PSA Parallel Sorting Assignment

Name: Puram Anil Reddy
NUID:002929575

Task:

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:

```
Run:    Main ×

    /Users/ap/Library/Java/JavaVirtualMachines/openjdk-17.0.2/Contents/Home/bin
    Size of Array:40000

    Degree of parallelism: 2
    cutoff: 6000          10times Time:64ms
    cutoff: 12000         10times Time:33ms
    cutoff: 18000         10times Time:17ms
    cutoff: 24000         10times Time:15ms
    cutoff: 30000         10times Time:14ms
    cutoff: 36000         10times Time:28ms
    cutoff: 42000         10times Time:24ms
    cutoff: 48000         10times Time:21ms
    cutoff: 54000         10times Time:20ms
    cutoff: 60000         10times Time:20ms

    Degree of parallelism: 4
    cutoff: 6000          10times Time:23ms
    cutoff: 12000         10times Time:14ms
    cutoff: 18000         10times Time:13ms
    cutoff: 24000         10times Time:13ms
    cutoff: 30000         10times Time:14ms
    cutoff: 36000         10times Time:15ms
    cutoff: 42000         10times Time:18ms
    cutoff: 48000         10times Time:19ms
    cutoff: 54000         10times Time:19ms
    cutoff: 60000         10times Time:22ms
```

```
Degree of parallelism: 8
cutoff: 6000        10times Time:14ms
cutoff: 12000       10times Time:12ms
cutoff: 18000       10times Time:12ms
cutoff: 24000       10times Time:13ms
cutoff: 30000       10times Time:13ms
cutoff: 36000       10times Time:13ms
cutoff: 42000       10times Time:19ms
cutoff: 48000       10times Time:18ms
cutoff: 54000       10times Time:19ms
cutoff: 60000       10times Time:19ms

Degree of parallelism: 16
cutoff: 6000        10times Time:11ms
cutoff: 12000       10times Time:11ms
cutoff: 18000       10times Time:11ms
cutoff: 24000       10times Time:13ms
cutoff: 30000       10times Time:13ms
cutoff: 36000       10times Time:13ms
cutoff: 42000       10times Time:19ms
cutoff: 48000       10times Time:19ms
cutoff: 54000       10times Time:18ms
cutoff: 60000       10times Time:18ms

Degree of parallelism: 32
cutoff: 6000        10times Time:11ms
cutoff: 12000       10times Time:11ms
cutoff: 18000       10times Time:10ms
cutoff: 24000       10times Time:13ms
cutoff: 30000       10times Time:13ms
cutoff: 36000       10times Time:13ms
cutoff: 42000       10times Time:19ms
cutoff: 48000       10times Time:18ms
cutoff: 54000       10times Time:18ms
cutoff: 60000       10times Time:19ms
```

```
cutoff: 60000          10times Time:18ms


Degree of parallelism: 32
cutoff: 6000           10times Time:11ms
cutoff: 12000          10times Time:11ms
cutoff: 18000          10times Time:10ms
cutoff: 24000          10times Time:13ms
cutoff: 30000          10times Time:13ms
cutoff: 36000          10times Time:13ms
cutoff: 42000          10times Time:19ms
cutoff: 48000          10times Time:18ms
cutoff: 54000          10times Time:18ms
cutoff: 60000          10times Time:19ms


Degree of parallelism: 64
cutoff: 6000           10times Time:13ms
cutoff: 12000          10times Time:11ms
cutoff: 18000          10times Time:11ms
cutoff: 24000          10times Time:13ms
cutoff: 30000          10times Time:13ms
cutoff: 36000          10times Time:13ms
cutoff: 42000          10times Time:18ms
cutoff: 48000          10times Time:19ms
cutoff: 54000          10times Time:19ms
cutoff: 60000          10times Time:19ms


Process finished with exit code 0
```

