Ren Junyan (NUID: 001529948)

INFO 6205

Program Structures & Algorithms

Fall 2020

Assignment No5

1. 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.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.

2. Output:

(1) Factor of cutoff and size of array(the number of threads is unchanged)

```
D:\Java\jdk\bin\java.exe "-javaagent:D:\intel
Degree of parallelism: 7
the size of array is: 1000000
cutoff: 510000      10times Time:1318ms
cutoff: 520000      10times Time:705ms
cutoff: 530000      10times Time:690ms
cutoff: 540000      10times Time:667ms
cutoff: 550000      10times Time:663ms
cutoff: 560000      10times Time:656ms
cutoff: 570000      10times Time:669ms
cutoff: 580000      10times Time:684ms
cutoff: 590000      10times Time:662ms
cutoff: 600000      10times Time:657ms
Average time: 737.0ms

Degree of parallelism: 7
the size of array is: 2000000
cutoff: 510000      10times Time:1056ms
cutoff: 520000      10times Time:1070ms
cutoff: 530000      10times Time:1161ms
cutoff: 540000      10times Time:1128ms
cutoff: 550000      10times Time:1145ms
cutoff: 560000      10times Time:1154ms
cutoff: 570000      10times Time:1077ms
cutoff: 580000      10times Time:1033ms
cutoff: 590000      10times Time:1027ms
cutoff: 600000      10times Time:1238ms
Average time: 1108.0ms
```

```
the size of array is: 4000000
cutoff: 510000      10times Time:2140ms
cutoff: 520000      10times Time:2132ms
cutoff: 530000      10times Time:2178ms
cutoff: 540000      10times Time:2174ms
cutoff: 550000      10times Time:2166ms
cutoff: 560000      10times Time:2169ms
cutoff: 570000      10times Time:2155ms
cutoff: 580000      10times Time:2169ms
cutoff: 590000      10times Time:2248ms
cutoff: 600000      10times Time:2126ms
Average time: 2165.0ms

Degree of parallelism: 7
the size of array is: 8000000
cutoff: 510000      10times Time:4811ms
cutoff: 520000      10times Time:4527ms
cutoff: 530000      10times Time:4889ms
cutoff: 540000      10times Time:4693ms
cutoff: 550000      10times Time:4403ms
cutoff: 560000      10times Time:4436ms
cutoff: 570000      10times Time:4481ms
cutoff: 580000      10times Time:4702ms
cutoff: 590000      10times Time:4918ms
cutoff: 600000      10times Time:4930ms
Average time: 4679.0ms
```

```
the size of array is: 16000000
cutoff: 510000      10times Time:9890ms
cutoff: 520000      10times Time:9814ms
cutoff: 530000      10times Time:10230ms
cutoff: 540000      10times Time:10515ms
cutoff: 550000      10times Time:9628ms
cutoff: 560000      10times Time:9585ms
cutoff: 570000      10times Time:9527ms
cutoff: 580000      10times Time:9624ms
cutoff: 590000      10times Time:9608ms
cutoff: 600000      10times Time:9492ms
Average time: 9791.0ms

Degree of parallelism: 7
the size of array is: 32000000
cutoff: 510000      10times Time:21280ms
cutoff: 520000      10times Time:21392ms
cutoff: 530000      10times Time:21100ms
cutoff: 540000      10times Time:21821ms
cutoff: 550000      10times Time:21490ms
cutoff: 560000      10times Time:21529ms
cutoff: 570000      10times Time:21799ms
cutoff: 580000      10times Time:21634ms
cutoff: 590000      10times Time:21688ms
cutoff: 600000      10times Time:21232ms
Average time: 21496.0ms
```

