Assignment No. 4

Task

• 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.

• (Part 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.

• (Part 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).

• (Part 3) Implement the main program to run the following benchmarks: measure the running times of this sort, using four different initial array ordering situations: random, ordered, partially ordered, and reverse ordered.

• Show the results of your experiments and draws a conclusion (or more) about the efficacy of this method of the parallelizing sort.

• 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.

Relationship Conclusion:

The conclusion comes out to be that the optimal choice is four threads as the algorithm's performance does not increase significantly beyond 4.

The cutoff value of 25% of the array size results in the lowest performance

For recursion depth (d) and a number of threads available (t):

$$t = 2^d$$

Maximum depth possible:

$$\lg (\text{array size}/ \text{cutoff})$$

Any depth more significant than the max depth is not feasible as the partitioned

arrays hit the cutoff and turned into a system sort.

Evidence to support the conclusion:

Array Size = 50000

Project ▾

ⓒ ParSort.java ×   ⓒ Main.java ×

Run: ▢ Main ×

```
C:\Users\chand\.jdks\openjdk-17.0.2\bin\java.exe ...
Size of Array: 50000
Degree of parallelism: 2
cutoff: 5000        10times Time:123ms
cutoff: 10000       10times Time:123ms
cutoff: 15000       10times Time:59ms
cutoff: 20000       10times Time:33ms
cutoff: 25000       10times Time:33ms
cutoff: 30000       10times Time:30ms
cutoff: 35000       10times Time:51ms
cutoff: 40000       10times Time:80ms
cutoff: 45000       10times Time:27ms
cutoff: 50000       10times Time:29ms
Degree of parallelism: 4
cutoff: 5000        10times Time:41ms
cutoff: 10000       10times Time:31ms
cutoff: 15000       10times Time:30ms
cutoff: 20000       10times Time:33ms
cutoff: 25000       10times Time:29ms
cutoff: 30000       10times Time:30ms
