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Program Structures & Algorithms

Fall 2021

Assignment No. 5

Task

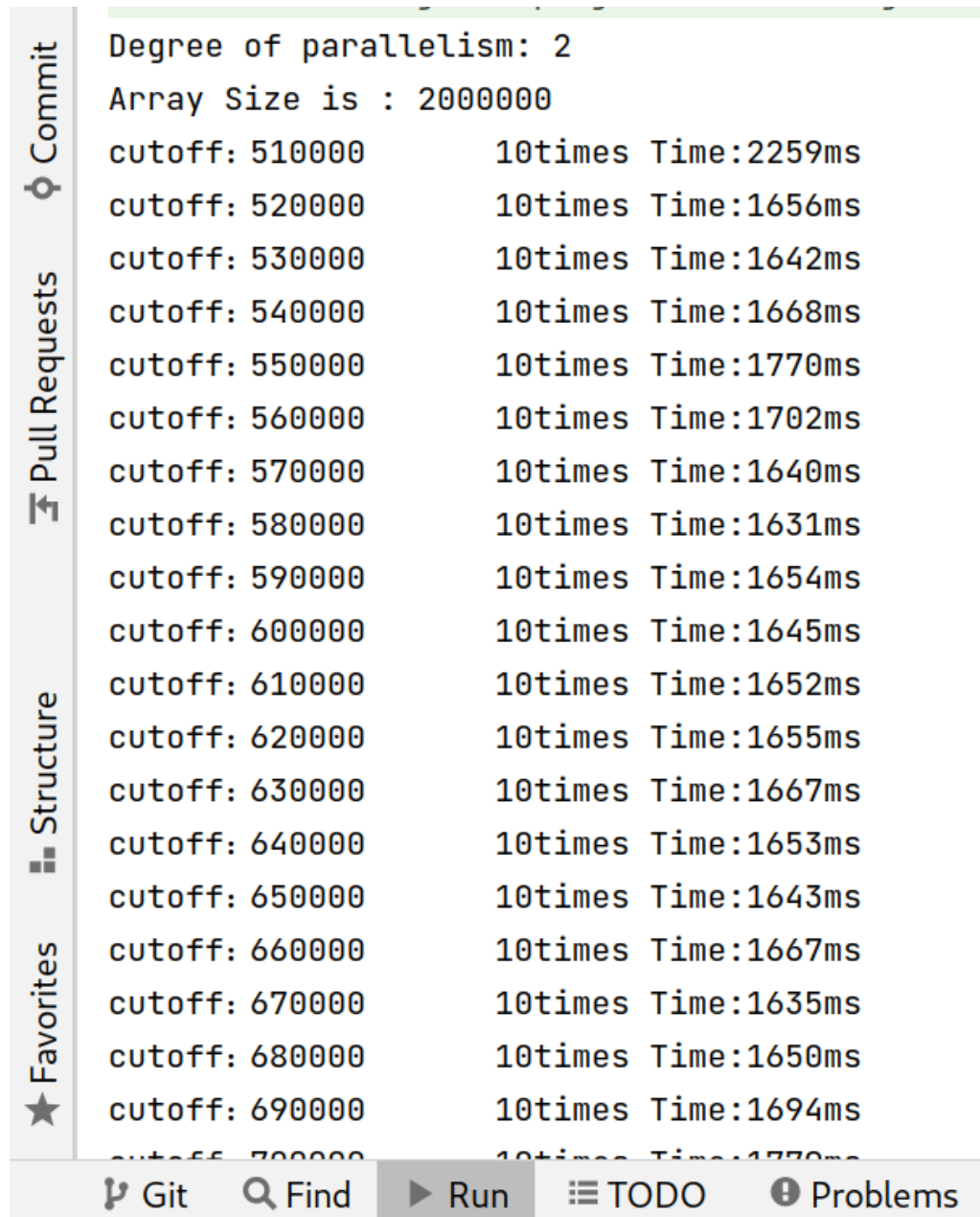
Task is to implement a parallel sorting algorithm such that each partition of the array is sorted in parallel. You will consider two different schemes for deciding whether to sort in parallel.

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.

Output

First I wrote code in main.java for thread count (power of 2) and fixed array size.

