

Program Structures & Algorithms

Assignment : 04

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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 cut off that you will adjust based on the first input in the command line when running (the default is, say, 1000). Your task is to experiment and select a suitable value for this cutoff. Use the system sort instead if there are fewer elements to sort than the cutoff.
- Recursion depth or the number of accessible threads (Part 2). Using the results of this analysis, you may choose the ideal number (t) of distinct threads (remember to stay to powers of 2) and make arrangements for that number of partitions to be parallelized (by preventing recursion after the depth of $\lg t$ is reached).
- • (Part 3) Create a primary application that will execute the aforementioned benchmarks and track their execution times. Show the results of your experiments and draw a conclusion (or more) about the efficacy of this method of 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:

After running various experiments with different combinations of the cutoff values, threads and array sizes. From the below provided observations of the runtimes

Conclusion: Four threads is the recommended number, and adding more threads won't significantly improve algorithm performance.

When the cutoff value is 25% of the array size, the lowest runtime is achieved.

For recursion depth (d) and number of threads available (t): $t = 2^d$

Maximum depth possible:

$$\lg \left(\frac{\text{arraysize}}{\text{Cutoff}} \right)$$

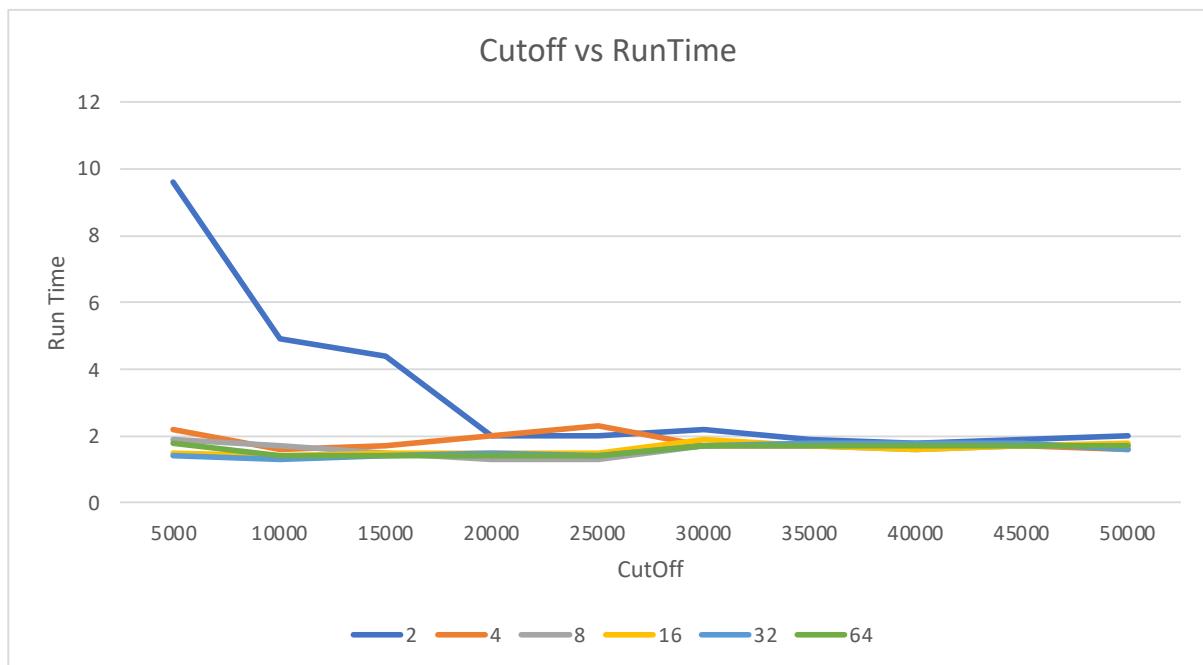
Any depth more than the maximum depth is not possible since the partitioned arrays reached the cutoff and transformed into a system sort.

Evidence to the Conclusion :

Below are values obtained in “ms” for various array size combinations, threads and cutoffs.