cutoff: 35000       10times Time:29ms
cutoff: 40000       10times Time:30ms
cutoff: 45000       10times Time:33ms
cutoff: 50000       10times Time:31ms
Degree of parallelism: 8
cutoff: 5000        10times Time:41ms
cutoff: 10000       10times Time:27ms
```

```
cutoff: 15000          10times Time:28ms
cutoff: 20000          10times Time:30ms
cutoff: 25000          10times Time:28ms
cutoff: 30000          10times Time:30ms
cutoff: 35000          10times Time:29ms
cutoff: 40000          10times Time:26ms
cutoff: 45000          10times Time:27ms
cutoff: 50000          10times Time:29ms
Degree of parallelism: 16
cutoff: 5000           10times Time:31ms
cutoff: 10000          10times Time:24ms
cutoff: 15000          10times Time:24ms
cutoff: 20000          10times Time:21ms
cutoff: 25000          10times Time:24ms
cutoff: 30000          10times Time:27ms
cutoff: 35000          10times Time:29ms
cutoff: 40000          10times Time:27ms
cutoff: 45000          10times Time:27ms
cutoff: 50000          10times Time:30ms
Degree of parallelism: 32
cutoff: 5000           10times Time:22ms
cutoff: 10000          10times Time:22ms
cutoff: 15000          10times Time:22ms
cutoff: 20000          10times Time:21ms
cutoff: 25000          10times Time:22ms
cutoff: 30000          10times Time:26ms
cutoff: 35000          10times Time:27ms
```

```
cutoff: 40000        10times Time:29ms
cutoff: 45000        10times Time:27ms
cutoff: 50000        10times Time:25ms
Degree of parallelism: 64
cutoff: 5000         10times Time:29ms
cutoff: 10000        10times Time:21ms
cutoff: 15000        10times Time:23ms
cutoff: 20000        10times Time:21ms
cutoff: 25000        10times Time:22ms
cutoff: 30000        10times Time:27ms
cutoff: 35000        10times Time:28ms
cutoff: 40000        10times Time:28ms
cutoff: 45000        10times Time:30ms
cutoff: 50000        10times Time:29ms


Process finished with exit code 0
```
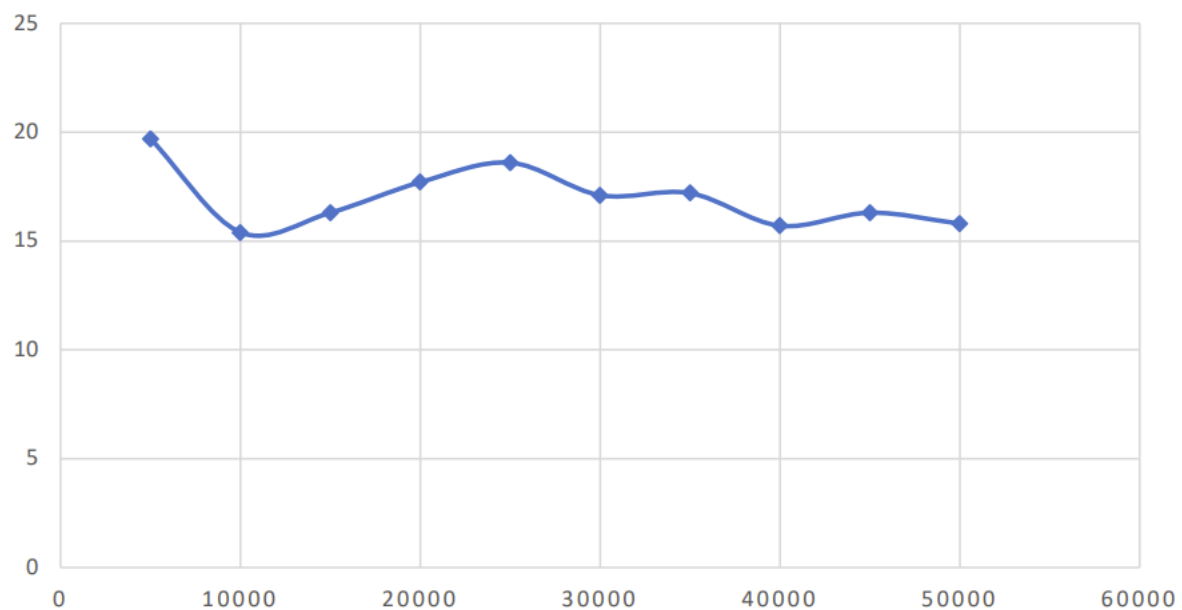
CUTOFF VS RUNTIME (THREAD=16, SIZE=50000)