1. Available thread count : 2 ; Array size: 2000000 ; Sorted 10 times(average)



The screenshot shows an IDE window with a vertical toolbar on the left containing icons for 'Commit', 'Pull Requests', 'Structure', and 'Favorites'. The main editor area displays the following text:

```
Degree of parallelism: 2
Array Size is : 2000000
cutoff: 510000      10times Time:2259ms
cutoff: 520000      10times Time:1656ms
cutoff: 530000      10times Time:1642ms
cutoff: 540000      10times Time:1668ms
cutoff: 550000      10times Time:1770ms
cutoff: 560000      10times Time:1702ms
cutoff: 570000      10times Time:1640ms
cutoff: 580000      10times Time:1631ms
cutoff: 590000      10times Time:1654ms
cutoff: 600000      10times Time:1645ms
cutoff: 610000      10times Time:1652ms
cutoff: 620000      10times Time:1655ms
cutoff: 630000      10times Time:1667ms
cutoff: 640000      10times Time:1653ms
cutoff: 650000      10times Time:1643ms
cutoff: 660000      10times Time:1667ms
cutoff: 670000      10times Time:1635ms
cutoff: 680000      10times Time:1650ms
cutoff: 690000      10times Time:1694ms
cutoff: 700000      10times Time:1770ms
```

At the bottom of the IDE, there is a toolbar with icons and labels for 'Git', 'Find', 'Run', 'TODO', and 'Problems'.

2. Available thread count : 4 ; Array size: 2000000 ; Sorted 10 times(average)

Commit	Degree of parallelism: 4
	Array Size is : 2000000
	cutoff: 510000 10times Time:2087ms
	cutoff: 520000 10times Time:1264ms
	cutoff: 530000 10times Time:1274ms
	cutoff: 540000 10times Time:1254ms
	cutoff: 550000 10times Time:1339ms
	cutoff: 560000 10times Time:1260ms
	cutoff: 570000 10times Time:1268ms
	cutoff: 580000 10times Time:1242ms
	cutoff: 590000 10times Time:1276ms
	cutoff: 600000 10times Time:1236ms
	cutoff: 610000 10times Time:1243ms
	cutoff: 620000 10times Time:1259ms
	cutoff: 630000 10times Time:1276ms
	cutoff: 640000 10times Time:1233ms
	cutoff: 650000 10times Time:1262ms
	cutoff: 660000 10times Time:1259ms
	cutoff: 670000 10times Time:1267ms
	cutoff: 680000 10times Time:1261ms
	cutoff: 690000 10times Time:1285ms
	cutoff: 700000 10times Time:1242ms

3. Available thread count : 8 ; Array size: 2000000 ; Sorted 10

Pull Requests	Commit	Degree of parallelism: 8	
		Array Size is : 2000000	
		cutoff: 510000	10times Time:2683ms
		cutoff: 520000	10times Time:1260ms
		cutoff: 530000	10times Time:1489ms
		cutoff: 540000	10times Time:1292ms
		cutoff: 550000	10times Time:1089ms
		cutoff: 560000	10times Time:1112ms
		cutoff: 570000	10times Time:1074ms
		cutoff: 580000	10times Time:1103ms
Structure		cutoff: 590000	10times Time:1233ms
		cutoff: 600000	10times Time:1153ms
		cutoff: 610000	10times Time:1058ms
		cutoff: 620000	10times Time:1055ms
		cutoff: 630000	10times Time:1048ms
		cutoff: 640000	10times Time:1061ms
		cutoff: 650000	10times Time:1066ms
		cutoff: 660000	10times Time:1071ms
		cutoff: 670000	10times Time:1113ms
		cutoff: 680000	10times Time:1073ms
Favorites		cutoff: 690000	10times Time:1065ms
		cutoff: 700000	10times Time:1077ms