Array Size = 50000 :

Cutoff	Thread					
	2	4	8	16	32	64
5000	9.6	2.2	1.9	1.5	1.4	1.8
10000	4.9	1.6	1.7	1.4	1.3	1.4
15000	4.4	1.7	1.5	1.5	1.4	1.4
20000	2	2	1.3	1.5	1.5	1.4
25000	2	2.3	1.3	1.5	1.4	1.4
30000	2.2	1.7	1.7	1.9	1.7	1.7
35000	1.9	1.7	1.7	1.7	1.8	1.7
40000	1.8	1.7	1.6	1.6	1.8	1.7
45000	1.9	1.7	1.7	1.7	1.8	1.7
50000	2	1.6	1.7	1.8	1.6	1.7



Output Screenshots:

Sat 18 Feb 10:08 PM

Programs - INFO6205-PSA-Assessments/src/main/java/edu/neu/coe/info6205/sort/par/Main.java - Eclipse IDE

Project Explorer

Main.java ParSort.java

```
1 package edu.neu.coe.info6205.sort.par;
2
3 import java.io.BufferedReader;
```

Problems Javadoc Declaration Search Console

<terminated> Main (1) [Java Application] /Library/Java/JavaVirtualMachines/jdk-18.0.2.1.jdk/Contents/Home/bin/java (18-Feb-2023, 9:59:55 pm - 9:59:58 pm) [pid: 27813]

Size of Array: 50000

Degree of parallelism: 2

cutoff	10times Time
5000	96ms
10000	10ms
15000	4ms
20000	20ms
25000	20ms
30000	22ms
35000	19ms
40000	18ms
45000	19ms
50000	20ms

Degree of parallelism: 4

cutoff	10times Time
5000	22ms
10000	16ms
15000	17ms
20000	20ms
25000	23ms
30000	17ms
35000	17ms
40000	17ms
45000	17ms
50000	16ms

Degree of parallelism: 8

cutoff	10times Time
5000	19ms
10000	17ms
15000	15ms
20000	13ms
25000	13ms
30000	17ms
35000	17ms
40000	16ms
45000	17ms
50000	17ms

Degree of parallelism: 16

cutoff	10times Time
5000	15ms
10000	14ms
15000	15ms
20000	15ms
25000	15ms
30000	19ms
35000	17ms
40000	16ms
45000	17ms
50000	18ms

Degree of parallelism: 32

cutoff	10times Time
5000	14ms
10000	13ms
15000	14ms
20000	15ms
25000	14ms
30000	17ms
35000	18ms
40000	18ms
45000	18ms
50000	16ms

Degree of parallelism: 64

cutoff	10times Time
5000	18ms
10000	14ms
15000	14ms
20000	14ms
25000	14ms
30000	17ms
35000	17ms
40000	17ms
45000	17ms
50000	17ms

Writable Smart Insert 32 : 10 : 1035

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Programs - INFO6205-PSA-Assessments/src/main/java/edu/neu/coe/info6205/sort/par/Main.java - Eclipse IDE

Project Explorer

Main.java ParSort.java

```
1 package edu.neu.coe.info6205.sort.par;
2
3 import java.io.BufferedReader;
```

Problems Javadoc Declaration Search Console

<terminated> Main (1) [Java Application] /Library/Java/JavaVirtualMachines/jdk-18.0.2.1.jdk/Contents/Home/bin/java (18-Feb-2023, 9:59:55 pm - 9:59:58 pm) [pid: 27813]

Size of Array: 50000

Degree of parallelism: 2

cutoff	10times Time
5000	96ms
10000	10ms
15000	4ms
20000	20ms
25000	20ms
30000	22ms
35000	19ms
40000	18ms
45000	19ms
50000	20ms

Degree of parallelism: 4

cutoff	10times Time
5000	22ms
10000	16ms
15000	17ms
20000	20ms
25000	23ms
30000	17ms
35000	17ms
40000	17ms
45000	17ms
50000	16ms

Degree of parallelism: 8

cutoff	10times Time
5000	19ms
10000	17ms
15000	15ms
20000	13ms
25000	13ms
30000	17ms
35000	17ms
40000	16ms
45000	17ms
50000	17ms

Degree of parallelism: 16

cutoff	10times Time
5000	15ms
10000	14ms
15000	15ms
20000	15ms
25000	15ms
30000	19ms
35000	17ms
40000	16ms
45000	17ms
50000	18ms