Git   ▶ Run   ☰ TODO   ⊗ Problems   ⅀ Terminal   ⚒ Build   ≫ Dependencies

Build completed successfully in 831 ms (moments ago)

```
Size of Array:90000

Degree of parallelism: 2
cutoff: 6000         10times Time:100ms
cutoff: 12000        10times Time:46ms
cutoff: 18000        10times Time:35ms
cutoff: 24000        10times Time:35ms
cutoff: 30000        10times Time:37ms
cutoff: 36000        10times Time:46ms
cutoff: 42000        10times Time:36ms
cutoff: 48000        10times Time:32ms
cutoff: 54000        10times Time:35ms
cutoff: 60000        10times Time:30ms

Degree of parallelism: 4
cutoff: 6000         10times Time:36ms
cutoff: 12000        10times Time:27ms
cutoff: 18000        10times Time:27ms
cutoff: 24000        10times Time:32ms
cutoff: 30000        10times Time:24ms
cutoff: 36000        10times Time:25ms
cutoff: 42000        10times Time:25ms
cutoff: 48000        10times Time:31ms
cutoff: 54000        10times Time:31ms
cutoff: 60000        10times Time:32ms
```

▶ Run   ≡ TODO   ⊘ Problems   ⊵ Terminal   ⚒ Build   ⬙ Dependencies

```
Degree of parallelism: 8
cutoff: 6000        10times Time:34ms
cutoff: 12000       10times Time:25ms
cutoff: 18000       10times Time:25ms
cutoff: 24000       10times Time:25ms
cutoff: 30000       10times Time:27ms
cutoff: 36000       10times Time:28ms
cutoff: 42000       10times Time:26ms
cutoff: 48000       10times Time:32ms
cutoff: 54000       10times Time:31ms
cutoff: 60000       10times Time:32ms

Degree of parallelism: 16
cutoff: 6000        10times Time:29ms
cutoff: 12000       10times Time:24ms
cutoff: 18000       10times Time:25ms
cutoff: 24000       10times Time:29ms
cutoff: 30000       10times Time:29ms
cutoff: 36000       10times Time:25ms
cutoff: 42000       10times Time:25ms
cutoff: 48000       10times Time:32ms
cutoff: 54000       10times Time:31ms
cutoff: 60000       10times Time:32ms

Degree of parallelism: 32
cutoff: 6000        10times Time:26ms
cutoff: 12000       10times Time:25ms
```

```
Degree of parallelism: 32
cutoff: 6000          10times Time:26ms
cutoff: 12000         10times Time:25ms
cutoff: 18000         10times Time:26ms
cutoff: 24000         10times Time:25ms
cutoff: 30000         10times Time:25ms
cutoff: 36000         10times Time:25ms
cutoff: 42000         10times Time:24ms
cutoff: 48000         10times Time:32ms
cutoff: 54000         10times Time:30ms
cutoff: 60000         10times Time:32ms

Degree of parallelism: 64
cutoff: 6000          10times Time:27ms
cutoff: 12000         10times Time:24ms
cutoff: 18000         10times Time:26ms
cutoff: 24000         10times Time:24ms
cutoff: 30000         10times Time:25ms
cutoff: 36000         10times Time:24ms
cutoff: 42000         10times Time:24ms
cutoff: 48000         10times Time:31ms
cutoff: 54000         10times Time:33ms
cutoff: 60000         10times Time:32ms


Process finished with exit code 0
```