4. Available thread count : 16 ; Array size: 2000000 ; Sorted 10 times(average)

Commit	Degree of parallelism: 16
	Array Size is : 2000000
Pull Requests	cutoff: 510000 10times Time:2212ms
	cutoff: 520000 10times Time:1439ms
	cutoff: 530000 10times Time:1464ms
	cutoff: 540000 10times Time:1345ms
	cutoff: 550000 10times Time:1131ms
	cutoff: 560000 10times Time:1170ms
	cutoff: 570000 10times Time:1154ms
	cutoff: 580000 10times Time:1151ms
	cutoff: 590000 10times Time:1103ms
	cutoff: 600000 10times Time:1208ms
Structure	cutoff: 610000 10times Time:1101ms
	cutoff: 620000 10times Time:1135ms
	cutoff: 630000 10times Time:1069ms
	cutoff: 640000 10times Time:1049ms
	cutoff: 650000 10times Time:1055ms
Favorites	cutoff: 660000 10times Time:1053ms
	cutoff: 670000 10times Time:1048ms
	cutoff: 680000 10times Time:1042ms
	cutoff: 690000 10times Time:1045ms

5. Available thread count : 32 ; Array size: 2000000 ; Sorted 10 times(average)

★ Favorites

■ Structure

↕ Pull Requests

⊖ Commit

Degree of parallelism: 32
Array Size is : 2000000
cutoff: 510000 10times Time:2447ms
cutoff: 520000 10times Time:1299ms
cutoff: 530000 10times Time:1061ms
cutoff: 540000 10times Time:1112ms
cutoff: 550000 10times Time:1066ms
cutoff: 560000 10times Time:1063ms
cutoff: 570000 10times Time:1054ms
cutoff: 580000 10times Time:1036ms
cutoff: 590000 10times Time:1062ms
cutoff: 600000 10times Time:1099ms
cutoff: 610000 10times Time:1037ms
cutoff: 620000 10times Time:1043ms
cutoff: 630000 10times Time:1036ms
cutoff: 640000 10times Time:1039ms
cutoff: 650000 10times Time:1033ms
cutoff: 660000 10times Time:1036ms
cutoff: 670000 10times Time:1040ms
cutoff: 680000 10times Time:1050ms
cutoff: 690000 10times Time:1169ms
cutoff: 700000 10times Time:1041ms

Git

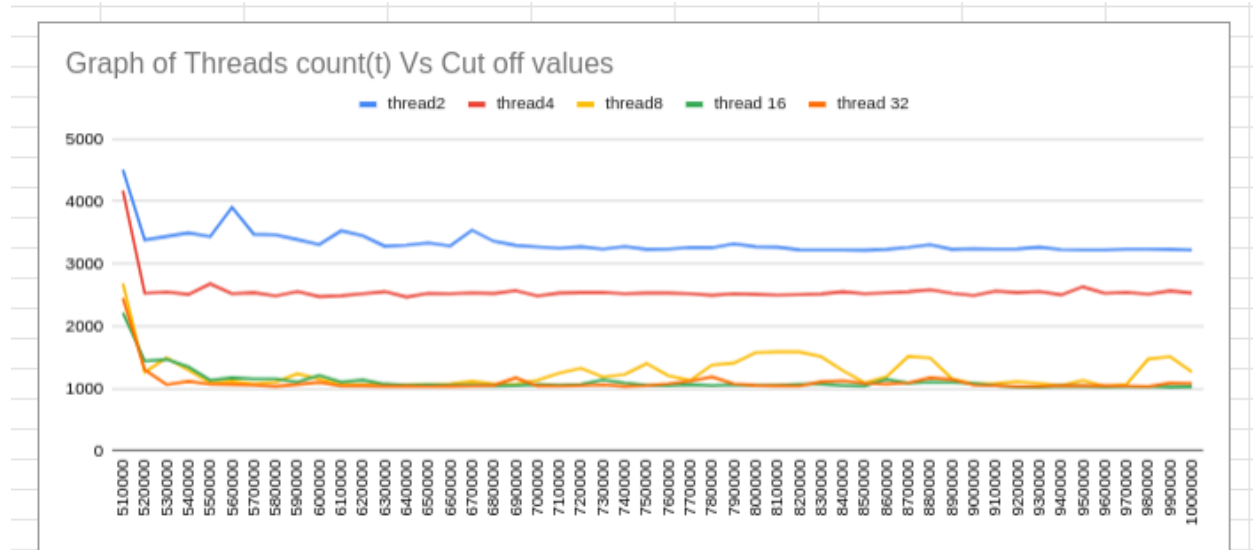
Find

Run

TODO

Problem

Graphical representation of evidence



The above experiment was conducted using a cutoff range of 510000 – 920000, an array size of 2000000, and thread counts ranging from 2 to 32. According to the results of the above trials, the appropriate cutoff value is between 640000 and 820000. As a result, 640000 is the most efficient thread count 32.