Degree of parallelism: 32

cutoff	10times Time
5000	14ms
10000	13ms
15000	14ms
20000	15ms
25000	14ms
30000	17ms
35000	18ms
40000	18ms
45000	18ms
50000	16ms

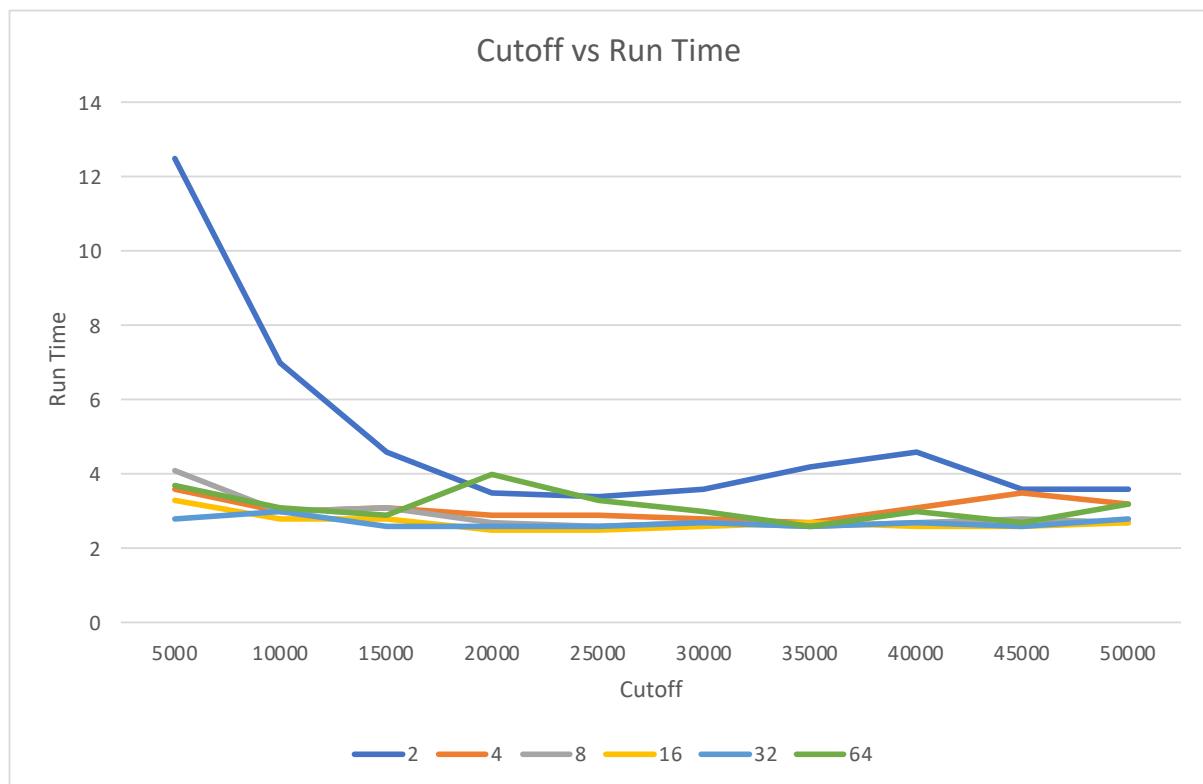
Degree of parallelism: 64

cutoff	10times Time
5000	18ms
10000	14ms
15000	14ms
20000	14ms
25000	14ms
30000	17ms
35000	17ms
40000	17ms
45000	17ms
50000	17ms

Writable Smart Insert 32 : 10 : 1035

Array Size = 100000 :

Cutoff	Thread					
	2	4	8	16	32	64
5000	12.5	3.6	4.1	3.3	2.8	3.7
10000	7	3	3	2.8	3	3.1
15000	4.6	3.1	3.1	2.8	2.6	2.9
20000	3.5	2.9	2.7	2.5	2.6	4
25000	3.4	2.9	2.6	2.5	2.6	3.3
30000	3.6	2.8	2.7	2.6	2.7	3
35000	4.2	2.7	2.6	2.7	2.6	2.6
40000	4.6	3.1	2.7	2.6	2.7	3
45000	3.6	3.5	2.8	2.6	2.6	2.7
50000	3.6	3.2	2.7	2.7	2.8	3.2