Array Size = 100000

Project

ParSort.java ×   Main.java ×

Run: Main ×

```
C:\Users\chand\.jdks\openjdk-17.0.2\bin\java.exe ...
Size of Array: 100000
Degree of parallelism: 2
cutoff: 5000        10times Time:185ms
cutoff: 10000       10times Time:117ms
cutoff: 15000       10times Time:61ms
cutoff: 20000       10times Time:69ms
cutoff: 25000       10times Time:86ms
cutoff: 30000       10times Time:66ms
cutoff: 35000       10times Time:71ms
cutoff: 40000       10times Time:69ms
cutoff: 45000       10times Time:120ms
cutoff: 50000       10times Time:56ms
Degree of parallelism: 4
cutoff: 5000        10times Time:76ms
cutoff: 10000       10times Time:49ms
cutoff: 15000       10times Time:50ms
cutoff: 20000       10times Time:48ms
cutoff: 25000       10times Time:45ms
cutoff: 30000       10times Time:43ms
cutoff: 35000       10times Time:67ms
cutoff: 40000       10times Time:44ms
cutoff: 45000       10times Time:40ms
cutoff: 50000       10times Time:41ms
Degree of parallelism: 8
cutoff: 5000        10times Time:68ms
cutoff: 10000       10times Time:45ms
```

```
cutoff: 15000        10times Time:41ms
cutoff: 20000        10times Time:36ms
cutoff: 25000        10times Time:43ms
cutoff: 30000        10times Time:46ms
cutoff: 35000        10times Time:48ms
cutoff: 40000        10times Time:45ms
cutoff: 45000        10times Time:43ms
cutoff: 50000        10times Time:41ms
Degree of parallelism: 16
cutoff: 5000         10times Time:56ms
cutoff: 10000        10times Time:42ms
cutoff: 15000        10times Time:43ms
cutoff: 20000        10times Time:42ms
cutoff: 25000        10times Time:41ms
cutoff: 30000        10times Time:41ms
cutoff: 35000        10times Time:42ms
cutoff: 40000        10times Time:42ms
cutoff: 45000        10times Time:42ms
cutoff: 50000        10times Time:42ms
Degree of parallelism: 32
cutoff: 5000         10times Time:41ms
cutoff: 10000        10times Time:41ms
cutoff: 15000        10times Time:38ms
cutoff: 20000        10times Time:39ms
cutoff: 25000        10times Time:38ms
cutoff: 30000        10times Time:40ms
cutoff: 35000        10times Time:41ms
```
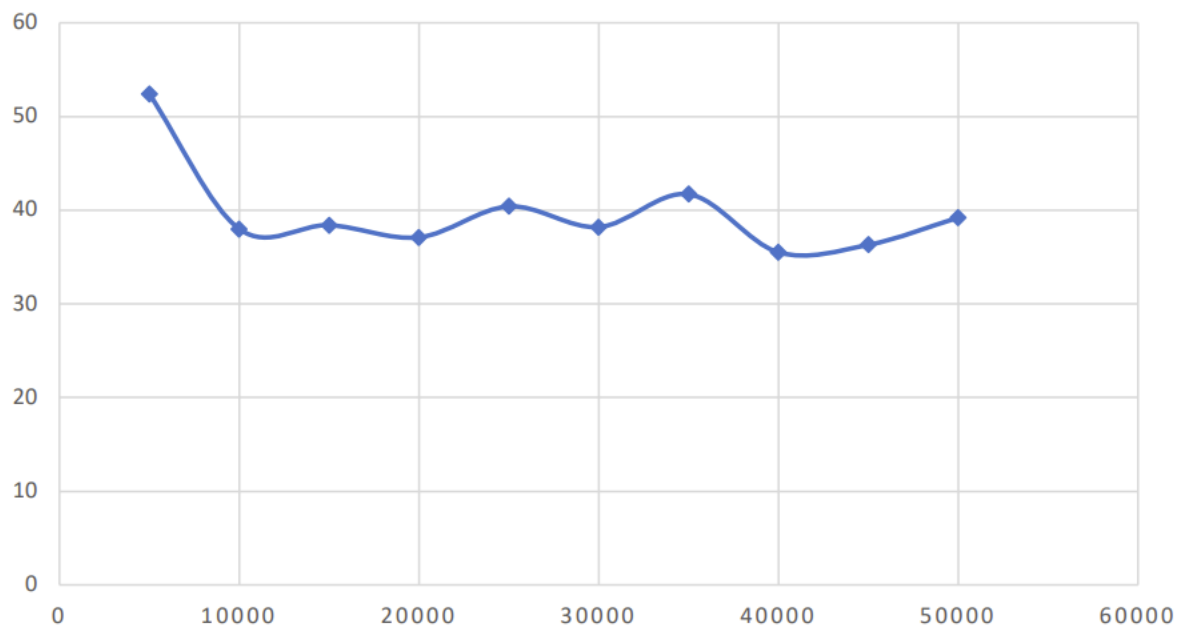
```
cutoff: 40000        10times Time:45ms
cutoff: 45000        10times Time:45ms
cutoff: 50000        10times Time:42ms
Degree of parallelism: 64
cutoff: 5000         10times Time:51ms
cutoff: 10000        10times Time:46ms
cutoff: 15000        10times Time:44ms
cutoff: 20000        10times Time:45ms
cutoff: 25000        10times Time:45ms
cutoff: 30000        10times Time:47ms
cutoff: 35000        10times Time:45ms
cutoff: 40000        10times Time:44ms
cutoff: 45000        10times Time:49ms
cutoff: 50000        10times Time:42ms


Process finished with exit code 0
```

