INFO 6205

Program Structures & Algorithms

Fall 2020

Assignment No: 5

- **Task:** To implement a parallel sorting algorithm such that each partition of the array is sorted in parallel. Considering two different schemes for deciding whether to sort in parallel-
  - A cutoff (defaults to, say, 1000) which will update according to the first argument in the command line when running.
  - Recursion depth or the number of available threads. Using this determination, 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).
- Show the results of experiments and draw a conclusion (or more) about the efficacy of this method of parallelizing sort. The experiments should involve sorting arrays of sufficient size for the parallel sort to make a difference. Run with many different array sizes (they must be sufficiently large to make parallel sorting worthwhile) and different cutoff schemes.
- **Output:**

```
Size of Array: 500000
Degree of parallelism: 2
cutoff : 5000            10times Time:1027ms
cutoff : 10000           10times Time:563ms
cutoff : 15000           10times Time:527ms
cutoff : 20000           10times Time:489ms
cutoff : 25000           10times Time:472ms
cutoff : 30000           10times Time:522ms
cutoff : 35000           10times Time:463ms
cutoff : 40000           10times Time:450ms
cutoff : 45000           10times Time:509ms
cutoff : 50000           10times Time:468ms
Degree of parallelism: 4
cutoff : 5000            10times Time:748ms
cutoff :  10000                10times Time:537ms
cutoff :  15000                10times Time:482ms
cutoff :  20000                10times Time:477ms
cutoff :  25000                10times Time:465ms
cutoff :  30000                10times Time:506ms
cutoff :  35000                10times Time:466ms
cutoff :  40000                10times Time:440ms
cutoff :  45000                10times Time:470ms
cutoff :  50000                10times Time:509ms
Degree of parallelism:  8
cutoff :  5000                 10times Time:553ms
cutoff :  10000                10times Time:519ms
cutoff :  15000                10times Time:496ms
cutoff :  20000                10times Time:465ms
cutoff :  25000                10times Time:487ms
cutoff :  30000                10times Time:466ms
cutoff :  35000                10times Time:459ms
cutoff :  40000                10times Time:450ms
cutoff :  45000                10times Time:443ms
cutoff :  50000                10times Time:465ms
Degree of parallelism:  16
cutoff :  5000                 10times Time:517ms
cutoff :  10000                10times Time:495ms
cutoff :  15000                10times Time:480ms
cutoff :  20000                10times Time:458ms
cutoff :  25000                10times Time:461ms
cutoff :  30000                10times Time:473ms
cutoff :  35000                10times Time:438ms
cutoff :  40000                10times Time:456ms
cutoff :  45000                10times Time:472ms
cutoff :  50000                10times Time:446ms
Degree of parallelism:  32
cutoff :  5000                 10times Time:559ms
cutoff :  10000                10times Time:505ms
cutoff :  15000                10times Time:483ms
cutoff :  20000                10times Time:457ms
cutoff :  25000                10times Time:451ms
cutoff :  30000                10times Time:485ms
cutoff :  35000                10times Time:476ms
cutoff :  40000                10times Time:453ms
cutoff :  45000                10times Time:461ms
cutoff :  50000                10times Time:519ms
Degree of parallelism:  64
cutoff :  5000                 10times Time:547ms
cutoff :  10000                10times Time:555ms
cutoff :  15000                10times Time:478ms
cutoff :  20000                10times Time:453ms
cutoff :  25000                10times Time:514ms
cutoff :  30000                10times Time:466ms
cutoff :  35000                10times Time:472ms
cutoff :  40000                 10times Time:465ms
cutoff :  45000                 10times Time:548ms
cutoff :  50000                 10times Time:588ms
```

```
Size of Array: 1000000

Degree of parallelism:  2
cutoff :  5000                  10times Time:1905ms
cutoff :  10000                 10times Time:1096ms
cutoff :  15000                 10times Time:1031ms
cutoff :  20000                 10times Time:985ms
cutoff :  25000                 10times Time:1098ms
cutoff :  30000                 10times Time:959ms
cutoff :  35000                 10times Time:919ms
cutoff :  40000                 10times Time:979ms
cutoff :  45000                 10times Time:936ms
cutoff :  50000                 10times Time:1005ms
Degree of parallelism:  4
cutoff :  5000                  10times Time:1211ms
cutoff :  10000                 10times Time:1137ms
cutoff :  15000                 10times Time:984ms
cutoff :  20000                 10times Time:935ms
cutoff :  25000                 10times Time:922ms
cutoff :  30000                 10times Time:934ms
cutoff :  35000                 10times Time:1033ms
cutoff :  40000                 10times Time:1075ms
cutoff :  45000                 10times Time:934ms
cutoff :  50000                 10times Time:982ms
Degree of parallelism:  8
cutoff :  5000                  10times Time:1052ms
cutoff :  10000                 10times Time:1020ms
cutoff :  15000                 10times Time:1085ms
cutoff :  20000                 10times Time:917ms
cutoff :  25000                 10times Time:936ms
cutoff :  30000                 10times Time:1148ms
cutoff :  35000                 10times Time:965ms
cutoff :  40000                 10times Time:976ms
cutoff :  45000                 10times Time:919ms
cutoff :  50000                 10times Time:1004ms
Degree of parallelism:  16
cutoff :  5000                  10times Time:1094ms
cutoff :  10000                 10times Time:1855ms
cutoff :  15000                 10times Time:1872ms
cutoff :  20000                 10times Time:1041ms
cutoff :  25000                 10times Time:1672ms
cutoff :  30000                 10times Time:1014ms
cutoff :  35000                 10times Time:1904ms
cutoff :  40000                 10times Time:1219ms
cutoff :  45000                 10times Time:1047ms
cutoff :  50000                 10times Time:1135ms
```