Output Screenshots:

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Programs - INFO6205-PSA-Assignments/src/main/java/edu/neu/coe/info6205/sort/par/Main.java - Eclipse IDE

Project Explorer X Main.java ParSort.java

```
1 package edu.neu.coe.info6205.sort.par;
2
3 import java.io.BufferedReader;
4
5 /**
6 * This code has been fleshed out by Zivao Qiao. Thanks very much.
7 */
8
9
10 public class Main {
11     public static void main(String[] args) {
12         int[] array = new int[100000];
13
14         // Initialize array with some values
15         for (int i = 0; i < array.length; i++) {
16             array[i] = (int) (Math.random() * 100000);
17         }
18
19         long startTime = System.currentTimeMillis();
20
21         // Call sort function
22         ParSort.sort(array);
23
24         long endTime = System.currentTimeMillis();
25
26         System.out.println("Time taken: " + (endTime - startTime));
27     }
28 }
```

Problems Declaration Search Console

<terminated> Main (11) [Java Application] /Library/Java/JavaVirtualMachines/jdk-18.0.2.1.jdk/Contents/Home/bin/java (18-Feb-2023, 10:11:56 pm - 10:11:59 pm) [pid: 35114]

Size of Array: 100000

Degree of parallelism: 2

cutoff:	10times Time:
5000	125ms
10000	70ms
15000	46ms
20000	35ms
25000	34ms
30000	36ms
35000	42ms
40000	46ms
45000	36ms
50000	36ms

Degree of parallelism: 4

cutoff:	10times Time:
5000	36ms
10000	30ms
15000	31ms
20000	29ms
25000	29ms
30000	28ms
35000	27ms
40000	31ms
45000	35ms
50000	32ms

Degree of parallelism: 8

cutoff:	10times Time:
5000	41ms
10000	30ms
15000	31ms
20000	27ms
25000	26ms
30000	27ms
35000	26ms
40000	27ms
45000	28ms
50000	27ms

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Programs - INFO6205-PSA-Assignments/src/main/java/edu/neu/coe/info6205/sort/par/Main.java - Eclipse IDE

Project Explorer X Main.java ParSort.java

```
1 package edu.neu.coe.info6205.sort.par;
2
3 import java.io.BufferedReader;
4
5 /**
6 * This code has been fleshed out by Zivao Qiao. Thanks very much.
7 */
8
9
10 public class Main {
11     public static void main(String[] args) {
12         int[] array = new int[100000];
13
14         // Initialize array with some values
15         for (int i = 0; i < array.length; i++) {
16             array[i] = (int) (Math.random() * 100000);
17         }
18
19         long startTime = System.currentTimeMillis();
20
21         // Call sort function
22         ParSort.sort(array);
23
24         long endTime = System.currentTimeMillis();
25
26         System.out.println("Time taken: " + (endTime - startTime));
27     }
28 }
```

Problems Declaration Search Console

<terminated> Main (11) [Java Application] /Library/Java/JavaVirtualMachines/jdk-18.0.2.1.jdk/Contents/Home/bin/java (18-Feb-2023, 10:11:56 pm - 10:11:59 pm) [pid: 35114]

Size of Array: 100000

Degree of parallelism: 16

cutoff:	10times Time:
5000	33ms
10000	28ms
15000	28ms
20000	25ms
25000	25ms
30000	26ms
35000	27ms
40000	26ms
45000	26ms
50000	27ms

Degree of parallelism: 32

cutoff:	10times Time:
5000	28ms
10000	30ms
15000	26ms
20000	26ms
25000	26ms
30000	27ms
35000	26ms
40000	27ms
45000	26ms
50000	28ms

Degree of parallelism: 64

cutoff:	10times Time:
5000	37ms
10000	31ms
15000	29ms
20000	40ms
25000	33ms
30000	30ms
35000	26ms
40000	30ms
45000	27ms
50000	32ms