Let's validate this by running a test with a thread count of 32 and a range of 640000 to 820000. for various array sizes by altering main.java according to array size

Available thread count : 32 ; Array size: 3000000 ; Sorted 10 times(average)

★ Favorites

■ Structure

↕ Pull Requests

⦿ Commit

Degree of parallelism: 32
Array Size is : 3000000
cutoff: 510000 10times Time:2738ms
cutoff: 520000 10times Time:1708ms
cutoff: 530000 10times Time:1689ms
cutoff: 540000 10times Time:1698ms
cutoff: 550000 10times Time:1711ms
cutoff: 560000 10times Time:1700ms
cutoff: 570000 10times Time:1698ms
cutoff: 580000 10times Time:1701ms
cutoff: 590000 10times Time:1699ms
cutoff: 600000 10times Time:1683ms
cutoff: 610000 10times Time:1688ms
cutoff: 620000 10times Time:1697ms
cutoff: 630000 10times Time:1711ms
cutoff: 640000 10times Time:1680ms
cutoff: 650000 10times Time:1687ms
cutoff: 660000 10times Time:1692ms
cutoff: 670000 10times Time:1699ms
cutoff: 680000 10times Time:1699ms
cutoff: 690000 10times Time:1676ms
cutoff: 700000 10times Time:1680ms

🔗 Git

🔍 Find

▶ Run

☰ TODO

⚠ Problem

Available thread count : 32 ; Array size: 4000000 ; Sorted 10 times(average)

★ Favorites	■ Structure	↕ Pull Requests	⚙ Commit	Degree of parallelism: 32	
				Array Size is : 4000000	
				cutoff: 510000	10times Time:3319ms
				cutoff: 520000	10times Time:2252ms
				cutoff: 530000	10times Time:2229ms
				cutoff: 540000	10times Time:2207ms
				cutoff: 550000	10times Time:2263ms
				cutoff: 560000	10times Time:2231ms
				cutoff: 570000	10times Time:2240ms
				cutoff: 580000	10times Time:2224ms
				cutoff: 590000	10times Time:2225ms
				cutoff: 600000	10times Time:2216ms
				cutoff: 610000	10times Time:2206ms
				cutoff: 620000	10times Time:2215ms
				cutoff: 630000	10times Time:2207ms
				cutoff: 640000	10times Time:2235ms
				cutoff: 650000	10times Time:2231ms
				cutoff: 660000	10times Time:2229ms
				cutoff: 670000	10times Time:2229ms
				cutoff: 680000	10times Time:2231ms
				cutoff: 690000	10times Time:2207ms
				cutoff: 700000	10times Time:2221ms

Available thread count : 32 ; Array size: 5000000 ; Sorted 10 times(average)

Commit	Degree of parallelism: 32
	Array Size is : 5000000
	cutoff: 510000 10times Time:4367ms
	cutoff: 520000 10times Time:2934ms
	cutoff: 530000 10times Time:2855ms
	cutoff: 540000 10times Time:2869ms
	cutoff: 550000 10times Time:2876ms
	cutoff: 560000 10times Time:2888ms
	cutoff: 570000 10times Time:2867ms
	cutoff: 580000 10times Time:2807ms
	cutoff: 590000 10times Time:2818ms
	cutoff: 600000 10times Time:2817ms
	cutoff: 610000 10times Time:2803ms
	cutoff: 620000 10times Time:2824ms
	cutoff: 630000 10times Time:2749ms
	cutoff: 640000 10times Time:2765ms
	cutoff: 650000 10times Time:2755ms
	cutoff: 660000 10times Time:2769ms
	cutoff: 670000 10times Time:2753ms
	cutoff: 680000 10times Time:2752ms
	cutoff: 690000 10times Time:2715ms
	cutoff: 700000 10times Time:2750ms

Conclusion

According to the results of the above studies, even though we increased the Array size from 2000000 to 5000000 by a factor of 1000000, it took longer, but when the cutoff value is 640000 and the thread count is 32, the algorithm works most efficiently.

Cut off Time : 640000 Thread count : 32