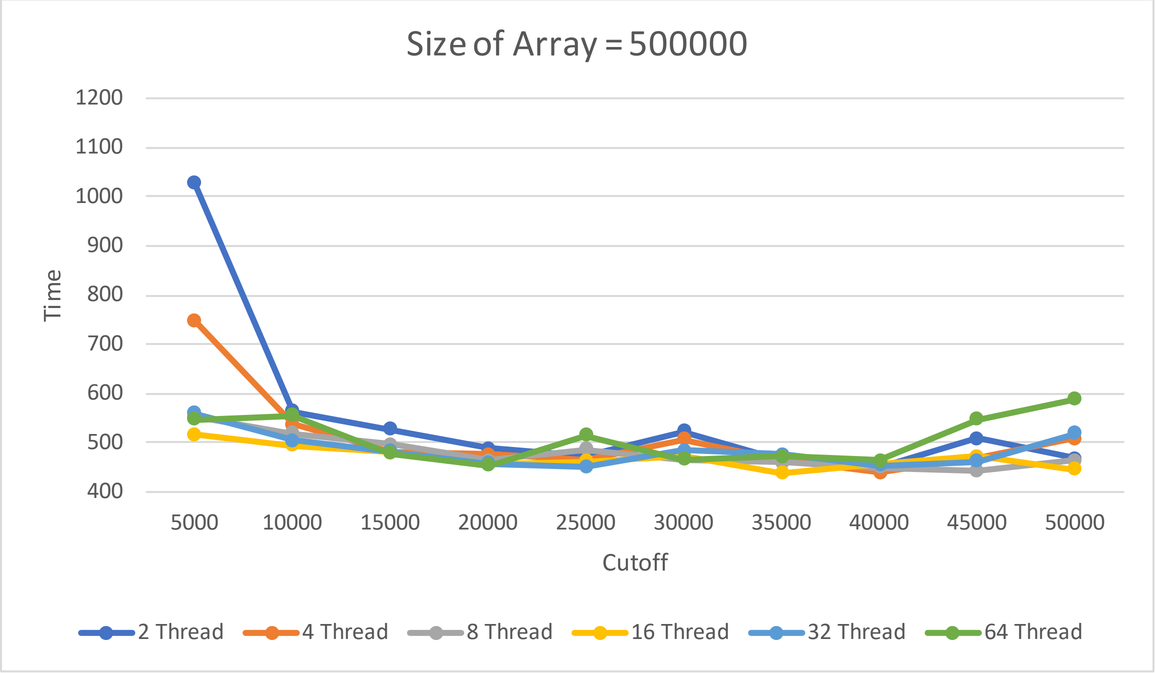
```
Degree of parallelism: 32
cutoff :  5000              10times Time:3475ms
cutoff :  10000             10times Time:1189ms
cutoff :  15000             10times Time:1784ms
cutoff :  20000             10times Time:1059ms
cutoff :  25000             10times Time:1433ms
cutoff :  30000             10times Time:1093ms
cutoff :  35000             10times Time:948ms
cutoff :  40000             10times Time:1011ms
cutoff :  45000             10times Time:1002ms
cutoff :  50000             10times Time:979ms
Degree of parallelism: 64
cutoff :  5000              10times Time:1091ms
cutoff :  10000             10times Time:1193ms
cutoff :  15000             10times Time:1656ms
cutoff :  20000             10times Time:1058ms
cutoff :  25000             10times Time:974ms
cutoff :  30000             10times Time:939ms
cutoff :  35000             10times Time:944ms
cutoff :  40000             10times Time:931ms
cutoff :  45000             10times Time:1007ms
cutoff :  50000             10times Time:1140ms
```