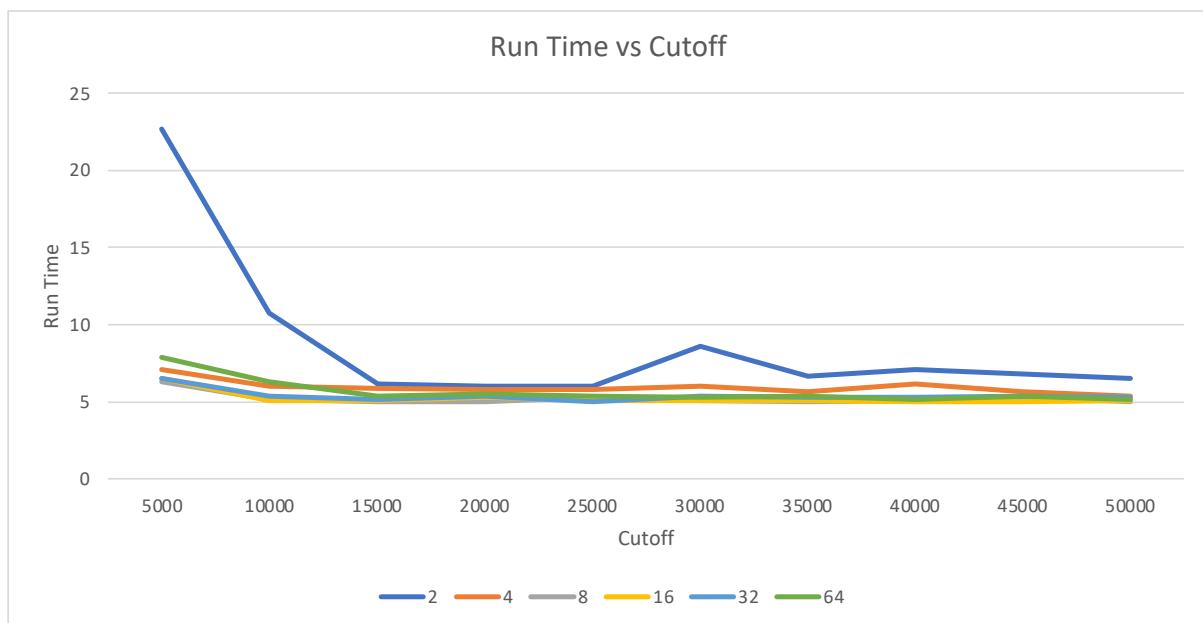
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Array size = 200000 :

Cutoff	Thread					
	2	4	8	16	32	64
5000	22.7	7.1	6.3	6.5	6.5	7.9
10000	10.8	6	5.2	5.1	5.4	6.3
15000	6.2	5.9	5	5.1	5.2	5.4
20000	6	5.8	5	5.3	5.4	5.5
25000	6	5.8	5.3	5.1	5	5.4
30000	8.6	6	5.1	5.1	5.4	5.3
35000	6.7	5.7	5	5.1	5.3	5.4
40000	7.1	6.2	5.1	5	5.3	5.2
45000	6.8	5.7	5.3	5	5.4	5.4
50000	6.5	5.4	5	5.1	5.3	5.2



Output Screenshot :

Eclipse File Edit Source Refactor Navigate Search Project Run Window Help

Programs - INFO6205-PSA-Assignments/src/main/java/edu/neu/coe/info6205/sort/par/Main.java - Eclipse IDE

Project Explorer X Main.java ParSort.java

```
> edu.neu.coe.info6205.equable
> edu.neu.coe.info6205.functions
> edu.neu.coe.info6205.graphs.BFS_and_prims
> edu.neu.coe.info6205.graphs.dag
> edu.neu.coe.info6205.graphs.Dijkstra
> edu.neu.coe.info6205.graphs.generic_BFS_and_prims
> edu.neu.coe.info6205.graphs.gis
> edu.neu.coe.info6205.graphs.tunnels
> edu.neu.coe.info6205.graphs.unirected
> edu.neu.coe.info6205.greedy
> edu.neu.coe.info6205.lab_1
> edu.neu.coe.info6205.life.base
> edu.neu.coe.info6205.life.library
> edu.neu.coe.info6205.pq
> edu.neu.coe.info6205.randomwalk
> edu.neu.coe.info6205.reduction
> edu.neu.coe.info6205.runLengthEncoding
> edu.neu.coe.info6205.sort
> edu.neu.coe.info6205.sort.classic
> edu.neu.coe.info6205.sort.counting
> edu.neu.coe.info6205.sort.elementary
> edu.neu.coe.info6205.sort.hashCode
> edu.neu.coe.info6205.sort.linearithmic
> > edu.neu.coe.info6205.sort.par
> > Main.java
> > ParSort.java
```

