 10times Time:213ms

parallelism degree = 2 and the size is: 1000000

cutoff : 5000----- 10times Time:529ms

cutoff : 10000----- 10times Time:471ms

cutoff : 15000----- 10times Time:477ms

cutoff : 20000----- 10times Time:494ms

cutoff : 25000----- 10times Time:474ms

cutoff : 30000----- 10times Time:475ms

cutoff : 35000----- 10times Time:503ms

cutoff : 40000----- 10times Time:489ms

cutoff : 45000----- 10times Time:494ms

cutoff : 50000----- 10times Time:499ms

parallelism degree = 4 and the size is: 1000000

cutoff : 5000----- 10times Time:524ms

cutoff : 10000----- 10times Time:462ms

cutoff : 15000----- 10times Time:461ms

cutoff : 20000----- 10times Time:470ms

cutoff : 25000----- 10times Time:459ms

cutoff : 30000----- 10times Time:443ms

cutoff : 35000----- 10times Time:458ms

cutoff : 40000----- 10times Time:458ms

cutoff : 45000----- 10times Time:457ms

cutoff : 50000----- 10times Time:455ms

parallelism degree = 8 and the size is: 1000000

cutoff : 5000----- 10times Time:520ms

cutoff : 10000----- 10times Time:470ms

cutoff : 15000----- 10times Time:469ms

cutoff : 20000----- 10times Time:487ms

cutoff : 25000----- 10times Time:499ms

cutoff : 30000----- 10times Time:547ms

cutoff : 35000----- 10times Time:548ms

cutoff : 40000----- 10times Time:502ms

cutoff : 45000----- 10times Time:527ms

cutoff : 50000----- 10times Time:512ms

parallelism degree = 16 and the size is: 1000000

cutoff : 5000----- 10times Time:643ms

cutoff : 10000----- 10times Time:594ms

cutoff : 15000----- 10times Time:505ms

cutoff : 20000----- 10times Time:443ms

cutoff : 25000----- 10times Time:481ms

cutoff : 30000----- 10times Time:507ms

cutoff : 35000----- 10times Time:475ms

cutoff : 40000----- 10times Time:487ms

cutoff : 45000----- 10times Time:460ms

cutoff : 50000----- 10times Time:567ms

parallelism degree = 32 and the size is: 1000000

cutoff : 5000----- 10times Time:635ms

cutoff : 10000----- 10times Time:630ms

cutoff : 15000----- 10times Time:712ms

cutoff : 20000----- 10times Time:733ms

cutoff : 25000----- 10times Time:574ms

cutoff : 30000----- 10times Time:499ms

cutoff : 35000----- 10times Time:504ms

cutoff : 40000----- 10times Time:590ms

cutoff : 45000----- 10times Time:551ms

cutoff : 50000----- 10times Time:504ms

parallelism degree = 64 and the size is: 1000000

cutoff : 5000----- 10times Time:643ms

cutoff : 10000----- 10times Time:615ms

cutoff : 15000----- 10times Time:582ms

cutoff : 20000----- 10times Time:618ms

cutoff : 25000----- 10times Time:574ms

cutoff : 30000----- 10times Time:522ms

cutoff : 35000----- 10times Time:445ms

cutoff : 40000----- 10times Time:410ms

cutoff : 45000----- 10times Time:564ms

cutoff : 50000----- 10times Time:541ms

parallelism degree = 2 and the size is: 2000000

cutoff : 5000----- 10times Time:1268ms

cutoff : 10000----- 10times Time:1137ms

cutoff : 15000----- 10times Time:1164ms

cutoff : 20000----- 10times Time:1019ms

cutoff : 25000----- 10times Time:1227ms

cutoff : 30000----- 10times Time:1288ms

cutoff : 35000----- 10times Time:1642ms

cutoff : 40000----- 10times Time:1361ms

cutoff : 45000----- 10times Time:1212ms

cutoff : 50000----- 10times Time:1302ms

parallelism degree = 4 and the size is: 2000000

cutoff : 5000----- 10times Time:1179ms

cutoff : 10000----- 10times Time:1047ms

cutoff : 15000----- 10times Time:1160ms

cutoff : 20000----- 10times Time:1301ms

cutoff : 25000----- 10times Time:1205ms

cutoff : 30000----- 10times Time:1308ms

cutoff : 35000----- 10times Time:1320ms

cutoff : 40000----- 10times Time:1172ms

cutoff : 45000----- 10times Time:1392ms

cutoff : 50000----- 10times Time:1339ms

parallelism degree = 8 and the size is: 2000000

cutoff : 5000----- 10times Time:1251ms

cutoff : 10000----- 10times Time:1026ms

cutoff : 15000----- 10times Time:1148ms

cutoff : 20000----- 10times Time:1209ms

cutoff : 25000----- 10times Time:1018ms

cutoff : 30000----- 10times Time:1105ms

cutoff : 35000----- 10times Time:1040ms

cutoff : 40000----- 10times Time:1080ms

cutoff : 45000----- 10times Time:1072ms

cutoff : 50000----- 10times Time:1062ms

parallelism degree = 16 and the size is: 2000000

cutoff : 5000----- 10times Time:1307ms

cutoff : 10000----- 10times Time:1106ms

cutoff : 15000----- 10times Time:1135ms

cutoff : 20000----- 10times Time:1112ms

cutoff : 25000----- 10times Time:1108ms

cutoff : 30000----- 10times Time:1062ms

cutoff : 35000----- 10times Time:1056ms

cutoff : 40000----- 10times Time:1037ms

cutoff : 45000----- 10times Time:1040ms

cutoff : 50000----- 10times Time:1071ms

parallelism degree = 32 and the size is: 2000000

cutoff : 5000----- 10times Time:1197ms

cutoff : 10000----- 10times Time:1099ms

cutoff : 15000----- 10times Time:1146ms

cutoff : 20000----- 10times Time:1066ms

cutoff : 25000----- 10times Time:1178ms

cutoff : 30000----- 10times Time:1050ms

cutoff : 35000----- 10times Time:1091ms

cutoff : 40000----- 10times Time:1116ms

cutoff : 45000----- 10times Time:1058ms

cutoff : 50000----- 10times Time:1005ms

parallelism degree = 64 and the size is: 2000000

cutoff : 5000----- 10times Time:1077ms

cutoff : 10000----- 10times Time:1076ms

cutoff : 15000----- 10times Time:1122ms

cutoff : 20000----- 10times Time:1111ms

cutoff : 25000----- 10times Time:1052ms

cutoff : 30000----- 10times Time:1130ms

cutoff : 35000----- 10times Time:1091ms

cutoff : 40000----- 10times Time:1097ms

cutoff : 45000----- 10times Time:1112ms

cutoff : 50000----- 10times Time:1031ms

Process finished with exit code 0

☉ Relationship Conclusion:

- The experiment was done on a MacBook Pro 2.6 GHz Quad-Core Intel Core i7.
- Array sizes taken are 500000, 1000000, 2000000 and thread sizes are 2, 4, 8, 16, 32 and 64 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.
- From the graph plotting, it can be concluded that the optimum size is 16, above which there won't be any significant use/help in reducing the time. It can also be observed that 25% of the array size is best to achieve the best time for performance of the program.
- $t = 2^d$ (d = Recursion Depth ,t = number of threads available)
- Maximum Depth Possible = $\lg(\text{arraySize}/\text{cutoff})$

Graphical Representation - Evidence to support the Relationship