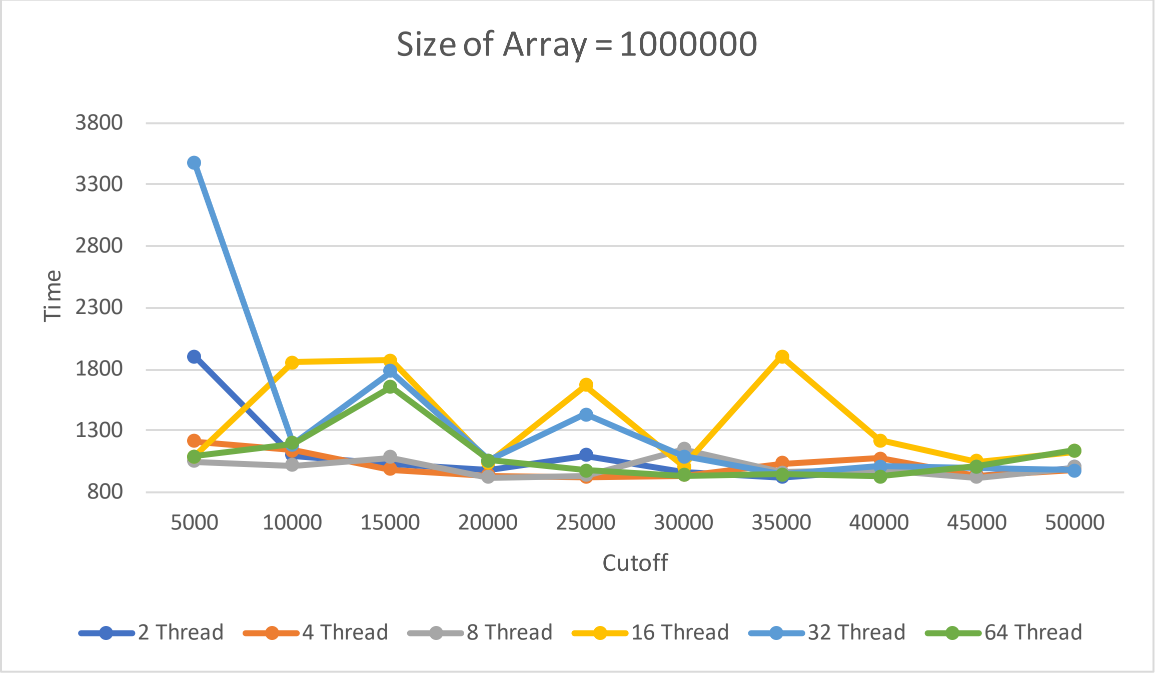
```
Size of Array: 2000000

Degree of parallelism: 2
cutoff :  5000              10times Time:3539ms
cutoff :  10000             10times Time:2121ms
cutoff :  15000             10times Time:1941ms
cutoff :  20000             10times Time:2066ms
cutoff :  25000             10times Time:1880ms
cutoff :  30000             10times Time:1950ms
cutoff :  35000             10times Time:1917ms
cutoff :  40000             10times Time:1856ms
cutoff :  45000             10times Time:1878ms
cutoff :  50000             10times Time:1886ms
Degree of parallelism: 4
cutoff :  5000              10times Time:2203ms
cutoff :  10000             10times Time:1921ms
cutoff :  15000             10times Time:1899ms
cutoff :  20000             10times Time:1925ms
cutoff :  25000             10times Time:1944ms
cutoff :  30000             10times Time:1922ms
cutoff :  35000             10times Time:1884ms
cutoff :  40000             10times Time:1854ms
cutoff :  45000             10times Time:1808ms
cutoff :  50000             10times Time:1894ms
Degree of parallelism: 8
cutoff :  5000              10times Time:2083ms
cutoff :  10000             10times Time:1984ms
cutoff :  15000             10times Time:2173ms
cutoff : 20000              10times Time:1906ms
cutoff : 25000              10times Time:1848ms
cutoff : 30000              10times Time:1873ms
cutoff : 35000              10times Time:1913ms
cutoff : 40000              10times Time:1870ms
cutoff : 45000              10times Time:1884ms
cutoff : 50000              10times Time:1840ms
Degree of parallelism: 16
cutoff : 5000               10times Time:2401ms
cutoff : 10000              10times Time:1926ms
cutoff : 15000              10times Time:1956ms
cutoff : 20000              10times Time:1920ms
cutoff : 25000              10times Time:1905ms
cutoff : 30000              10times Time:1860ms
cutoff : 35000              10times Time:1850ms
cutoff : 40000              10times Time:1892ms
cutoff : 45000              10times Time:1912ms
cutoff : 50000              10times Time:1897ms
Degree of parallelism: 32
cutoff : 5000               10times Time:2152ms
cutoff : 10000              10times Time:1947ms
cutoff : 15000              10times Time:1921ms
cutoff : 20000              10times Time:1897ms
cutoff : 25000              10times Time:1906ms
cutoff : 30000              10times Time:1936ms
cutoff : 35000              10times Time:1866ms
cutoff : 40000              10times Time:1843ms
cutoff : 45000              10times Time:1867ms
cutoff : 50000              10times Time:1891ms
Degree of parallelism: 64
cutoff : 5000               10times Time:2188ms
cutoff : 10000              10times Time:1912ms
cutoff : 15000              10times Time:1949ms
cutoff : 20000              10times Time:1919ms
cutoff : 25000              10times Time:1878ms
cutoff : 30000              10times Time:1891ms
cutoff : 35000              10times Time:1844ms
cutoff : 40000              10times Time:1863ms
cutoff : 45000              10times Time:1883ms
cutoff : 50000              10times Time:1921ms
```