Problems Javadoc Declaration Search Console

<terminated> Main [1] [Java Application] /Library/Java/JavaVirtualMachines/jdk-18.0.2.1.jdk/Contents/Home/bin/java (18-Feb-2023, 9:15:19 pm – 9:15:24 pm) [pid: 366]

Size of Array: 20000

Degree of parallelism: 2

cutoff	10times Time
5000	227ms
10000	108ms
15000	62ms
20000	60ms
25000	60ms
30000	86ms
35000	67ms
40000	71ms
45000	68ms
50000	65ms

Degree of parallelism: 4

cutoff	10times Time
5000	71ms
10000	60ms
15000	59ms
20000	58ms
25000	58ms
30000	60ms
35000	57ms
40000	62ms
45000	57ms
50000	54ms

Degree of parallelism: 8

cutoff	10times Time
5000	63ms
10000	52ms
15000	50ms
20000	50ms
25000	53ms
30000	51ms
35000	50ms
40000	51ms
45000	53ms
50000	50ms

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Programs - INFO6205-PSA-Assignments/src/main/java/edu/neu/coe/info6205/sort/par/Main.java - Eclipse IDE

Project Explorer X Main.java ParSort.java

```
> edu.neu.coe.info6205.equable
> edu.neu.coe.info6205.functions
> edu.neu.coe.info6205.graphs.BFS_and_prims
> edu.neu.coe.info6205.graphs.dag
> edu.neu.coe.info6205.graphs.Dijkstra
> edu.neu.coe.info6205.graphs.generic_BFS_and_prims
> edu.neu.coe.info6205.graphs.gis
> edu.neu.coe.info6205.graphs.tunnels
> edu.neu.coe.info6205.graphs.unirected
> edu.neu.coe.info6205.greedy
> edu.neu.coe.info6205.lab_1
> edu.neu.coe.info6205.life.base
> edu.neu.coe.info6205.life.library
> edu.neu.coe.info6205.pq
> edu.neu.coe.info6205.randomwalk
> edu.neu.coe.info6205.reduction
> edu.neu.coe.info6205.runLengthEncoding
> edu.neu.coe.info6205.sort
> edu.neu.coe.info6205.sort.classic
> edu.neu.coe.info6205.sort.counting
> edu.neu.coe.info6205.sort.elementary
> edu.neu.coe.info6205.sort.hashCode
> edu.neu.coe.info6205.sort.linearithmic
> > edu.neu.coe.info6205.sort.par
> > Main.java
> > ParSort.java
```

Problems Javadoc Declaration Search Console

<terminated> Main [1] [Java Application] /Library/Java/JavaVirtualMachines/jdk-18.0.2.1.jdk/Contents/Home/bin/java (18-Feb-2023, 9:15:19 pm – 9:15:24 pm) [pid: 366]

cutoff: 50000 10times Time:50ms

Degree of parallelism: 16

cutoff	10times Time
5000	65ms
10000	51ms
15000	51ms
20000	53ms
25000	51ms
30000	51ms
35000	51ms
40000	50ms
45000	50ms
50000	51ms

Degree of parallelism: 32

cutoff	10times Time
5000	65ms
10000	54ms
15000	52ms
20000	54ms
25000	50ms
30000	54ms
35000	53ms
40000	54ms
45000	54ms
50000	53ms

Degree of parallelism: 64

cutoff	10times Time
5000	79ms
10000	63ms
15000	54ms
20000	55ms
25000	54ms
30000	53ms
35000	54ms
40000	52ms
45000	54ms
50000	52ms

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> > INFO6205-PSA-Assignments [Spring2023 1] - /Users/

Output :

Size of Array: 50000

Degree of parallelism: 2

cutoff : 5000	10times Time:96ms
cutoff : 10000	10times Time:49ms
cutoff : 15000	10times Time:44ms
cutoff : 20000	10times Time:20ms
cutoff : 25000	10times Time:20ms
cutoff : 30000	10times Time:22ms
cutoff : 35000	10times Time:19ms
cutoff : 40000	10times Time:18ms
cutoff : 45000	10times Time:19ms
cutoff : 50000	10times Time:20ms