Git   ▶ Run   ☰ TODO   ❶ Problems   ❯ Terminal   ⚒ Build   ❧ Dependencies

Build completed successfully in 691 ms (a minute ago)

```
Size of Array:150000

Degree of parallelism: 2
cutoff: 6000         10times Time:156ms
cutoff: 12000        10times Time:65ms
cutoff: 18000        10times Time:55ms
cutoff: 24000        10times Time:77ms
cutoff: 30000        10times Time:60ms
cutoff: 36000        10times Time:49ms
cutoff: 42000        10times Time:54ms
cutoff: 48000        10times Time:54ms
cutoff: 54000        10times Time:54ms
cutoff: 60000        10times Time:54ms

Degree of parallelism: 4
cutoff: 6000         10times Time:54ms
cutoff: 12000        10times Time:43ms
cutoff: 18000        10times Time:44ms
cutoff: 24000        10times Time:43ms
cutoff: 30000        10times Time:44ms
cutoff: 36000        10times Time:44ms
cutoff: 42000        10times Time:41ms
cutoff: 48000        10times Time:40ms
cutoff: 54000        10times Time:41ms
cutoff: 60000        10times Time:42ms
```

```
Degree of parallelism: 8
cutoff: 6000        10times Time:50ms
cutoff: 12000       10times Time:40ms
cutoff: 18000       10times Time:38ms
cutoff: 24000       10times Time:39ms
cutoff: 30000       10times Time:41ms
cutoff: 36000       10times Time:40ms
cutoff: 42000       10times Time:42ms
cutoff: 48000       10times Time:45ms
cutoff: 54000       10times Time:46ms
cutoff: 60000       10times Time:41ms

Degree of parallelism: 16
cutoff: 6000        10times Time:50ms
cutoff: 12000       10times Time:39ms
cutoff: 18000       10times Time:39ms
cutoff: 24000       10times Time:40ms
cutoff: 30000       10times Time:38ms
cutoff: 36000       10times Time:40ms
cutoff: 42000       10times Time:41ms
cutoff: 48000       10times Time:41ms
cutoff: 54000       10times Time:40ms
cutoff: 60000       10times Time:40ms

Degree of parallelism: 32
cutoff: 6000        10times Time:44ms
cutoff: 12000       10times Time:46ms
cutoff: 18000       10times Time:40ms
```

Git   ▶ Run   ≔ TODO   ❶ Problems   ⏽ Terminal   ⚒ Build   ⬙ Dependencies

Build completed successfully in 657 ms (moments ago)

```
Degree of parallelism: 32
cutoff: 6000          10times Time:44ms
cutoff: 12000         10times Time:46ms
cutoff: 18000         10times Time:40ms
cutoff: 24000         10times Time:38ms
cutoff: 30000         10times Time:39ms
cutoff: 36000         10times Time:39ms
cutoff: 42000         10times Time:41ms
cutoff: 48000         10times Time:41ms
cutoff: 54000         10times Time:40ms
cutoff: 60000         10times Time:40ms

Degree of parallelism: 64
cutoff: 6000          10times Time:43ms
cutoff: 12000         10times Time:39ms
cutoff: 18000         10times Time:40ms
cutoff: 24000         10times Time:41ms
cutoff: 30000         10times Time:39ms
cutoff: 36000         10times Time:39ms
cutoff: 42000         10times Time:41ms
cutoff: 48000         10times Time:41ms
cutoff: 54000         10times Time:41ms
cutoff: 60000         10times Time:40ms

Process finished with exit code 0
```

Git   ▶ Run   ≣ TODO   ❶ Problems   ⊵ Terminal   ⚒ Build   ⬙ Dependencies

Array Size : 150000

Cutoff	2	4	8	16	32	64
6000	438	129	181	236	346	315
12000	155	111	136	146	155	73
18000	218	123	101	66	70	54
24000	166	124	109	67	66	53
30000	157	113	82	58	67	61
36000	121	105	81	60	62	69
42000	173	107	82	61	62	64
48000	169	106	81	59	63	65
54000	99	70	70	66	67	75
60000	98	69	66	66	68	73

Array size : 90000

Cutoff	2	4	8	16	32	64
6000	307	93	53	102	143	47
12000	106	80	56	39	33	36
18000	126	64	33	30	29	29
24000	112	65	31	33	29	27
30000	46	40	30	37	32	31
36000	47	34	31	40	33	31
42000	52	34	35	37	31	34
48000	47	30			31	39
54000	42	41	42	42	42	91
60000	45	41	41	43	44	45

Merge & Center

Array size : 40000

Cutoff	2	4	8	16	32	64
6000	191	52	32	50	20	18
12000	79	42	20	17	14	15
18000	90	23	16	16	15	15
24000	63	28	16	18	16	20
30000	23	27	22	21	20	24
36000	87	25	23	21	22	25
42000	59	29	26	23	23	27
48000	47	25	26	24	26	26
54000	53	35	38	35	39	36
60000	38	32	62	34	35	32

Conclusion:

After running simulations of experiments with different combinations of the cutoff values, threads, and array sizes. Four threads are optimal beyond that there won't be much improvement
If the cutoff value is 25% of the array size,the least run time is achieved
For recursion depth (d) and number of threads available (t):
t = 2 power d
Maximum depth possible:
lg ($array\ size\ /cutoff$)
Any depth greater than the maximum depth is not possible because the partitioned arrays hit the cutoff and became a system sort.