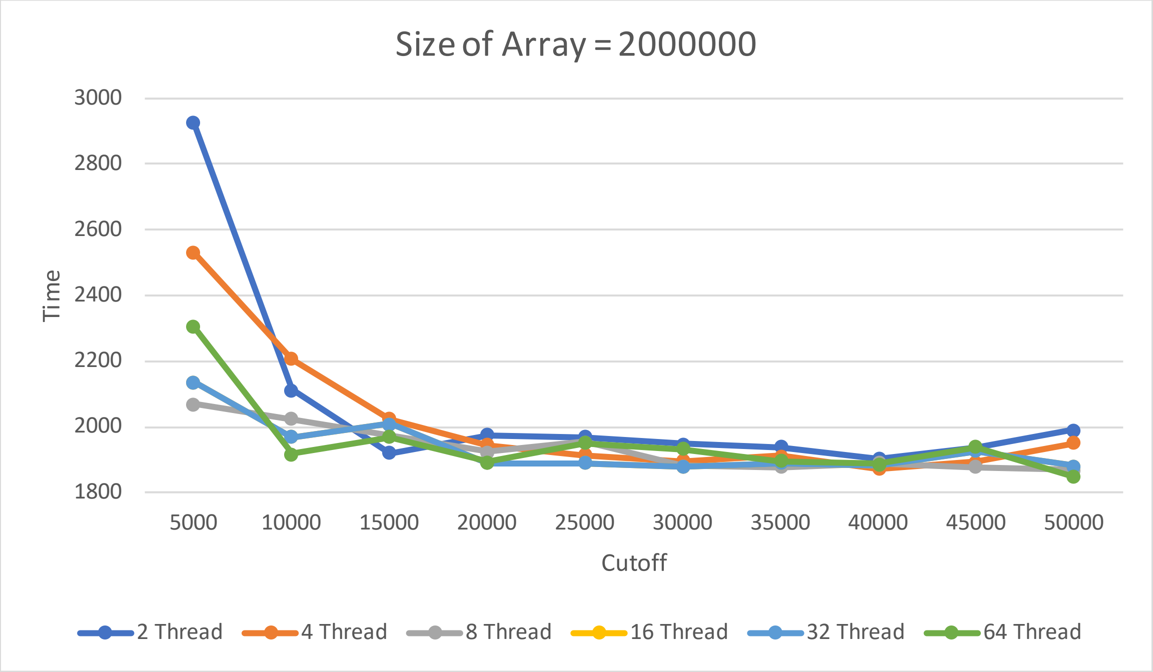
- **Relationship conclusion:** It can be concluded from the results mentioned above and the graphs that-
  - After changing the cutoff value and the number of threads for different size of arrays, the number of thread bigger than 4 does no improvement on the performance. So, keeping 4 threads is the optimal choice.

- Referring to the graph, it can be said that for the cutoff value of 25% of the size of array, the lowest performance time is achieved.
- Thus, with cutoff value as 25% and number of threads as 4 the optimal performance can be observed.

- **Evidence to support relationship:**






Size of Array = 2000000
Time
3000
2800
2600
2400
2200
2000
1800
5000
10000
15000
20000
25000
30000
35000
40000
45000
50000
Cutoff
2 Thread
4 Thread
8 Thread
16 Thread
32 Thread
64 Thread