Degree of parallelism: 4

cutoff : 5000	10times Time:22ms
cutoff : 10000	10times Time:16ms
cutoff : 15000	10times Time:17ms
cutoff : 20000	10times Time:20ms
cutoff : 25000	10times Time:23ms
cutoff : 30000	10times Time:17ms
cutoff : 35000	10times Time:17ms
cutoff : 40000	10times Time:17ms
cutoff : 45000	10times Time:17ms
cutoff : 50000	10times Time:16ms

Degree of parallelism: 8

cutoff : 5000	10times Time:19ms
cutoff : 10000	10times Time:17ms
cutoff : 15000	10times Time:15ms
cutoff : 20000	10times Time:13ms
cutoff : 25000	10times Time:13ms
cutoff : 30000	10times Time:17ms
cutoff : 35000	10times Time:17ms
cutoff : 40000	10times Time:16ms
cutoff : 45000	10times Time:17ms
cutoff : 50000	10times Time:17ms

Degree of parallelism: 16

cutoff : 5000	10times Time:15ms
cutoff : 10000	10times Time:14ms
cutoff : 15000	10times Time:15ms
cutoff : 20000	10times Time:15ms

cutoff : 25000	10times Time:15ms
cutoff : 30000	10times Time:19ms
cutoff : 35000	10times Time:17ms
cutoff : 40000	10times Time:16ms
cutoff : 45000	10times Time:17ms
cutoff : 50000	10times Time:18ms

Degree of parallelism: 32

cutoff : 5000	10times Time:14ms
cutoff : 10000	10times Time:13ms
cutoff : 15000	10times Time:14ms
cutoff : 20000	10times Time:15ms
cutoff : 25000	10times Time:14ms
cutoff : 30000	10times Time:17ms
cutoff : 35000	10times Time:18ms
cutoff : 40000	10times Time:18ms
cutoff : 45000	10times Time:18ms
cutoff : 50000	10times Time:16ms

Degree of parallelism: 64

cutoff : 5000	10times Time:18ms
cutoff : 10000	10times Time:14ms
cutoff : 15000	10times Time:14ms
cutoff : 20000	10times Time:14ms
cutoff : 25000	10times Time:14ms
cutoff : 30000	10times Time:17ms
cutoff : 35000	10times Time:17ms
cutoff : 40000	10times Time:17ms
cutoff : 45000	10times Time:17ms
cutoff : 50000	10times Time:17ms

Size of Array: 100000

Degree of parallelism: 2

cutoff : 5000	10times Time:125ms
cutoff : 10000	10times Time:70ms
cutoff : 15000	10times Time:46ms
cutoff : 20000	10times Time:35ms
cutoff : 25000	10times Time:34ms
cutoff : 30000	10times Time:36ms
cutoff : 35000	10times Time:42ms
cutoff : 40000	10times Time:46ms
cutoff : 45000	10times Time:36ms
cutoff : 50000	10times Time:36ms

Degree of parallelism: 4

cutoff : 5000	10times Time:36ms
cutoff : 10000	10times Time:30ms
cutoff : 15000	10times Time:31ms
cutoff : 20000	10times Time:29ms
cutoff : 25000	10times Time:29ms
cutoff : 30000	10times Time:28ms
cutoff : 35000	10times Time:27ms
cutoff : 40000	10times Time:31ms
cutoff : 45000	10times Time:35ms
cutoff : 50000	10times Time:32ms

Degree of parallelism: 8

cutoff : 5000	10times Time:41ms
cutoff : 10000	10times Time:30ms
cutoff : 15000	10times Time:31ms
cutoff : 20000	10times Time:27ms
cutoff : 25000	10times Time:26ms
cutoff : 30000	10times Time:27ms
cutoff : 35000	10times Time:26ms
cutoff : 40000	10times Time:27ms
cutoff : 45000	10times Time:28ms
cutoff : 50000	10times Time:27ms