Structure

Bookmarks

CUTOFF VS RUNTIME (THREAD=16, SIZE=100000)

Array Size = 200000

Project ▼

ParSort.java ×   Main.java ×

QuickSort_3way

ForkJoinPool

Run: Main ×

```
C:\Users\chand\.jdks\openjdk-17.0.2\bin\java.exe ...
Size of Array: 200000
Degree of parallelism: 2
    cutoff: 5000        10times Time:330ms
    cutoff: 10000       10times Time:177ms
    cutoff: 15000       10times Time:106ms
    cutoff: 20000       10times Time:160ms
    cutoff: 25000       10times Time:99ms
    cutoff: 30000       10times Time:115ms
    cutoff: 35000       10times Time:120ms
    cutoff: 40000       10times Time:104ms
    cutoff: 45000       10times Time:104ms
    cutoff: 50000       10times Time:101ms
    Degree of parallelism: 4
    cutoff: 5000        10times Time:108ms
    cutoff: 10000       10times Time:78ms
    cutoff: 15000       10times Time:86ms
    cutoff: 20000       10times Time:80ms
    cutoff: 25000       10times Time:80ms
    cutoff: 30000       10times Time:89ms
    cutoff: 35000       10times Time:83ms
    cutoff: 40000       10times Time:83ms
    cutoff: 45000       10times Time:86ms
    cutoff: 50000       10times Time:83ms
    Degree of parallelism: 8
    cutoff: 5000        10times Time:101ms
```

```
cutoff: 10000        10times Time:74ms
     off: 15000       10times Time:78ms
     off: 20000       10times Time:75ms
cutoff: 25000        10times Time:77ms
cutoff: 30000        10times Time:73ms
cutoff: 35000        10times Time:72ms
cutoff: 40000        10times Time:73ms
cutoff: 45000        10times Time:74ms
cutoff: 50000        10times Time:69ms
Degree of parallelism: 16
cutoff: 5000         10times Time:101ms
cutoff: 10000        10times Time:71ms
cutoff: 15000        10times Time:76ms
cutoff: 20000        10times Time:74ms
cutoff: 25000        10times Time:76ms
cutoff: 30000        10times Time:55ms
cutoff: 35000        10times Time:80ms
cutoff: 40000        10times Time:63ms
cutoff: 45000        10times Time:76ms
cutoff: 50000        10times Time:50ms
Degree of parallelism: 32
cutoff: 5000         10times Time:173ms
cutoff: 10000        10times Time:93ms
cutoff: 15000        10times Time:80ms
cutoff: 20000        10times Time:69ms
cutoff: 25000        10times Time:64ms
```

```
    cutoff: 30000        10times Time:96ms
    cutoff: 35000        10times Time:90ms
    cutoff: 40000        10times Time:81ms
    cutoff: 45000        10times Time:76ms
    cutoff: 50000        10times Time:82ms
    Degree of parallelism: 64
    cutoff: 5000         10times Time:127ms
    cutoff: 10000        10times Time:78ms
    cutoff: 15000        10times Time:79ms
    cutoff: 20000        10times Time:70ms
    cutoff: 25000        10times Time:64ms
    cutoff: 30000        10times Time:79ms
    cutoff: 35000        10times Time:72ms
    cutoff: 40000        10times Time:78ms
    cutoff: 45000        10times Time:72ms
    cutoff: 50000        10times Time:71ms


    Process finished with exit code 0
```

CUTOFF VS RUNTIME (THREAD=16, SIZE=200000)