(2) Factor of cutoff and number of threads(the size of array is unchanged)

```
D:\Java\jdk\bin\java.exe "-javaagent:D:\:
Degree of parallelism: 1
the size of array is: 1000000
cutoff: 510000        10times Time:1369ms
cutoff: 520000        10times Time:1007ms
cutoff: 530000        10times Time:971ms
cutoff: 540000        10times Time:1004ms
cutoff: 550000        10times Time:994ms
cutoff: 560000        10times Time:981ms
cutoff: 570000        10times Time:981ms
cutoff: 580000        10times Time:982ms
cutoff: 590000        10times Time:989ms
cutoff: 600000        10times Time:988ms
Average time: 1026.0ms

Degree of parallelism: 2
the size of array is: 1000000
cutoff: 510000        10times Time:1036ms
cutoff: 520000        10times Time:1015ms
cutoff: 530000        10times Time:968ms
cutoff: 540000        10times Time:973ms
cutoff: 550000        10times Time:984ms
cutoff: 560000        10times Time:977ms
cutoff: 570000        10times Time:973ms
cutoff: 580000        10times Time:969ms
cutoff: 590000        10times Time:970ms
cutoff: 600000        10times Time:985ms
Average time: 985.0ms

Degree of parallelism: 64
the size of array is: 1000000
cutoff: 510000        10times Time:927ms
cutoff: 520000        10times Time:939ms
cutoff: 530000        10times Time:930ms
cutoff: 540000        10times Time:925ms
cutoff: 550000        10times Time:1102ms
cutoff: 560000        10times Time:957ms
cutoff: 570000        10times Time:964ms
cutoff: 580000        10times Time:965ms
cutoff: 590000        10times Time:965ms
cutoff: 600000        10times Time:965ms
Average time: 963.0ms

Degree of parallelism: 128
the size of array is: 1000000
cutoff: 510000        10times Time:974ms
cutoff: 520000        10times Time:972ms
cutoff: 530000        10times Time:984ms
cutoff: 540000        10times Time:973ms
cutoff: 550000        10times Time:973ms
cutoff: 560000        10times Time:970ms
cutoff: 570000        10times Time:972ms
cutoff: 580000        10times Time:987ms
cutoff: 590000        10times Time:969ms
cutoff: 600000        10times Time:976ms
Average time: 975.0ms
```
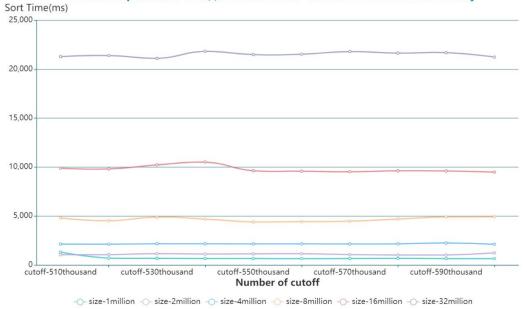
```
Degree of parallelism: 4
the size of array is: 1000000
cutoff: 510000        10times Time:964ms
cutoff: 520000        10times Time:979ms
cutoff: 530000        10times Time:975ms
cutoff: 540000        10times Time:978ms
cutoff: 550000        10times Time:976ms
cutoff: 560000        10times Time:972ms
cutoff: 570000        10times Time:980ms
cutoff: 580000        10times Time:975ms
cutoff: 590000        10times Time:965ms
cutoff: 600000        10times Time:944ms
Average time: 970.0ms

Degree of parallelism: 8
the size of array is: 1000000
cutoff: 510000        10times Time:933ms
cutoff: 520000        10times Time:931ms
cutoff: 530000        10times Time:922ms
cutoff: 540000        10times Time:930ms
cutoff: 550000        10times Time:928ms
cutoff: 560000        10times Time:938ms
cutoff: 570000        10times Time:924ms
cutoff: 580000        10times Time:945ms
cutoff: 590000        10times Time:934ms
cutoff: 600000        10times Time:923ms
Average time: 930.0ms

Degree of parallelism: 256
the size of array is: 1000000
cutoff: 510000        10times Time:975ms
cutoff: 520000        10times Time:976ms
cutoff: 530000        10times Time:992ms
cutoff: 540000        10times Time:978ms
cutoff: 550000        10times Time:969ms
cutoff: 560000        10times Time:969ms
cutoff: 570000        10times Time:972ms
cutoff: 580000        10times Time:984ms
cutoff: 590000        10times Time:990ms
cutoff: 600000        10times Time:971ms
Average time: 977.0ms

Degree of parallelism: 512
the size of array is: 1000000
cutoff: 510000        10times Time:974ms
cutoff: 520000        10times Time:967ms
cutoff: 530000        10times Time:967ms
cutoff: 540000        10times Time:950ms
cutoff: 550000        10times Time:921ms
cutoff: 560000        10times Time:924ms
cutoff: 570000        10times Time:925ms
cutoff: 580000        10times Time:933ms
cutoff: 590000        10times Time:941ms
cutoff: 600000        10times Time:927ms
Average time: 942.0ms
```

```
Degree of parallelism: 16
the size of array is: 1000000
cutoff: 510000        10times Time:946ms
cutoff: 520000        10times Time:930ms
cutoff: 530000        10times Time:926ms
cutoff: 540000        10times Time:930ms
cutoff: 550000        10times Time:929ms
cutoff: 560000        10times Time:929ms
cutoff: 570000        10times Time:935ms
cutoff: 580000        10times Time:933ms
cutoff: 590000        10times Time:930ms
cutoff: 600000        10times Time:921ms
Average time: 930.0ms

Degree of parallelism: 32
the size of array is: 1000000
cutoff: 510000        10times Time:930ms
cutoff: 520000        10times Time:938ms
cutoff: 530000        10times Time:928ms
cutoff: 540000        10times Time:929ms
cutoff: 550000        10times Time:915ms
cutoff: 560000        10times Time:924ms
cutoff: 570000        10times Time:940ms
cutoff: 580000        10times Time:926ms
cutoff: 590000        10times Time:917ms
cutoff: 600000        10times Time:932ms
Average time: 927.0ms
```
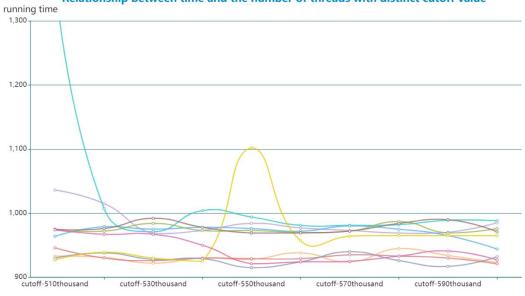
3. Relationship conclusion:

For parallel sort, the value of cutoff is related to the times of recursion, affecting the number of divided partitions, but it seems to be independent of the time of implementation. On the other hand, the time of parallel sort grows gradually quickly with the surge of size of array based on the same value of cutoff showed clearly on the graph1, that is obvious result. Besides, running time will decrease slightly when we try changing the number of threads in powers of 2 according to graph2, but overall, it seems not to affect running time clearly.

4. Evidence to support relationship:

Relationship between time(t) and the number of cutoff in different size of array

Sort Time(ms)

Number of cutoff

-○- size-1million -○- size-2million -○- size-4million -○- size-8million -○- size-16million -○- size-32million

Relationship between time and the number of threads with distinct cutoff value

running time

-○- degree-1 -○- degree-2 -○- degree-4 -○- degree-8 -○- degree-16 -○- degree-32 -○- degree-64 -○- degree-128 -○- degree-256 -○- degree-512