Degree of parallelism: 16

cutoff : 5000	10times Time:33ms
cutoff : 10000	10times Time:28ms
cutoff : 15000	10times Time:28ms
cutoff : 20000	10times Time:25ms
cutoff : 25000	10times Time:25ms
cutoff : 30000	10times Time:26ms
cutoff : 35000	10times Time:27ms
cutoff : 40000	10times Time:26ms
cutoff : 45000	10times Time:26ms
cutoff : 50000	10times Time:27ms

Degree of parallelism: 32

cutoff : 5000	10times Time:28ms
cutoff : 10000	10times Time:30ms
cutoff : 15000	10times Time:26ms
cutoff : 20000	10times Time:26ms
cutoff : 25000	10times Time:26ms
cutoff : 30000	10times Time:27ms
cutoff : 35000	10times Time:26ms
cutoff : 40000	10times Time:27ms

cutoff : 45000 10times Time:26ms
cutoff : 50000 10times Time:28ms

Degree of parallelism: 64

cutoff : 5000 10times Time:37ms
cutoff : 10000 10times Time:31ms
cutoff : 15000 10times Time:29ms
cutoff : 20000 10times Time:40ms
cutoff : 25000 10times Time:33ms
cutoff : 30000 10times Time:30ms
cutoff : 35000 10times Time:26ms
cutoff : 40000 10times Time:30ms
cutoff : 45000 10times Time:27ms
cutoff : 50000 10times Time:32ms

Size of Array: 200000

Degree of parallelism: 2

cutoff : 5000 10times Time:227ms
cutoff : 10000 10times Time:108ms
cutoff : 15000 10times Time:62ms
cutoff : 20000 10times Time:60ms
cutoff : 25000 10times Time:60ms
cutoff : 30000 10times Time:86ms
cutoff : 35000 10times Time:67ms
cutoff : 40000 10times Time:71ms
cutoff : 45000 10times Time:68ms
cutoff : 50000 10times Time:65ms

Degree of parallelism: 4

cutoff : 5000 10times Time:71ms
cutoff : 10000 10times Time:60ms
cutoff : 15000 10times Time:59ms
cutoff : 20000 10times Time:58ms
cutoff : 25000 10times Time:58ms
cutoff : 30000 10times Time:60ms
cutoff : 35000 10times Time:57ms
cutoff : 40000 10times Time:62ms
cutoff : 45000 10times Time:57ms
cutoff : 50000 10times Time:54ms

Degree of parallelism: 8

cutoff : 5000	10times Time:63ms
cutoff : 10000	10times Time:52ms
cutoff : 15000	10times Time:50ms
cutoff : 20000	10times Time:50ms
cutoff : 25000	10times Time:53ms
cutoff : 30000	10times Time:51ms
cutoff : 35000	10times Time:50ms
cutoff : 40000	10times Time:51ms
cutoff : 45000	10times Time:53ms
cutoff : 50000	10times Time:50ms

Degree of parallelism: 16

cutoff : 5000	10times Time:65ms
cutoff : 10000	10times Time:51ms
cutoff : 15000	10times Time:51ms
cutoff : 20000	10times Time:53ms
cutoff : 25000	10times Time:51ms
cutoff : 30000	10times Time:51ms
cutoff : 35000	10times Time:51ms
cutoff : 40000	10times Time:50ms
cutoff : 45000	10times Time:50ms
cutoff : 50000	10times Time:51ms

Degree of parallelism: 32

cutoff : 5000	10times Time:65ms
cutoff : 10000	10times Time:54ms
cutoff : 15000	10times Time:52ms
cutoff : 20000	10times Time:54ms
cutoff : 25000	10times Time:50ms
cutoff : 30000	10times Time:54ms
cutoff : 35000	10times Time:53ms
cutoff : 40000	10times Time:53ms
cutoff : 45000	10times Time:54ms
cutoff : 50000	10times Time:53ms

Degree of parallelism: 64

cutoff : 5000	10times Time:79ms
cutoff : 10000	10times Time:63ms
cutoff : 15000	10times Time:54ms
cutoff : 20000	10times Time:55ms
cutoff : 25000	10times Time:54ms
cutoff : 30000	10times Time:53ms

cutoff : 35000	10times Time:54ms
cutoff : 40000	10times Time:52ms
cutoff : 45000	10times Time:54ms
cutoff : 50000	10times Time:52ms